AN APPARATUS FOR CANCER DIAGNOSIS

[Background of the Invention]

1. Technical Field

The present invention relates to an apparatus for screening cancer, and more particularly, to an apparatus for screening cancer which is capable of diagnosing cancer by confirming mass spectra of low-mass ions for cancer diagnosis based on biostatistical analysis on low-mass ions extracted from biological materials and utilizing the low-mass ion mass spectra.

2. Discussion of the Related Art

Cancer is a disease that involves indefinite proliferation of cells, and examples thereof notably include lung cancer, gastric cancer (GC), breast cancer (BRC) or colorectal cancer (CRC). However, cancer can practically develop into any place of the body. In the early stage of cancer diagnosis, focus was on the external change of biological tissue that occurred in accordance with the growth of cancer cells. Recently, attempts are made to develop a diagnosis and detection of cancer by utilizing trace amounts of biological molecules present in the biological tissue or cells, blood, glycol chain, DNA, etc. However, the most widely used way of diagnosing cancer is based on tissue sample taken by biopsy and imaging.

The biopsy has shortcomings including tremendous pain, expensive cost and lengthy time until the diagnosis. If a patient suspected of cancer indeed has cancer, there is a possibility that the cancer spreads during biopsy. Further, for specific sites of a body where biopsy is limited, diagnosing is often not available until suspicious tissues are extracted by surgical operation.

The imaging-based diagnosis basically determines the cancer based on the X-ray image, the nuclear magnetic resonance (NMR) images, or the like, using contrast agent to which disease-targeting substance is attached. The shortcomings of the imaging-based diagnosis include possibility of misdiagnosis depending on expertise of clinician or personnel who reads the data, and high dependency on the precision of the image-acquisition devices. Furthermore, even the device with the upmost precision is not able to detect a tumor under several mm in size, which means that early detection is unlikely. Further, in the process of image acquisition, as a patient is exposed to high energy electromagnetic wave which itself can induce mutation of genes, there is possibility that another disease may be induced and the number of diagnosis by imaging is limited.

Presence and absence of disease in gastric system is generally determined by observation by naked eyes with the use of endoscope. The process is painful and even when abnormality is observed during this examination, biopsy is still required to accurately determine whether the cancer is malignant/benign tumor, polypus, etc.

Colorectal cancer (CRC) is the third most commonly diagnosed cancer in the world and the cure thereof hugely depends on the stages of cancer development. That is, CRC is highly curable when detected at an early stage by screening. While early detection is very important, symptoms of this cancer are not palpable until the patient perceives the possibility from changed color of excretion due to presence of blood therein. Generally, a patient or a person suspected of CRC first goes thorough endoscopic examination of large intestines and then necessarily takes biopsy to accurately determine specific disease. That is, for CRC, early detection is critical, but since endoscopic examination of large intestines and biopsy take tremendous time and cost and also are inconvenient and painful, a diagnosis method is necessary, which can considerably reduce the number of subjects of the endoscopic

examination and biopsy which can be unnecessary.

Accordingly, by providing CRC screening at an early stage based on new molecular approach, patients will be benefited. The genomics, proteomics and molecular pathology have provided various biomarker candidates with clinical potentials. It will be possible to improve treatment effect by actively utilizing the biomarker candidates in the customized treatment of cancers according to stages and patients, and therefore, many researches are necessary to apply the above in the actual clinical treatment.

The recent CRC screening test includes determination of gross abnormality by endoscopic examination of large intestines, or fecal occult blood test (FOBT) which detects blood in feces. The endoscopic examination of large intestines has been utilized as a standard way of examination in the CRC screening, but due to invasiveness thereof, patients who can receive the examination are limited. Accordingly, many attempts have been focused on the examination of feces, for advantages such as noninvasiveness, no need for colonic irrigation, and transferability of the sample. The fecal marker may include feces oozing, excreted or exfoliated from the tumor. For example, hemoglobin in traditional FOBT was perceived as the oozing type of the marker in the large scale screening program. However, the markers known so far, including the above, have not met the satisfaction.

Meanwhile, it is possible to extract spectra of mass ions within blood using the matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF) mass spectrometer. The mass spectrometry, generally used in the researches on proteins, mainly categorizes 800 to 2500 m/s mass range as the target of analysis, because the specific range corresponds to the mass value region of peptide when the protein is dissociated by trypsin. It is also possible to extract the mass spectra of los-mass ions by using MALDI-TOF mass spectrometer. However, for the low-mass region below approximately 800 m/z where the matrix mass ions

coexist, research has not been active on this particular region.

The extracted low-mass ion mass spectra can be analyzed by the conventional software, MarkerViewTM (version 1.2). The inventors of the present invention analyzed mass spectra of the low-mass ions extracted from the serums of CRC patient group and normal group (control, CONT) using MarkerViewTM in a manner that will be explained in detail below with reference to FIG. 1.

The low-mass ion mass spectra in T2D file format was imported with MarkerViewTM from the set (A1) of samples of serums collected from 133 CRC patients of Table 101 and 153 normal controls of Table 102 (A11).

[Table 101]

CRC	Sex	Age year	Stage	Location	Cell Type	CEA ng/mL
CRC-A1	M	77	I	A-colon	AC	1.8
CRC-A2	M	50	I	Rectum	AC	1.9
CRC-A3	F	47	I	S-colon	AC	0.7
CRC-A4	F	56	III	S-colon	AC	1.2
CRC-A5	F	82	I	A-colon	AC	1.1
CRC-A6	M	59	I	Rectum	AC	1.9
CRC-A7	M	73	I	Rectum	AC	3.6
CRC-A8	M	71	I	S-colon	AC	3.6
CRC-A9	M	50	I	S-colon	AC	2.5
CRC-A10	M	56	I	S-colon	AC	7.3
CRC-A11	M	61	I	Rectum	AC	7.7
CRC-A12	F	78	I	Rectum	AC	2.6
CRC-A13	M	64	I	S-colon	AC	1.8
CRC-A14	F	50	I	Rectum	AC	1.6
CRC-A15	F	59	I	Rectum	AC	1.6
CRC-A16	M	73	I	Rectum	AC	1.9
CRC-A17	M	65	I	S-colon	AC	14.0
CRC-A18	M	72	I	S-colon	AC	4.6
CRC-A19	M	82	I	Rectum	AC	3.2
CRC-A20	M	52	III	S-colon	AC	3.2
CRC-A21	F	59	III	S-colon	AC	1.7
CRC-A22	F	73	III	S-colon	AC	5.7
CRC-A23	M	70	III	S-colon	AC	3.6
CRC-A24	M	75	II	A-colon	AC	2.1

CRC-A25	F	81	II	S-colon	AC	4.1
CRC-A26	F	76	II	Rectum	AC	25.3
CRC-A27	F	71	II	A-colon	AC	1.6
CRC-A28	M	72	II	A-colon	AC	3.8
CRC-A29	F	82	II	S-colon	AC	1.8
CRC-A30	F	68	II	D-colon	AC	1.7
CRC-A31	M	71	II	S-colon	AC	3.6
CRC-A32	F	67	II	A-colon	AC	1.9
CRC-A33	M	45	II	D-colon	MAC	3.3
CRC-A34	M	60	II	S-colon	AC	2.8
CRC-A35	M	74	II	S-colon	AC	5.3
CRC-A36	M	57	II	Rectum	AC	7.3
CRC-A37	F	65	II	S-colon	AC	2.1
CRC-A38	M	77	II	A-colon	AC	1.5
CRC-A39	M	71	II	D-colon	AC	4.1
CRC-A40	F	66	II	Rectum	AC	4.3
CRC-A41	F	49	II	A-colon	AC	1.6
CRC-A42	F	79	II	A-colon	AC	2.9
CRC-A43	M	69	II	S-colon	AC	4.2
CRC-A44	M	66	II	S-colon	AC	12.0
CRC-A45	M	74	II	A-colon	AC	1.5
CRC-A46	M	69	II	T-colon	AC	1.2
CRC-A47	M	43	II	S-colon	AC	2.2
CRC-A48	F	67	II	A-colon	AC	1.4
CRC-A49	M	72	II	A-colon	AC	4.9
CRC-A50	F	67	II	A-colon	AC	7.3
CRC-A51	F	75	II	Rectum	AC	12.6
CRC-A52	M	68	II	D-colon	AC	4.7
CRC-A53	F	60	II	S-colon	AC	3.3
CRC-A54	M	74	II	S-colon	AC	9.0
CRC-A55	M	68	III	A-colon	AC	9.2
CRC-A56	F	55	III	Rectum	AC	2.1
CRC-A57	F	61	III	A-colon	AC	12.7
CRC-A58	M	59	III	S-colon	AC	2.7
CRC-A59	M	67	III	Rectum	AC	9.5
CRC-A60	M	48	III	S-colon	AC	1.3
CRC-A61	M	58	III	Rectum	AC	1.7
CRC-A62	F	50	III	S-colon	AC	4.8
CRC-A63	F	51	III	S-colon	AC	7.0
CRC-A64	F	74	III	T-colon	AC	2.5
CRC-A65	M	60	III	Rectum	AC	3.5
CRC-A66	M	52	III	S-colon	AC	2.5
CRC-A67	M	54	III	A-colon	AC	5.3
CRC-A68	M	82	III	S-colon	AC	2.4
CRC-A69	M	54	III	S-colon	AC	5.3
CRC-A70	F	79	III	Rectum	AC	14.1
CRC-A71	F	44	III	S-colon	AC	1.4
CRC-A72	M	66	III	Rectum	AC	1.2

CRC-A73	M	53	III	A-colon	AC	4.2
CRC-A74	M	64	III	T-colon	AC	1.8
CRC-A75	F	42	III	S-colon	AC	0.8
CRC-A76	M	49	III	Rectum	AC	2.7
CRC-A77	M	68	III	Rectum	AC	3.9
CRC-A78	M	51	III	S-colon	AC	5.2
CRC-A79	M	64	III	Rectum	AC	7.7
CRC-A80	M	42	III	S-colon	AC	2.8
CRC-A81	F	43	III	A-colon	AC	4.7
CRC-A82	M	66	III	S-colon	AC	9.1
CRC-A83	M	37	III	Rectum	AC	3.7
CRC-A84	F	81	III	Rectum	AC	8.4
CRC-A85	F	73	III	S-colon	AC	1.7
CRC-A86	M	54	III	Rectum	AC	6.4
CRC-A87	F	58	III	Rectum	AC	21.3
CRC-A88	F	42	III	Rectum	AC	0.7
CRC-A89	F	50	III	D-colon	AC	6.4
CRC-A90	M	56	III	S-colon	AC	7.3
CRC-A91	F	58	III	S-colon	AC	2.1
CRC-A92	F	70	IV	Rectum	AC	3.9
CRC-A93	M	68	IV	Rectum	AC	6.0
CRC-A94	M	53	IV	Rectum	AC	54.7
CRC-A95	F	63	IV	D-colon	AC	12.3
CRC-A96	F	63	IV	A-colon	AC	1.4
CRC-A97	M	63	II	D-colon	AC	4.9
CRC-A98	F	66	II	S-colon	AC	4.2
CRC-A99	M	48	II	Rectum	AC	28.4
CRC-A100	M	68	II	S-colon	AC	2.3
CRC-A101	M	48	II	S-colon	AC	4.8
CRC-A102	F	81	II	S-colon	AC	2.4
CRC-A103	M	56	II	A-colon	AC	34.6
CRC-A104	M	71	III	Rectum	AC	16.5
CRC-A105	M	66	III	S-colon	AC	689.8
CRC-A106	M	65	III	D-colon	AC	3.4
CRC-A107	F	65	III	S-colon	MAC	2.7
CRC-A108	F	51	III	Rectum	AC	1.4
CRC-A109	M	58	III	S-colon	AC	2.8
CRC-A110	F	48	III	A-colon	AC	0.9
CRC-A111	M	71	III	S-colon	AC	6.0
CRC-A112	M	68	III	A-colon	AC	2.7
CRC-A113	F	54	III	A-colon	AC	1.7
CRC-A114	M	66	IV	S-colon	AC	6.4
CRC-A115	F	72	IV	A-colon	AC	73.4
CRC-A116	F	69	IV	A-colon	AC	49.0
CRC-A117	M	75	IV	S-colon	AC	16.7
CRC-A118	F	49	III	S-colon	AC	1.0
CRC-A119	F	63	III	A-colon	AC	58.2
CRC-A120	M	74	III	A-colon	AC	2.8

CRC-A121	F	54	III	T-colon	AC	2.2
CRC-A122	M	68	III	Rectum	AC	22.5
CRC-A123	M	66	III	Rectum	MAC	1.2
CRC-A124	M	72	IV	Rectum	SC	8.2
CRC-A125	M	73	IV	Rectum	AC	52.2
CRC-A126	M	54	IV	A-colon	AC	2.0
CRC-A127	F	54	IV	S-colon	AC	29.8
CRC-A128	M	43	IV	Rectum	AC	36.4
CRC-A129	F	52	IV	A-colon	MAC	9.0
CRC-A130	M	48	IV	S-colon	AC	15.9
CRC-A131	M	62	IV	Rectum	AC	6.3
CRC-A132	M	77	I	D-colon	AC	6.4
CRC-A133	M	78	I	Rectum	AC	2.7

AC: Adenocarcinoma

CEA : Carcinoembryonic antigen

MAC: Mucinous adenocarcinoma

【Table 102】

Control	Sex	Age year	CEA ng/mL	Control	Sex	Age year	CEA ng/mL
CONT-A1	M	39	1.3	CONT-A78	F	64	2.9
CONT-A2	F	70	1.2	CONT-A79	F	52	1.9
CONT-A3	M	66	1.3	CONT-A80	F	37	2.1
CONT-A4	M	53	0.8	CONT-A81	F	49	2.6
CONT-A5	F	69	1.0	CONT-A82	F	48	1.5
CONT-A6	F	68	1.8	CONT-A83	F	30	<0.5
CONT-A7	M	35	1.7	CONT-A84	F	56	1.4
CONT-A8	M	62	3.7	CONT-A85	F	50	1.2
CONT-A9	M	62	1.1	CONT-A86	F	49	2.1
CONT-A10	M	48	5.3	CONT-A87	F	38	0.6
CONT-A11	M	48	1.8	CONT-A88	F	59	1.6
CONT-A12	M	66	1.6	CONT-A89	F	51	1.0
CONT-A13	M	66	1.4	CONT-A90	F	41	1.8
CONT-A14	M	66	4.2	CONT-A91	F	48	1.2
CONT-A15	M	54	1.4	CONT-A92	F	39	0.5
CONT-A16	M	54	1.0	CONT-A93	F	51	1.1
CONT-A17	M	62	2.0	CONT-A94	F	44	1.5
CONT-A18	F	45	0.7	CONT-A95	F	38	1.5
CONT-A19	M	39	3.2	CONT-A96	F	48	1.9
CONT-A20	M	67	1.8	CONT-A97	F	70	4.8
CONT-A21	M	63	5.5	CONT-A98	F	54	2.8

CONT-A22	M	48	2.8	CONT-A99	F	38	2.8
CONT-A23	M	66	3.2	CONT-A100	F	50	1.1
CONT-A24	M	55	5.0	CONT-A101	F	54	1.8
CONT-A25	M	55	1.0	CONT-A102	M	49	1.2
CONT-A26	M	62	7.0	CONT-A103	F	38	0.9
CONT-A27	F	57	1.2	CONT-A104	F	44	-
CONT-A28	M	61	0.9	CONT-A105	M	52	-
CONT-A29	M	50	1.9	CONT-A106	F	45	-
CONT-A30	M	46	1.5	CONT-A107	F	54	-
CONT-A31	M	51	4.0	CONT-A108	F	51	3.1
CONT-A32	F	68	1.8	CONT-A109	M	54	6.4
CONT-A33	F	68	1.4	CONT-A110	M	46	1.1
CONT-A34	M	64	1.7	CONT-A111	M	47	1.8
CONT-A35	M	30	0.7	CONT-A112	M	49	1.7
CONT-A36	F	52	2.1	CONT-A113	F	55	<0.5
CONT-A37	F	59	1.2	CONT-A114	M	36	0.7
CONT-A38	M	53	1.6	CONT-A115	M	59	0.8
CONT-A39	F	69	1.2	CONT-A116	M	46	3.7
CONT-A40	F	68	1.0	CONT-A117	F	46	<0.5
CONT-A41	F	65	3.1	CONT-A118	F	50	0.9
CONT-A42	M	31	1.2	CONT-A119	M	58	-
CONT-A43	F	59	0.7	CONT-A120	M	34	1.7
CONT-A44	M	43	1.4	CONT-A121	M	53	2.9
CONT-A45	M	66	2.3	CONT-A122	M	45	3.7
CONT-A46	M	48	4.2	CONT-A123	M	47	4.5
CONT-A47	F	41	2.1	CONT-A124	F	34	0.6
CONT-A48	F	65	3.8	CONT-A125	F	58	1.5
CONT-A49	F	67	1.5	CONT-A126	F	54	-
CONT-A50	F	45	0.6	CONT-A127	M	35	1.8
CONT-A51	M	30	1.0	CONT-A128	M	49	1.4
CONT-A52	M	55	1.2	CONT-A129	M	48	3.2
CONT-A53	M	54	2.1	CONT-A130	F	34	<0.5
CONT-A54	M	69	2.8	CONT-A131	M	45	4.4
CONT-A55	M	53	1.8	CONT-A132	F	45	0.8
CONT-A56	F	47	1.7	CONT-A133	M	52	-
CONT-A57	M	31	1.7	CONT-A134	F	44	-
CONT-A58	M	53	3.2	CONT-A135	F	46	-
CONT-A59	F	49	1.4	CONT-A136	M	58	-
CONT-A60	M	62	1.7	CONT-A137	M	45	4.3
CONT-A61	M	31	2.3	CONT-A138	M	61	1.4
CONT-A62	M	40	0.8	CONT-A139	M	42	2.7
CONT-A63	F	49	1.4	CONT-A140	M	48	3.0
CONT-A64	F	33	1.7	CONT-A141	M	53	1.9
CONT-A65	M	51	3.4	CONT-A142	F	54	2.3
CONT-A66	M	52	2.0	CONT-A143	F	39	1.3
CONT-A67	F	66	1.3	CONT-A144	F	55	1.3
CONT-A68	M	56	1.9	CONT-A145	M	53	-
CONT-A69	F	65	1.4	CONT-A146	F	46	-

CONT-A70	M	50	1.4	CONT-A147	F	45	-
CONT-A71	M	54	1.3	CONT-A148	F	63	-
CONT-A72	M	68	1.6	CONT-A149	F	51	-
CONT-A73	M	59	2.5	CONT-A150	M	51	-
CONT-A74	F	51	2.1	CONT-A151	F	52	-
CONT-A75	F	39	0.8	CONT-A152	F	52	-
CONT-A76	F	40	1.5	CONT-A153	F	70	-
CONT-A77	F	50	1.9				

The conditions of Table 103 were used for import.

【Table 103】

Mass tolerance	100 ppm
Minimum required response	10.0
Maximum number of peaks	10000

The imported peak intensities were then normalized (A12). MarkerView™ has a plurality of normalization methods, and among these, "Normalization Using Total Area Sums" was employed for the normalization. According to the method, partial sums of the intensities of the respective samples were obtained and averaged, and then each peak intensity was multiplied by a scaling factor so that the sums of the respective samples were in agreement with the averages. As a result, the partial sums of the intensities of the respective samples became identical after the normalization.

Next, the normalized peak intensities were Pareto-scaled (A13). That is, the peak intensities were Pareto-scaled by subtracting the averages of the respective mass ions from the respective normalized peak intensities, and dividing the same by the square root of the standard deviation.

Next, with respect to the Pareto-scaled peak intensities, discriminant scores (DS) were computed by performing the principal component analysis-based linear discriminant analysis (PCA-DA) (A14). The PCA-DA was performed by two stages, to obtain factor loading, which are the weighting factors of the respective mass ions, and the Pareto-scaled intensities were multiplied by the factor loading. The resultant values were summed, to compute the

discriminant scores of the respective samples. The import condition of Table 103 includes maximum 10,000 peaks with sufficient samples imported, so that there were 10,000 factor loading computed, and one DS was computed by summing 10,000 terms.

Next, it was determined whether the computed DS was positive number or not (A15), and if so, determined positive (A16), and if not, determined negative (A17). In other words, when implemented on CRC, the positive number was interpreted as CRC patient group, while negative number was interpreted as normal control group.

FIG. 2 illustrates distribution of DS which were computed by the method of FIG. 1 with respect to the set consisting of 133 clinically CRC-diagnosed patients and 153 non-cancer subjects. Reorganizing the interpretation results according to DS of FIG. 2 using confusion matrix will give:

【Table 104】

				Sensitivity	98.50%
Set A_1	True CRC	True CONT		Specificity	98.69%
Predicted CRC	131	2		PPV	98.50%
Predicted CONT	2	151		NPV	98.69%

Referring to FIG. 2 and Table 104, excellent discrimination result was obtained with all of the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) exceeding 98% by the conventional PCA-DA of the MarkerView™.

However, the robustness of the formula must be verified for clinical use. That is, even the mass spectra that were additionally measured by a number of times with respect to the dataset that was measured once and constituted discriminant formula, are required to maintain good discrimination results, and the discrimination result based on the same discriminant also has to be sound with respect to new CRC patient groups and non-cancer

subjects that were not taken into consideration in the designing of the discriminant. The process of repeatedly measuring mass spectra may include the process of freezing and thawing serums and mixing the serum newly with methanol/chloroform to obtain extract. These processes are considered the disturbances in the statistic analysis with respect to the mass spectra, and clinical implementation is only possible when the discriminant is least influenced by the disturbances.

The conventional PCA-DA explained above with reference to FIGS. 1 and 2 and Table 104 sometimes exhibit good discrimination result if applied individually to the set of specific samples, i.e., to individual training set. However, the discrimination result was unsatisfactory when applied with respect to the validation set (Tables 124, 126). It appears that the discriminant exhibiting very good discrimination result with respect to the training set, is not so robust because the 10,000 mass ions constituting the discriminant include a considerable amount of mass ions which may be at least unnecessary for the discrimination between CRC patients and non-cancer subjects and although not entirely problematic in the discrimination of training set, which can potentially cause confusion in the discrimination result in the discrimination of the validation set. Accordingly, a process is necessary, which exclusively locates mass ions that are absolutely necessary to obtain good and robust discrimination result, by actively removing mass ions which are at least unnecessary or which can potentially confuse discrimination result.

The incidence rate and prevalence rate of breast cancer (BRC) rapidly grew, following the thyroid cancer. Compared to the high incidence rate, BRC also has high cure rate following the thyroid cancer, for reasons mainly include development of effective drugs and change in public's awareness and also advancement of mammograpy which enables early detection of BRC. Like other carcinomas, BRC survival rate can be increased if detected and treated at an early stage. The survival rate is reported as high as 90% in the case of small-size

BRC with no lymph node metastasis. However, the survival rate drops to 10% when BRC is detected after metastasis into another area. In order to discover BRC as early as possible, doctor's diagnosis and radiologic breast checkup as well as self test are prerequisite. However, sensitivity of mammography stays at a low level of 60-70%, and the diagnosis rate considerably decreases in the case of dense breasts which are more commonly found in young women. These women are generally advised to take breast ultrasonic test, but this test has a shortcoming of high dependency on the skill of the sonographer. Additionally, breast magnetic resonance imaging (MRI) is used in the diagnosis of BRC, but high cost thereof makes MRI unsuitable option for the BRC diagnosis and further, the false positive rate is high.

Accordingly, the patients will be benefited if it is possible to apply new molecular approach to screen BRC at an early stage. The genomics, proteomics and molecular pathology have provided many biomarkers with potential clinical value. The treatment effect would be improved by actively utilize these markers via customization with stages of the cancer and the patients. However, researchers have a long way to go until they would finally be able to implement these for clinical treatment.

Meanwhile, it is possible to extract spectra of mass ions within blood using the matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF) mass spectrometer. The mass spectrometry, generally used in the researches on proteins, mainly categorizes 800 to 2500 m/s mass range as the target of analysis, because the specific range corresponds to the mass value region of peptide when the protein is dissociated by trypsin. It is also possible to extract the mass spectra of los-mass ions by using MALDI-TOF mass spectrometer. However, for the low-mass region below approximately 800 m/z where the matrix mass ions coexist, research has not been active on this particular region.

The extracted low-mass ion mass spectra can be analyzed by the conventional

software, MarkerView™ (version 1.2). The inventors of the present invention analyzed mass spectra of the low-mass ions extracted from the serums of BRC patient group and normal group (control, CONT) using MarkerView™ in a manner that will be explained in detail below with reference to FIG. 3.

The low-mass ion mass spectrum in T2D file format was imported with MarkerView™ from the set (C_1) of samples of serums collected from 54 BRC patients of Table 201 and 202 normal controls of Table 202 (B11).

【Table 201】

BRC	Sex	Age year	Node	ER	ER%	PR	PR%	HER2	Tumor Size cm
BRC-C1	F	48	-[a]	5	33-66%	6	33-66%	2	-
BRC-C2	F	35	-	6	33-66%	6	33-66%	1	-
BRC-C3	F	45	pN1a	5	33-66%	5	33-66%	0	1.5
BRC-C4	F	61	-	0	0%	0	0%	2	-
BRC-C5	F	70	pN0(sn)	0	0%	0	0%	1	<0.1
BRC-C6	F	58	ypN0	3	<10%	3	10-33%	3	0.5
BRC-C7	F	49	ypN0(i+)	0	0%	0	0%	2	1.9
BRC-C8	F	49	ypN2a	0	0%	0	0%	1	2.5
BRC-C9	F	39	pN1a	6	33-66%	7	>66%	1	2.2
BRC-C10	F	48	ypN2a	6	33-66%	4	<10%	3	5.8
BRC-C11	F	39	-	0	0%	0	0%	1	-
BRC-C12	F	56	pN1a	6	33-66%	6	33-66%	0	2.8
BRC-C13	F	59	pN0(sn)	6	33-66%	2	<10%	1	2.3
BRC-C14	F	31	pN1a	5	33-66%	4	10-33%	1	2.2
BRC-C15	F	46	pN3a	6	33-66%	6	33-66%	1	3.5
BRC-C16	F	56	-	7	>66%	4	10-33%	1	-
BRC-C17	F	55	-	0	0%	0	0%	2	-
BRC-C18	F	46	pN0	0	0%	0	0%	0	1.5
BRC-C19	F	60	ypN0	0	0%	0	0%	3	1.9
BRC-C20	F	49	pN0(sn)	5	33-66%	2	<10%	2	1.5
BRC-C21	F	55	pN1mi	0	0%	0	0%	3	1.8
BRC-C22	F	65	pN0	6	33-66%	6	33-66%	0	1.7
BRC-C23	F	35	ypN2a	6	66%	4	10-33%	2	2.6
BRC-C24	F	46	pN1a	6	33-66%	6	33-66%	3	2.5
BRC-C25	F	45	pN0(sn)	6	33-66%	6	33-66%	1	0.8
BRC-C26	F	42	pN0(sn)	3	10-33%	6	33-66%	0	1
BRC-C27	F	58	pN0(sn)	6	33-66%	6	33-66%	1	1.5
BRC-C28	F	62	pN1a	0	0%	0	0%	2	2.2

BRC-C29	F	61	-	0	0%	0	0%	1	-
BRC-C30	F	60	-	-	-	-	-	-	-
BRC-C31	F	51	-	-	-	-	-	-	-
BRC-C32	F	42	pN0	7	>66%	7	>66%	2	-
BRC-C33	F	43	pN0(sn)	3	10-33%	4	10-33%	0	2.3
BRC-C34	F	60	pN0(sn)	0	0%	0	0%	1	2.3
BRC-C35	F	61	-	6	33-66%	0	0%	2	-
BRC-C36	F	61	pN0(sn)	0	0%	2	<10%	2	1.8
BRC-C37	F	49	-	-	-	-	-	-	-
BRC-C38	F	45	ypN0	0	0%	0	0%	0	0.9
BRC-C39	F	59	pN0	0	0%	0	0%	3	1.1
BRC-C40	F	43	pN1	0	0%	0	0%	0	1.5
BRC-C41	F	46	pN1	8	100%	8	100%	0	1.3
BRC-C42	F	48	pN0	6	50-60%	5	10-20%	3	1.3
BRC-C43	F	39	pN0	0	0%	0	0%	0	2.2
BRC-C44	F	66	pN0	8	95%	8	95%	0	1.7
BRC-C45	F	39	ypN0	0	0%	0	0%	0	DCIS
BRC-C46	F	37	pN0	7	70-80%	8	80%	3	1.5
BRC-C47	F	64	pN0	8	95%	8	95%	0	0.5
BRC-C48	F	44	ypN1	7	90%	8	95%	0	2
BRC-C49	F	50	pN2	8	95%	8	100%	0	1.1
BRC-C50	F	47	pN0	7	70%	7	50-60%	1	0.5
BRC-C51	F	44	pN1	8	90%	8	95%	1	0.6
BRC-C52	F	50	pN0	0	0%	0	0%	2	2.2
BRC-C53	F	53	pN0	7	95%	8	95%	0	1.1
BRC-C54	F	65	pN0	8	95%	7	40%	0	1.5

【Table 202】

Control	Sex	Age year	CEA ng/mL
CONT-C1	F	70	1.2
CONT-C2	F	69	1
CONT-C3	F	68	1.8
CONT-C4	F	45	0.7
CONT-C5	F	57	1.2
CONT-C6	F	68	1.8
CONT-C7	F	68	1.4
CONT-C8	F	52	2.1
CONT-C9	F	59	1.2
CONT-C10	F	68	1
CONT-C11	F	65	3.1
CONT-C12	F	59	0.7
CONT-C13	F	41	2.1
CONT-C14	F	65	3.8

CONT-C15	F	67	1.5
CONT-C16	F	45	0.6
CONT-C17	F	47	1.7
CONT-C18	F	49	1.4
CONT-C19	F	49	1.4
CONT-C20	F	33	1.7
CONT-C21	F	66	1.3
CONT-C22	F	65	1.4
CONT-C23	F	51	2.1
CONT-C24	F	39	0.8
CONT-C25	F	66	1.6
CONT-C26	F	50	2.6
CONT-C27	F	53	2.6
CONT-C28	F	60	3.7
CONT-C29	F	66	1.1
CONT-C30	F	68	5.5
CONT-C31	F	56	1.3
CONT-C32	F	51	1.9
CONT-C33	F	51	1.6
CONT-C34	F	52	1.4
CONT-C35	F	56	1.7
CONT-C36	F	52	1.7
CONT-C37	F	60	1.8
CONT-C38	F	58	0.7
CONT-C39	F	58	3.1
CONT-C40	F	54	1.6
CONT-C41	F	60	1.1
CONT-C42	F	43	-
CONT-C43	F	40	-
CONT-C44	F	60	-
CONT-C45	F	46	-
CONT-C46	F	67	-
CONT-C47	F	49	-
CONT-C48	F	43	-
CONT-C49	F	57	-

CEA : Carcinoembryonic antigen

The conditions of Table 203 were used for import.

【Table 203】

Mass tolerance	100 ppm
Minimum required response	10.0
Maximum number of peaks	10000

The imported peak intensities were then normalized (A12). MarkerView™ has a plurality of normalization methods, and among these, "Normalization Using Total Area Sums" was employed for the normalization. According to the method, partial sums of the intensities of the respective samples were obtained and averaged, and then each peak intensity was multiplied by a scaling factor so that the partial sums of the respective samples were in agreement with the averages. As a result, the partial sums of the intensities of the respective samples became identical after the normalization.

Next, the normalized peak intensities were Pareto-scaled (B13). That is, the peak intensities were Pareto-scaled by subtracting the averages of the respective mass ions from the respective normalized peak intensities, and dividing the same by the square root of the standard deviation.

Next, with respect to the Pareto-scaled peak intensities, discriminant scores (DS) were computed by performing the principal component analysis-based linear discriminant analysis (PCA-DA) (B14). The PCA-DA was performed by two stages, to obtain factor loading, which are the weighting factors of the respective mass ions, and the Pareto-scaled intensities were multiplied by the factor loading. The resultant values were summed, to compute the discriminant scores of the respective samples. The import condition of Table 103 includes maximum 10,000 peaks with sufficient samples imported, so that there were 10,000 factor loading computed, and one DS was computed by summing 10,000 terms.

Next, it was determined whether the computed DS was positive number or not (B15), and if so, determined positive (B16), and if not, determined negative (B17). In other words, when implemented on BRC, the positive number was interpreted as BRC patient group, while negative number was interpreted as normal control group.

FIG. 4 illustrates distribution of DS which were computed by the method of FIG. 3

with respect to the set consisting of 54 clinically BRC-diagnosed patients and 49 non-cancer subjects. Reorganizing the interpretation results according to DS of FIG. 4 using confusion matrix will give:

【Table 204】

				Sensitivity	100.0%
Set A_1	True BRC	True CONT		Specificity	100.0%
Predicted BRC	54	0		PPV	100.0%
Predicted CONT	0	49		NPV	100.0%

Referring to FIG. 4 and Table 204, perfect discrimination result was obtained with all of the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) reaching 100% by the conventional PCA-DA of the MarkerView^{TM}.

However, the robustness of the formula must be verified for clinical use. That is, even the mass spectra that were additionally measured by a number of times with respect to the dataset that was measured once and constituted discriminant formula, are required to maintain good discrimination results, and the discrimination result based on the same discriminant also has to be sound with respect to new BRC patient groups and non-cancer subjects that were not taken into consideration in the designing of the discriminant. The process of repeatedly measuring mass spectra may include the process of freezing and thawing serums and mixing the serum newly with methanol/chloroform to obtain extract. These processes are considered the disturbances in the statistic analysis with respect to the mass spectra, and clinical implementation is only possible when the discriminant is least influenced by the disturbances.

The conventional PCA-DA explained above with reference to FIGS. 3 and 4 and

Table 204 sometimes exhibit good discrimination result if applied individually to the set of specific samples, i.e., to individual training set. However, the discrimination result was unsatisfactory when applied with respect to the validation set (Tables 224, 226). It appears that the discriminant exhibiting very good discrimination result with respect to the training set, is not so robust because the 10,000 mass ions constituting the discriminant include a considerable amount of mass ions which may be at least unnecessary for the discrimination between BRC patients and non-cancer subjects and although not entirely problematic in the discrimination of training set, which can potentially cause confusion in the discrimination result in the discrimination of the validation set. Accordingly, a process is necessary, which exclusively locates mass ions that are absolutely necessary to obtain good and robust discrimination result, by actively removing mass ions which are at least unnecessary, or which can potentially confuse discrimination result.

Meanwhile, gastric cancer (GC) is the most-commonly diagnosed cancer in South Korea (18.3%), with the incidence frequency recording highest among men, and third-highest among women following BRC and thyroid cancer (Major carcinoma incidence rates, 2003-2005, National Statistical Office). Although the rate of early detection is increasing thanks to endoscopic examination on general public and change in the public awareness, the death rate of this particular cancer still records highest frequency (22%) following lung cancer and liver cancer (2006. Statistical Year Book of Cause of Death. National Statistical Office).

Surgical treatment is the basic measure for complete recovery and the frequency of early GC is approximately 50% recently with the complete recovery rate exceeding 90%. However, unlike the early GC, metastatic or recurrent GC shows quite undesirable prognosis, in which the median survival time is as short as 1 year or shorter. The five year survival rate is also very low around 5% or below.

The palliative chemotherapy is accepted as a standard treatment of metastatic or

recurrent GC, based on the researches that confirmed effect of prolonged survival period in 3 phrase study compared with the best supportive care and also the effect of improved life quality.

Since 1990, treatment with 5-fluorouracil (5-FU) and platinum have been most widely used as the treatment for metastatic GC, and irinotecan, oxaliplatin, paclitaxel, docetaxel, capecitabine have been used in various combinations for clinical study to develop new drugs with improved efficacy and minimized side effects. No particular research has been reported so far, which confirmed markedly increased performance than 5-FU based chemotherapy. While ECF (epirubicin, cisplatin and 5-fluorouracil) provides good effect, this is accompanied with side effect of high toxicity.

Various studies are conducted to overcome the limitations mentioned above, and among these, efforts to discover biomarker are at the center. The biomarkers can be used in the early diagnosis of cancer, and also used as a target for the treatment of metastatic carcinoma. Combined use of marker with the existent anticancer agents exhibit efficacy in the CRC, lung cancer, BRC and pancreatic cancer, and many efforts are necessary to develop and research use in GC.

Accordingly, by providing GC screening at an early stage based on new molecular approach, patients will be benefited. The genomics, proteomics and molecular pathology have provided various biomarker candidates with clinical potentials. It will be possible to improve treatment effect by actively utilizing the biomarker candidates in the customized treatment of cancers according to stages and patients, and therefore, many researches are necessary to apply the above in the actual clinical treatment.

The recent GC screening test includes determination of gross abnormality by endoscopic examination of large intestines, or fecal occult blood test (FOBT) which detects blood in feces. The endoscopic examination of large intestines has been utilized as a standard

way of examination in the GC screening, but due to invasiveness thereof, patients who can receive the examination are limited. Accordingly, many attempts have been focused on the examination of feces, for advantages such as noninvasiveness, no need for colonic irrigation, and transferability of the sample. The fecal marker may include feces oozing, excreted or exfoliated from the tumor. For example, hemoglobin in traditional FOBT was perceived as the oozing type of the marker in the large scale screening program. However, the markers known so far, including the above, have not met the satisfaction.

Meanwhile, it is possible to extract spectra of mass ions within blood using the matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF) mass spectrometer. The mass spectrometry, generally used in the researches on proteins, mainly categorizes 800 to 2500 m/s mass range as the target of analysis, because the specific range corresponds to the mass value region of peptide when the protein is dissociated by trypsin. It is also possible to extract the mass spectra of los-mass ions by using MALDI-TOF mass spectrometer. However, for the low-mass region below approximately 800 m/z where the matrix mass ions coexist, research has not been active on this particular region.

The extracted low-mass ion mass spectra can be analyzed by the conventional software, MarkerView™ (version 1.2). The inventors of the present invention analyzed mass spectra of the low-mass ions extracted from the serums of GC patient group and normal group (control, CONT) using MarkerView™ in a manner that will be explained in detail below with reference to FIG. 1.

The low-mass ion mass spectra in T2D file format was imported with MarkerView™ from the set (A_1) of samples of serums collected from 49 GC patients of Table 301 and 84 normal controls of Table 302 (C11).

【Table 301】

GC	Sex	Age year	CEA ng/mL	Stage	GC	Sex	Age year	CEA ng/mL	Stage
GC-E1	M	62	5.41	I	GC-E26	M	64	-	III
GC-E2	M	58	-	I	GC-E27	M	53	-	III
GC-E3	M	62	1.34	I	GC-E28	M	61	-	III
GC-E4	M	48	-	I	GC-E29	F	52	3.36	IV
GC-E5	M	51	-	I	GC-E30	M	65	0.99	IV
GC-E6	M	44	-	I	GC-E31	M	41	-[a]	IV
GC-E7	F	44	-	I	GC-E32	M	78	4.93	IV
GC-E8	M	61	-	I	GC-E33	M	79	1.11	IV
GC-E9	M	76	-	I	GC-E34	M	76	2.37	IV
GC-E10	M	51	-	I	GC-E35	M	54	117.13	IV
GC-E11	F	60	1.2	II	GC-E36	M	58	2.24	IV
GC-E12	M	73	-	II	GC-E37	M	67	>1500	IV
GC-E13	F	57	-	II	GC-E38	F	71	1.92	IV
GC-E14	M	78	-	II	GC-E39	M	34	3.57	IV
GC-E15	M	75	-	II	GC-E40	M	69	1.39	IV
GC-E16	F	67	-	II	GC-E41	M	49	1.67	IV
GC-E17	M	50	-	II	GC-E42	F	34	13.44	IV
GC-E18	F	60	-	II	GC-E43	M	50	-	IV
GC-E19	F	47	-	II	GC-E44	M	55	-	IV
GC-E20	F	62	8.3	III	GC-E45	M	66	-	IV
GC-E21	M	64	-	III	GC-E46	F	40	-	IV
GC-E22	M	58	6.89	III	GC-E47	M	61	-	IV
GC-E23	F	47	2.86	III	GC-E48	M	70	-	IV
GC-E24	F	55	-	III	GC-E49	M	39	-	IV
GC-E25	F	46	-	III					

CEA : Carcinoembryonic antigen

【Table 302】

Control	Sex	Age year	CEA ng/mL	Control	Sex	Age year	CEA ng/mL
CONT-E1	M	39	1.3	CONT-E43	M	48	4.2
CONT-E2	F	70	1.2	CONT-E44	F	41	2.1
CONT-E3	M	66	1.3	CONT-E45	F	65	3.8
CONT-E4	M	53	0.8	CONT-E46	M	64	2.4
CONT-E5	F	69	1	CONT-E47	M	53	3.3
CONT-E6	F	68	1.8	CONT-E48	M	63	0.9
CONT-E7	M	35	1.7	CONT-E49	M	57	1.5
CONT-E8	M	62	3.7	CONT-E50	F	66	1.6
CONT-E9	M	62	1.1	CONT-E51	M	60	1.5
CONT-E10	M	48	5.3	CONT-E52	M	57	2.2
CONT-E11	M	48	1.8	CONT-E53	M	53	1.9

CONT-E12	M	66	1.6	CONT-E54	M	60	0.8
CONT-E13	M	66	1.4	CONT-E55	F	50	2.6
CONT-E14	M	66	4.2	CONT-E56	F	53	2.6
CONT-E15	M	54	1.4	CONT-E57	M	64	1.5
CONT-E16	M	54	1	CONT-E58	F	60	3.7
CONT-E17	M	62	2	CONT-E59	M	58	1.2
CONT-E18	F	45	0.7	CONT-E60	F	66	1.1
CONT-E19	M	39	3.2	CONT-E61	M	57	2.9
CONT-E20	M	67	1.8	CONT-E62	F	68	5.5
CONT-E21	M	63	5.5	CONT-E63	M	56	1.7
CONT-E22	M	48	2.8	CONT-E64	M	51	3.4
CONT-E23	M	55	5	CONT-E65	F	56	1.3
CONT-E24	M	55	1	CONT-E66	M	57	1.5
CONT-E25	M	62	7	CONT-E67	M	61	4.2
CONT-E26	F	57	1.2	CONT-E68	F	51	1.9
CONT-E27	M	61	0.9	CONT-E69	F	51	1.6
CONT-E28	M	50	1.9	CONT-E70	F	52	1.4
CONT-E29	M	46	1.5	CONT-E71	F	56	1.7
CONT-E30	M	51	4	CONT-E72	F	52	1.7
CONT-E31	F	68	1.8	CONT-E73	M	63	1
CONT-E32	F	68	1.4	CONT-E74	F	60	1.8
CONT-E33	M	64	1.7	CONT-E75	F	58	0.7
CONT-E34	F	52	2.1	CONT-E76	M	65	4.1
CONT-E35	F	59	1.2	CONT-E77	M	52	2.2
CONT-E36	M	53	1.6	CONT-E78	M	50	-[a]
CONT-E37	F	68	1	CONT-E79	F	72	-
CONT-E38	F	65	3.1	CONT-E80	F	57	-
CONT-E39	M	31	1.2	CONT-E81	M	50	-
CONT-E40	F	59	0.7	CONT-E82	F	70	-
CONT-E41	M	43	1.4	CONT-E83	F	42	-
CONT-E42	M	66	2.3	CONT-E84	F	51	-

The conditions of Table 203 were used for import.

【Table 303】

Mass tolerance	100 ppm
Minimum required response	10.0
Maximum number of peaks	10000

The imported peak intensities were then normalized (C12). MarkerView™ has a plurality of normalization methods, and among these, "Normalization Using Total Area

Sums" was employed for the normalization. According to the method, partial sums of the intensities of the respective samples were obtained and averaged, and then each peak intensity was multiplied by a scaling factor so that the partial sums of the respective samples were in agreement with the averages. As a result, the partial sums of the intensities of the respective samples became identical after the normalization.

Next, the normalized peak intensities were Pareto-scaled (C13). That is, the peak intensities were Pareto-scaled by subtracting the averages of the respective mass ions from the respective normalized peak intensities, and dividing the same by the square root of the standard deviation.

Next, with respect to the Pareto-scaled peak intensities, discriminant scores (DS) were computed by performing the principal component analysis-based linear discriminant analysis (PCA-DA) (C14). The PCA-DA was performed by two stages, to obtain factor loading, which are the weighting factors of the respective mass ions, and the Pareto-scaled intensities were multiplied by the factor loading. The resultant values were summed, to compute the discriminant scores of the respective samples. The import condition of Table 103 includes maximum 10,000 peaks with sufficient samples imported, so that there were 10,000 factor loading computed, and one DS was computed by summing 10,000 terms.

Next, it was determined whether the computed DS was positive number or not (C15), and if so, determined positive (C16), and if not, determined negative (C17). In other words, when implemented on GC, the positive number was interpreted as GC patient group, while negative number was interpreted as normal control group.

FIG. 6 illustrates distribution of DS which were computed by the method of FIG. 5 with respect to the set consisting of 49 clinically GC-diagnosed patients and 84 non-cancer subjects. Reorganizing the interpretation results according to DS of FIG. 6 using confusion matrix will give:

【Table 304】

				Sensitivity	97.96%
Set E_1	True GC	True CONT		Specificity	100.0%
Predicted GC	48	0		PPV	100.0%
Predicted CONT	1	84		NPV	98.82%

Referring to FIG. 6 and Table 304, perfect discrimination result was obtained with all of the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) exceeding 97% by the conventional PCA-DA of the MarkerView™.

However, the robustness of the formula must be verified for clinical use. That is, even the mass spectra that were additionally measured by a number of times with respect to the dataset that was measured once and constituted discriminant formula, are required to maintain good discrimination results, and the discrimination result based on the same discriminant also has to be sound with respect to new GC patient groups and non-cancer subjects that were not taken into consideration in the designing of the discriminant. The process of repeatedly measuring mass spectra may include the process of freezing and thawing serums and mixing the serum newly with methanol/chloroform to obtain extract. These processes are considered the disturbances in the statistic analysis with respect to the mass spectra, and clinical implementation is only possible when the discriminant is least influenced by the disturbances.

The conventional PCA-DA explained above with reference to FIGS. 5 and 6 and Table 304 sometimes exhibit good discrimination result if applied individually to the set of specific samples, i.e., to individual training set. However, the discrimination result was

unsatisfactory when applied with respect to the validation set (Tables 329, 331). It appears that the discriminant exhibiting very good discrimination result with respect to the training set, is not so robust because the 10,000 mass ions constituting the discriminant include a considerable amount of mass ions which may be at least unnecessary for the discrimination between GC patients and non-cancer subjects and although not entirely problematic in the discrimination of training set, which can potentially cause confusion in the discrimination result in the discrimination of the validation set. Accordingly, a process is necessary, which exclusively locates mass ions that are absolutely necessary to obtain good and robust discrimination result, by actively removing mass ions which are at least unnecessary, or which can potentially confuse discrimination result.

【Solution to Problem】

The present invention provides an apparatus for screening cancer, which reads low-mass ion mass spectrum for diagnosing cancer based on biostatistical analysis with respect to low-mass ions extracted from biological materials, and diagnoses cancer using the low-mass ion spectrum.

The present invention provides a discriminant which provides robust discrimination result with respect to CRC patent samples and non-cancer subject samples, by providing a discriminant that results in all the sensitivity, specificity, positive predictability and negative predictability exceeding 85% with respect to the mass spectrum additionally and repeatedly measured on new CRC patient samples and normal patent samples as well as the mass spectrum additionally and repeatedly measured on the CRC patient samples and normal patent samples from which the discriminant is obtained, and an apparatus for screening cancer which diagnoses CRC by analyzing the constituent low-mass ions.

The present invention provides a discriminant which provides robust discrimination

result with respect to BRC patent samples and non-cancer subject samples, by providing a discriminant that results in all the sensitivity, specificity, positive predictability and negative predictability exceeding 85% with respect to the mass spectrum additionally and repeatedly measured on new BRC patient samples and normal patent samples as well as the mass spectrum additionally and repeatedly measured on the BRC patient samples and normal patent samples from which the discriminant is obtained, and an apparatus for screening cancer which diagnoses BRC by analyzing the constituent low-mass ions.

The present invention provides a discriminant which provides robust discrimination result with respect to GC patent samples and non-cancer subject samples, by providing a discriminant that results in all the sensitivity, specificity, positive predictability and negative predictability exceeding approximately 80~90% with respect to the mass spectrum additionally and repeatedly measured on new GC patient samples and normal patent samples as well as the mass spectrum additionally and repeatedly measured on the GC patient samples and normal patent samples from which the discriminant is obtained, and an apparatus for screening cancer which diagnoses GC by analyzing the constituent low-mass ions.

[Technical Solutions]

An apparatus for cancer diagnosis may comprise

a low-mass ion detecting unit which detects mass spectra of low-mass ions of biological materials;

a cancer diagnosing unit which compares and analyzes patterns of mass spectra and diagnoses cancer; and

a display unit which displays cancer diagnosis information from the cancer diagnosing unit.

The low-mass ion detecting unit extracts the mass spectra of the low-mass ions by detecting

peak intensities, peak area and mass-to-charge ratio of the low-mass ions of the biological materials.

The low-mass ion detecting unit comprises a mass measurement device including mass spectrometer.

The cancer diagnosing unit comprises a first aligning means which aligns the low-mass ion mass spectra of the patients with cancer and the non-cancer subjects of a candidate training set;

a first discriminant score computing means which computes a discriminant score by performing biostatistical analysis with respect to the mass spectra as aligned;

factor loadings computing means which computes sensitivity and specificity according to the discriminant score and selects a first training set by the sensitivity and specificity, and computes factor loadings based on the first training set;

a cancer diagnosing ion selecting means which selects low-mass ions for cancer diagnosis from the candidate low-mass ions meeting a condition for candidate, based on a discriminating performance thereof;

a second aligning means which aligns the low-mass ion mass spectrum of a

biological sample for cancer screening with the first training set;

a second discriminant score computing means which computes a discriminant score based on peak intensities of the biological materials for cancer screening and the factor loadings; and

a cancer determining means which determines the subject for cancer screening

to be cancer positive or negative depending on the discriminant score.

The first discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the low-mass ion mass spectra of the candidate training set;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score by performing the biostatistical analysis with respect to the scaled peak intensities.

The scaling module performs Pareto scaling.

The discriminant score computing module performs the biostatistical analysis using a principal component analysis-based linear discriminant analysis (PCA-DA).

The discriminant score computing module computes the discriminant score using both the factor loadings acquired by the PCA-DA and the scaled peak intensities.

The factor loading computing means comprises a first training set selecting means which performs biostatistical analysis with respect to the aligned mass spectra and selects training cases that meet a condition for training from among the patients with cancer and the non-cancer subjects based on the result of the biostatistical analysis, and computes the factor loadings based on the first training set.

The first training set selecting means sets the first training set with the patients with cancer and the non-cancer subjects, if the result of the biostatistical analysis indicates that the sensitivity equals to or is greater than a threshold (N1), and the specificity equals to or is greater than a threshold (N2).

The thresholds (N1, N2) are 1, respectively.

The second discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the biological materials for cancer screening;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score based on the scaled peak intensities and the factor loadings.

The scaling module performs Pareto scaling.

The discriminant score computing module computes the discriminant score based on the scaled peak intensities of the low-mass ions for cancer diagnosis and the associated factor loadings.

The cancer determining means determines the subject for cancer screening to be cancer positive or negative depending on the discriminant score, in which the cancer determining means determines cancer positive if the discriminant score of the subject for cancer screening is greater than the threshold (S), or determines cancer negative if the discriminant score of the subject for cancer screening is less than the threshold (S).

The threshold(S) is 0.

The cancer determining means determines the cancer information of the subject for cancer screening based on an average of a plurality of the discriminant scores which are computed with respect to a plurality of low-mass ion mass spectra obtained as a result of repeatedly measuring the biological sample for cancer screening.

The cancer diagnosing ion selecting means comprises:

a candidate ion set selecting means which selects a candidate ion set with candidate low-mass ions that meet a condition for candidate from the first training set; and

a final ion set selecting means which selects a final ion set with low-mass ions for cancer diagnosis based on individual or combinational discriminating performance of the candidate low-mass ions of the candidate ion set.

The candidate ion set selecting means comprises a first low-mass ion selecting module which selects first low-mass ions for each training case, if a product of multiplying the peak intensity of each low-mass ion by the associated factor loading is greater than a threshold (T1).

The threshold (T1) is 0.1.

The candidate ion set selecting means comprises a candidate ion set pre-selecting module which selects the candidate ion set with second low-mass ions present commonly in cases above a threshold percent (T2) from among the first low-mass ions.

The threshold (T2) is 50.

The candidate ion set selecting means further comprises:

a sensitivity and specificity computing module which computes a discriminant score, indicative of whether each of the training cases is cancer positive or negative using the second low-mass ions, and computes sensitivity and specificity according to the discriminant score; and

a final candidate ion set selecting module which changes at least one from among the

thresholds (T1, T2) if the sensitivity is less than a threshold (N3) or the specificity is less than a threshold (N4), and selects the candidate ion set by repeating the processes.

The thresholds (N3 ,N4) are 0.9, respectively.

The criterion to evaluate the discriminating performance in the final ion set selecting means comprises a first criterion according to which a low-mass ion is selected if a sum of the sensitivity and the specificity thereof equals to or is greater than a threshold, or a combination of the candidate low-mass ions is selected if a sum of the sensitivity and the specificity thereof is greater than any other combinations in a comparison group.

The criterion to evaluate the discriminating performance in the final ion set selecting means comprises a second criterion according to which a combination of a least number of low-mass ions is selected from among the combinations of the candidate low-mass ions in a comparison group.

The criterion to evaluate the discriminating performance in the final ion set selecting means comprises a third criterion according to which a combination of the candidate low-mass ions is selected, if a difference between the lowest discriminant score of true positive cases and the highest discriminant score of true negative cases thereof is greater than any other combinations in a comparison group, wherein the discriminant score is computed based on the scaled peak intensities of the candidate low-mass ions and the associated factor loadings, and indicative of cancer positive or negative.

The final ion set selecting means comprises:

an ion classifying module which classifies the candidate low-mass ions into a high sensitivity set {Sns1, Sns2, Sns3 ... SnsI} which includes a high sensitivity low-mass ions with

sensitivity exceeding the specificity and arranges the high sensitivity low-mass ions in a descending order of the sum of the sensitivity and the specificity, and a high specificity set {Spc1, Spc2, Spc3 ... SpcJ} which includes a high specificity low-mass ions and arranges the high specificity low-mass ions in a descending order of the sum of the sensitivity and the specificity;

a pre-selecting module which selects a biomarker group with a combination selected from candidate combinations of two or more low-mass ions from

L upper high sensitivity low-mass ions {Sns1, Sns2, Sns3 ... SnsL} and L upper high

specificity low-mass ions {Spc1, Spc2, Spc3 ... SpcL}, if the combination meets one or more of the first, second and third criteria for evaluating the discriminating performance;

a re-selecting module which re-selects the group of low-mass ions with a combination selected from among the group of low-mass ions and candidate combinations in which one or more low-mass ions from M next upper high sensitivity low-mass ions and

M next upper high specificity low-mass ions are added to the group of low-mass ions, if the combination meets one or more of the first, second and third criteria; and

a final group of low-mass ions selecting module which finalizes the selection of the group of low-mass ions after repeating the re-selecting until there are no next upper low-mass ions left in the high sensitivity set or the high specificity set.

The final ion set selecting means further comprises:

an additional group of low-mass ions selecting module which selects additional groups of low-mass ions by repeating the three processes to select the group of low-mass ions with respect to the candidate ion set excluding the group of low-mass ions finalized by the final

group of low-mass ions selecting module, until there are less than L low-mass ions left in the high sensitivity set or the high specificity set; and

a final cancer diagnosing low-mass ion selecting module which selects a combination of low-mass ions of top K groups of low-mass ions in terms of accuracy from among the group of low-mass ions and the additional groups of low-mass ions.

The L is 2, M is 1, K is 1, 2 or 3.

The final ion set selecting means performs a low-mass ion selecting process with respect to a training set enlarged by adding a second training set, independent of the first training set, to the first training set.

The patients with cancer comprise

CRC patients with colorectal cancer, BCR patients with breast cancer, GC patients with gastric cancer, or patients with other types of cancer

The low-mass ion detector extracts mass spectra of the low-mass ions by detecting peak intensities of the low-mass ions using mass spectrometer, from biological samples of a plurality of CRC patients and normal subjects,

the cancer diagnosing unit comprises,

a first aligning means which aligns the low-mass ion mass spectra of the CRC patients and the normal subjects of a candidate training set,

a first discriminant score computing means which computes a discriminant score by performing biostatistical analysis with respect to the mass spectra as aligned,

factor loadings computing means which computes sensitivity and specificity according to the

discriminant score and computes factor loadings by selecting a first training set based on the result,

a CRC-diagnosing ion selecting means which selects low-mass ions for CRC screening from the candidate low-mass ions meeting a condition for candidate, based on a discriminating performance thereof,

a second aligning means which aligns the low-mass ion mass spectra of the biological samples for interpretation with the first training set,

a second discriminant score computing means which computes a discriminant score based on a peak intensity of the low-mass ions for interpretation and the factor loading value, and

a CRC determining means which determines the subject for interpretation to be CRC positive or negative depending on the discriminant score, in which

the CRC-diagnosing ion selecting means classifies the plurality of CRC patients and the normal subjects into first cases comprising a plurality of CRC patients and a plurality of normal subjects, and second cases comprising CRC patients and non-CRC patients, and

as the first and second cases are executed, respectively,

the low-mass ions for CRC screening are classified into low-mass ions for first CRC screening with respect to the first cases and second low-mass ions for second CRC screening with respect to the second cases.

The mass of each of the low-mass ions for first CRC screening is one or more selected from a group consisting of: 8.0260, 22.9797, 74.0948, 76.0763, 102.0916, 105.1078, 106.0899, 107.0477, 118.0822, 23.0395, 137.0423, 137.0729, 147.0573, 147.1058, 169.0653, 181.0656, 190.0849, 191.0848, 91.3324, 195.0785, 212.3195, 231.0667, 235.0053, 256.0939, 266.9557,

267.9501, 288.2033, 91.0997, 295.0663, 300.1297, 301.1269, 316.2288, 317.2311, 335.1862, 340.2241, 343.2451, 45.2583, 357.0666, 357.2784, 366.2310, 368.2551, 369.3302, 377.0570, 379.1438, 379.4765, 83.0529, 384.1745, 388.2688, 401.0531, 423.0313, 428.1878, 454.2090, 465.3014, 466.1923, 68.1851, 469.2831, 477.1721, 478.1678, 480.1715, 482.3220, 483.3258, 496.8683, 497.7636, 03.8719, 508.3407, 510.3265, 512.3119, 513.3177, 518.2931, 518.8555, 519.2967, 519.8598, 25.3449, 534.2739, 537.2800, 538.3306, 540.2629, 540.8144, 542.8457, 544.8692, 548.2856, 66.8375, 581.1957, 582.1888, 583.2242, 656.0270, 667.3291, 709.3519, 710.3581, 711.3617, 12.3683, 713.3798, 991.6196, 992.6209, 1016.6113, 1020.4817, 1206.5305, 1207.5571, 1465.6184, 1466.6096, 1467.5969, 2450.9701, 2451.9662 and 2452.9546 m/z (margin of error: ±0.1 m/z).

The non-CRC patients of the second cases comprise one or more of a BCR patient group, a NHL patient group with non-Hodgkin lymphoma (NHL) and a GC patient group, and

the mass of the low-mass ions for second CRC screening is one or more selected from a group consisting of: 60.0476, 138.0540, 172.6653, 173.1158, 179.1451, 191.1277, 279.0855, 280.0895, 280.2642, 281.1440, 296.2574, 312.3248, 332.3224, 333.3324, 369.3406, 465.3161, 486.6356, 488.6882, 544.8908, 551.3287, 566.8737, 707.3475 and 733.3569 m/z (margin of error: ±0.1 m/z).

The discriminant score comprises a first class discriminant score based on the first class of the low-mass ions and a second discriminant score based on the second class of the low-mass ions, in which

the subject for interpretation is determined to be CRC positive, if the first class discriminant score is greater than CS11, and the second class discriminant score is greater than CS21, or

the subject for interpretation is determined to be CRC negative, if the first class discriminant

score is less than CS12, or the second class discrminant score is less than CS22.

The CS11, CS12, CS21 and CS22 are 0, respectively.

The low-mass ion group for discriminating CRC patients from the normal subjects using the CRC-diagnosing ion selecting means comprises fibrinogen or fibrinogen alpha chain.

The low-mass ion group for discriminating the CRC patients from the normal subjects comprises transthyretin.

The first discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the low-mass ion mass spectra of the candidate training set;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score by performing the biostatistical analysis with respect to the scaled peak intensities.

The scaling module performs Pareto scaling.

The discriminant score computing module performs the biostatistical analysis using a principal component analysis-based linear discriminant analysis (PCA-DA).

The discriminant score computing module computes the discriminant score using both the factor loadings acquired by the PCA-DA and the scaled peak intensities.

The factor loading computing means comprises a first training set selecting means which performs biostatistical analysis with respect to the aligned mass spectra and selects training cases that meet a condition for training from among the patients with CRC and the non-CRC subjects based on the result of the biostatistical analysis, and computes the factor loadings

based on the first training set.

The first training set selecting means sets the first training set with the patients with CRC and the non-CRC subjects, if the result of the biostatistical analysis indicates that the sensitivity equals to or is greater than a threshold (N1), and the specificity equals to or is greater than a threshold (N2).

The thresholds (N1, N2) are 1, respectively.

The second discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the biological materials for cancer screening;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score based on the scaled peak intensities and the factor loadings.

The scaling module performs Pareto scaling.

The discriminant score computing module computes the discriminant score based on the scaled peak intensities of the low-mass ions for CRC diagnosis and the associated factor loadings.

The cancer determining means determines the subject for cancer screening to be CRC positive or negative depending on the discriminant score, in which the cancer determining means determines CRC positive if the discriminant score of the subject for cancer screening is greater than the threshold (S), or determines CRC negative if the discriminant score of the subject for cancer screening is less than the threshold (S).

The threshold(S) is 0.

The cancer determining means determines the CRC information of the subject for cancer screening based on an average of a plurality of the discriminant scores which are computed with respect to a plurality of low-mass ion mass spectra obtained as a result of repeatedly measuring the biological sample for cancer screening.

The CRC-diagnosing ion selecting means comprises:

a candidate ion set selecting means which selects a candidate ion set with candidate low-mass ions that meet a condition for candidate from the first training set; and

a final ion set selecting means which selects a final ion set with low-mass ions for cancer screening based on individual or combinational discriminating performance of the candidate low-mass ions of the candidate ion set.

The candidate ion set selecting means comprises a first low-mass ion selecting module which selects first low-mass ions for each training case, if a product of multiplying the peak intensity of each low-mass ion by the associated factor loading is greater than a threshold (T1).

The threshold (T1) is 0.1.

The candidate ion set selecting means comprises a candidate ion set pre-selecting module which selects the candidate ion set with second low-mass ions present commonly in cases above a threshold percent (T2) from among the first low-mass ions.

The threshold (T2) is 50.

The candidate ion set selecting means further comprises:

a sensitivity and specificity computing module which computes a discriminant score, indicative of whether each of the training cases is CRC positive or negative using the second low-mass ions, and computes sensitivity and specificity according to the discriminant score; and

a final candidate ion set selecting module which changes at least one from among the thresholds (T1, T2) if the sensitivity is less than a threshold (N3) or the specificity is less than a threshold (N4), and selects the candidate ion set by repeating the processes.

The thresholds (N3 ,N4) are 0.9, respectively.

The criterion to evaluate the discriminating performance in the final ion set selecting means comprises a first criterion according to which a low-mass ion is selected if a sum of the sensitivity and the specificity thereof equals to or is greater than a threshold, or a combination of the candidate low-mass ions is selected if a sum of the sensitivity and the specificity thereof is greater than any other combinations in a comparison group.

The criterion to evaluate the discriminating performance in the final ion set selecting means comprises a second criterion according to which a combination of a least number of low-mass ions is selected from among the combinations of the candidate low-mass ions in a comparison group.

The criterion to evaluate the discriminating performance in the final ion set selecting means comprises a third criterion according to which a combination of the candidate low-mass ions is selected, if a difference between the lowest discriminant score of true positive cases and the highest discriminant score of true negative cases thereof is greater than any other combinations in a comparison group, wherein the discriminant score is computed based on the scaled peak intensities of the candidate low-mass ions and the associated factor loadings,

and indicative of CRC positive or negative.

The final ion set selecting means comprises:

an ion classifying module which classifies the candidate low-mass ions into a high sensitivity set {Sns1, Sns2, Sns3 ... SnsI} which includes a high sensitivity low-mass ions with sensitivity exceeding the specificity and arranges the high sensitivity low-mass ions in a descending order of the sum of the sensitivity and the specificity, and a high specificity set {Spc1, Spc2, Spc3 ... SpcJ} which includes a high specificity low-mass ions and arranges the high specificity low-mass ions in a descending order of the sum of the sensitivity and the specificity;

a pre-selecting module which selects a biomarker group with a combination selected from candidate combinations of two or more low-mass ions from

L upper high sensitivity low-mass ions {Sns1, Sns2, Sns3 ... SnsL} and L upper high

specificity low-mass ions {Spc1, Spc2, Spc3 ... SpcL}, if the combination meets one or more of the first, second and third criteria for evaluating the discriminating performance;

a re-selecting module which re-selects the group of low-mass ions with a combination selected from among the group of low-mass ions and candidate combinations in which one or more low-mass ions from M next upper high sensitivity low-mass ions and

M next upper high specificity low-mass ions are added to the group of low-mass ions, if the combination meets one or more of the first, second and third criteria; and

a final group of low-mass ions selecting module which finalizes the selection of the group of low-mass ions after repeating the re-selecting until there are no next upper low-mass ions left in the high sensitivity set or the high specificity set.

The final ion set selecting means further comprises:

an additional group of low-mass ions selecting module which selects additional groups of low-mass ions by repeating the three processes to select the group of low-mass ions with respect to the candidate ion set excluding the group of low-mass ions finalized by the final group of low-mass ions selecting module, until there are less than L low-mass ions left in the high sensitivity set or the high specificity set; and

a final CRC-diagnosing low-mass ion selecting module which selects a combination of low-mass ions of top K groups of low-mass ions in terms of accuracy from among the group of low-mass ions and the additional groups of low-mass ions.

The L is 2, M is 1, K is 1, 2 or 3.

The final ion set selecting means performs a low-mass ion selecting process with respect to a training set enlarged by adding a second training set, independent of the first training set, to the first training set.

The low-mass ion detector extracts mass spectra of the low-mass ions by detecting peak intensities of the low-mass ions using mass spectrometer, from biological samples of a plurality of BCR patients and normal subjects,

the cancer diagnosing unit comprises,

a first aligning means which aligns the low-mass ion mass spectra of the BCR patients and the normal subjects of a candidate training set,

a first discriminant score computing means which computes a discriminant score by performing biostatistical analysis with respect to the mass spectra as aligned,

factor loadings computing means which computes sensitivity and specificity according to the discriminant score and computes factor loadings by selecting a first training set based on the result,

a BCR diagnosing ion selecting means which selects low-mass ions for BCR diagnosis from the candidate low-mass ions meeting a condition for candidate, based on a discriminating performance thereof,

a second aligning means which aligns the low-mass ion mass spectra of the biological samples for interpretation with the first training set,

a second discriminant score computing means which computes a discriminant score based on a peak intensity of the low-mass ions for interpretation and the factor loading value, and

a BCR determining means which determines the subject for interpretation to be positive or negative of BCR depending on the discriminant score, in which

the BCR diagnosing ion selecting means classifies the plurality of BCR patients and the normal subjects into first cases, or

classifies the plurality of BCR patients and the normal subjects into second cases comprising a plurality of BCR patients and a plurality of non-BCR subjects, and third cases comprising BCR patients and non-BCR patients, and

as the first, second and third cases are executed, respectively,

the low-mass ions for screening BCR are classified into low-mass ions for first BCR screening with respect to the first cases, second low-mass ions for second BCR screening with respect to the second cases, and third low-mass ions for third BCR screening with respect to the third cases.

The non-BCR patients of the first cases comprise one or more of a patient group of normal subjects, a CRC patient group, a NHL patient group with non-Hodgkin lymphoma (NHL) and a GC patient group, and the mass of the low-mass ions for first BCR screening is one or more selected from a group consisting of: 74.0937, 74.1155, 76.0728, 136.1067, 173.4872, 193.0665, 208.0565, 212.0949, 231.0726, 258.1364, 279.0841, 280.0847, 282.2777, 313.2638, 331.2024, 332.3181, 401.0588, 427.3441, 432.9954, 452.2269, 476.6038, 490.3427, 498.3237, 499.3265, 512.3145, 562.3074, 583.2323, 584.2415, 646.3851 m/z (margin of error: ±0.1 m/z).

The mass of the low-mass ions for second BCR screening is one or more selected from a group consisting of: 38.9779, 46.0647, 74.1164, 76.0733, 97.0686, 122.0777, 123.0821, 130.1539, 185.7723, 191.1175, 208.0530, 212.0960, 225.1870, 229.0005, 231.0675, 244.0962, 281.0913, 284.3205, 313.2618, 332.3150, 342.2482, 368.2624, 398.3034, 416.0901, 424.3216, 426.3389, 428.1885, 497.3194, 513.3193, 532.6918, 538.3428, 540.3250, 570.3234, 580.3281, 581.2310, 581.3377, 610.3273, 616.3286, 618.3352, 646.3959, 725.3469, 757.1117 m/z (margin of error: ±0.1 m/z).

The non-BCR patients of the third cases comprise one or more of a CRC patient group, a patient group with non-Hodgkin lymphoma (NHL) and a GC patient group, and the mass of the low-mass ions for third BCR screening is one or more selected from a group consisting of: 38.9736, 38.9892, 44.0491, 44.0656, 74.0938, 87.0991, 104.1316, 104.3161, 105.1091, 136.1021, 155.1798, 156.0412, 172.3072, 178.1330, 182.0738, 189.9525, 192.1294, 193.0660, 196.0871, 212.3221, 217.0923, 222.0231, 228.0348, 231.0726, 234.0422, 260.1013, 279.0843, 280.0849, 282.2791, 289.2960, 298.3425, 313.2630, 316.3269, 331.2036, 332.3169, 333.3233, 337.1047, 424.3272, 426.3406, 432.9948, 433.9894, 446.0196, 454.3014, 469.2924, 478.8688, 479.8724, 480.3180, 483.3301, 487.3152,

488.3287, 488.6580, 496.4331, 496.7718, 497.7764, 502.8741, 511.3367, 518.8776, 520.8826, 534.2829, 535.2882, 542.8770, 544.7878, 544.8728, 546.3358, 559.2911, 568.1146, 583.2284, 731.3330, 733.3526, 734.3563, 735.3665, 757.0995, 757.3512, 1465.5872, 1466.5971 m/z (margin of error: ±0.1 m/z).

The discriminant score is a first class discriminant score based on the first class low-mass ions, in which the subject for interpretation is determined to be positive of BCR if the discriminant score is greater than BS11, or determined to be negative of BCR if the discriminant score is less than BS12.

The BS11 and BS12 are 0, respectively.

The discriminant score comprises a second class discriminant score based on the second class low-mass ions and a third class discriminant score based on the third class low-mass ions, in which

the subject for interpretation is determined to be positive of BCR, if the second class discriminant score is greater than BS21 and the third class discriminant score is greater than BS31, or

determined to be negative of BCR, if the second class discriminant score is less than BS22 or the third class discriminant score is less than BS32.

The BS21, BS22, BS31 and BS32 are 0, respectively.

The first discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the low-mass ion mass spectra of the candidate training set;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score by performing the biostatistical analysis with respect to the scaled peak intensities.

The scaling module performs Pareto scaling.

The discriminant score computing module performs the biostatistical analysis using a principal component analysis-based linear discriminant analysis (PCA-DA).

The discriminant score computing module computes the discriminant score using both the factor loadings acquired by the PCA-DA and the scaled peak intensities.

The factor loading computing means comprises a first training set selecting means which performs biostatistical analysis with respect to the aligned mass spectra and selects training cases that meet a condition for training from among the BRC patients and the non-BRC subjects based on the result of the biostatistical analysis, and computes the factor loadings based on the first training set.

The first training set selecting means sets the first training set with the patients with BRC and the non-BRC subjects, if the result of the biostatistical analysis indicates that the sensitivity equals to or is greater than a threshold (N1), and the specificity equals to or is greater than a threshold (N2).

The thresholds (N1, N2) are 1, respectively.

The second discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the biological materials for cancer screening;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score based on the scaled peak intensities and the factor loadings.

The scaling module performs Pareto scaling.

The discriminant score computing module computes the discriminant score based on the scaled peak intensities of the low-mass ions for BRC screening and the associated factor loadings.

The cancer determining means determines the subject for cancer screening to be BRC positive or negative depending on the discriminant score, in which the cancer determining means determines BRC positive if the discriminant score of the subject for cancer screening is greater than the threshold (S), or determines BRC negative if the discriminant score of the subject for cancer screening is less than the threshold (S).

The threshold(S) is 0.

The e cancer determining means determines the BRC information of the subject for cancer screening based on an average of a plurality of the discriminant scores which are computed with respect to a plurality of low-mass ion mass spectra obtained as a result of repeatedly measuring the biological sample for cancer screening.

The BRC-diagnosing ion selecting means comprises:

a candidate ion set selecting means which selects a candidate ion set with candidate low-mass ions that meet a condition for candidate from the first training set; and

a final ion set selecting means which selects a final ion set with low-mass ions for cancer

screening based on individual or combinational discriminating performance of the candidate low-mass ions of the candidate ion set.

The candidate ion set selecting means comprises a first low-mass ion selecting module which selects first low-mass ions for each training case, if a product of multiplying the peak intensity of each low-mass ion by the associated factor loading is greater than a threshold (T1).

The threshold (T1) is 0.1.

The candidate ion set selecting means comprises a candidate ion set pre-selecting module which selects the candidate ion set with second low-mass ions present commonly in cases above a threshold percent (T2) from among the first low-mass ions.

The threshold (T2) is 50.

The candidate ion set selecting means further comprises:

a sensitivity and specificity computing module which computes a discriminant score, indicative of whether each of the training cases is BRC positive or negative using the second low-mass ions, and computes sensitivity and specificity according to the discriminant score; and

a final candidate ion set selecting module which changes at least one from among the thresholds (T1, T2) if the sensitivity is less than a threshold (N3) or the specificity is less than a threshold (N4), and selects the candidate ion set by repeating the processes.

The thresholds (N3 ,N4) are 0.9, respectively.

The criterion to evaluate the discriminating performance in the final ion set selecting means

comprises a first criterion according to which a low-mass ion is selected if a sum of the sensitivity and the specificity thereof equals to or is greater than a threshold, or a combination of the candidate low-mass ions is selected if a sum of the sensitivity and the specificity thereof is greater than any other combinations in a comparison group.

The criterion to evaluate the discriminating performance in the final ion set selecting means comprises a second criterion according to which a combination of a least number of low-mass ions is selected from among the combinations of the candidate low-mass ions in a comparison group.

The criterion to evaluate the discriminating performance in the final ion set selecting means comprises a third criterion according to which a combination of the candidate low-mass ions is selected, if a difference between the lowest discriminant score of true positive cases and the highest discriminant score of true negative cases thereof is greater than any other combinations in a comparison group, wherein the discriminant score is computed based on the scaled peak intensities of the candidate low-mass ions and the associated factor loadings, and indicative of BRC positive or negative.

The final ion set selecting means comprises:

an ion classifying module which classifies the candidate low-mass ions into a high sensitivity set {Sns1, Sns2, Sns3 ... SnsI} which includes a high sensitivity low-mass ions with sensitivity exceeding the specificity and arranges the high sensitivity low-mass ions in a descending order of the sum of the sensitivity and the specificity, and a high specificity set {Spc1, Spc2, Spc3 ... SpcJ} which includes a high specificity low-mass ions and arranges the high specificity low-mass ions in a descending order of the sum of the sensitivity and the specificity;

a pre-selecting module which selects a biomarker group with a combination selected from candidate combinations of two or more low-mass ions from

L upper high sensitivity low-mass ions {Sns1, Sns2, Sns3 ... SnsL} and L upper high

specificity low-mass ions {Spc1, Spc2, Spc3 ... SpcL}, if the combination meets one or more of the first, second and third criteria for evaluating the discriminating performance;

a re-selecting module which re-selects the group of low-mass ions with a combination selected from among the group of low-mass ions and candidate combinations in which one or more low-mass ions from M next upper high sensitivity low-mass ions and

M next upper high specificity low-mass ions are added to the group of low-mass ions, if the combination meets one or more of the first, second and third criteria; and

a final group of low-mass ions selecting module which finalizes the selection of the group of low-mass ions after repeating the re-selecting until there are no next upper low-mass ions left in the high sensitivity set or the high specificity set.

The final ion set selecting means further comprises:

an additional group of low-mass ions selecting module which selects additional groups of low-mass ions by repeating the three processes to select the group of low-mass ions with respect to the candidate ion set excluding the group of low-mass ions finalized by the final group of low-mass ions selecting module, until there are less than L low-mass ions left in the high sensitivity set or the high specificity set; and

a final BRC-diagnosing low-mass ion selecting module which selects a combination of low-mass ions of top K groups of low-mass ions in terms of accuracy from among the group of low-mass ions and the additional groups of low-mass ions.

The L is 2, M is 1, K is 1, 2 or 3.

The final ion set selecting means performs a low-mass ion selecting process with respect to a training set enlarged by adding a second training set, independent of the first training set, to the first training set.

The low-mass ion detector extracts mass spectra of the low-mass ions by detecting peak intensities of the low-mass ions using mass spectrometer, from biological samples of a plurality of GC patients and normal subjects,

the cancer diagnosing unit comprises,

a first aligning means which aligns the low-mass ion mass spectra of the GC patients and the normal subjects of a candidate training set,

a first discriminant score computing means which computes a discriminant score by performing biostatistical analysis with respect to the mass spectra as aligned,

factor loadings computing means which computes sensitivity and specificity according to the discriminant score and computes factor loadings by selecting a first training set based on the result,

a GC-diagnosing ion selecting means which selects low-mass ions for GC screening from the candidate low-mass ions meeting a condition for candidate, based on a discriminating performance thereof,

a second aligning means which aligns the low-mass ion mass spectra of the biological samples for interpretation with the first training set,

a second discriminant score computing means which computes a discriminant score based on

a peak intensity of the low-mass ions for interpretation and the factor loading value, and

a GC-determining means which determines the subject for interpretation to be positive or negative of GC depending on the discriminant score, in which

the GC-diagnosing ion selecting means classifies the plurality of GC patients and the normal subjects into a first class comprising a plurality of GC patients and a plurality of normal subjects, a second class comprising the plurality of GC patients and a plurality of CRC patients, a third class comprising the plurality of GC patients and a plurality of BCR patients, and a fourth class comprising the plurality of GC patients and a plurality of NHL patients, or

classifies the plurality of GC patients and the non-GC subjects into the first class and a fifth class comprising the plurality of GC patients and the normal subjects, and a plurality of CRC patients, BCR and NHL subjects, and

as the first, second, third, fourth and fifth cases are executed, respectively,

the low-mass ions for GC screening are classified into low-mass ions for first GC screening with respect to the first cases, second low-mass ions for second GC screening with respect to the second cases, third low-mass ions for third GC screening with respect to the third cases, fourth low-mass ions for third GC screening with respect to the third cases, and fifth low-mass ions for third GC screening with respect to the third cases.

The mass of the low-mass ions for first GC screening is one or more selected from a group consisting of: 22.9851, 87.0959, 123.0842, 314.2151, 324.1365, 366.2424, 488.6538, 490.3374, 526.3426, 532.3719, 576.2893, 606.2658, 616.1397, 1466.5612 m/z (margin of error: ±0.1 m/z).

The mass of the low-mass ions for second GC screening is one or more selected from a group

consisting of: 18.0260, 22.9830, 38.9752, 72.0788, 86.1216, 122.0584, 137.0721, 144.1092, 156.0171, 172.3740, 172.6583, 207.0729, 265.2034, 356.1278, 380.1643, 381.0949, 401.0680, 431.9882, 442.3197, 445.0278, 458.3228, 489.3564, 489.5293, 490.2775, 490.3586, 525.3611, 528.3633, 535.2970, 553.3205, 557.4392, 584.2675, 585.2726, 587.2805, 710.3687, 946.4028, 1466.6433 m/z (margin of error: ±0.1 m/z).

The mass of the low-mass ions for third GC screening is one or more selected from a group consisting of: 22.9852, 74.0764, 104.1387, 105.1157, 106.0555, 148.0788, 173.4924, 176.1198, 184.1123, 212.1032, 217.9461, 226.0798, 228.0046, 284.3291, 299.1308, 299.3423, 314.2316, 338.1143, 377.0710, 387.9830, 426.3417, 427.3321, 430.3313, 432.9929, 456.2963, 459.2425, 480.3312, 481.3399, 482.3368, 487.3295, 488.3316, 490.3400, 496.8846, 506.9148, 509.3577, 532.3532, 534.2973, 535.3013, 537.3199, 550.3255, 560.3121, 562.3203, 574.3090, 580.3417, 583.2274, 584.2345, 584.3355, 585.2423, 600.3366, 616.1446 m/z (margin of error: ±0.1 m/z).

The mass of the low-mass ions for fourth GC screening is one or more selected from a group consisting of: 18.0264, 22.9798, 23.0539, 38.9638, 38.9937, 46.0666, 86.1328, 112.0850, 123.0738, 129.0710, 155.1762, 164.0701, 165.0955, 175.1219, 176.1298, 178.1388, 179.1466, 192.1245, 201.2036, 204.1077, 212.3577, 213.0575, 229.0033, 232.0822, 234.0749, 235.0331, 240.0907, 251.9799, 274.0827, 284.3265, 314.2277, 326.3916, 383.0532, 417.0381, 429.3172, 430.3169, 434.2556, 456.3015, 459.2257, 460.9913, 489.3314, 490.3361, 491.3348, 532.2725, 534.2841, 569.3303 m/z (margin of error: ±0.1 m/z).

The mass of the low-mass ions for fifth GC screening is one or more selected from a group consisting of: 38.9674, 76.0758, 123.0414, 156.0432, 163.1135, 164.0712, 184.1062, 184.1375, 190.1141, 193.0672, 215.0444, 228.0389, 230.0004, 256.3291, 257.2950,

265.9579, 267.9562, 289.2849, 295.1666, 301.1386, 315.2230, 330.2485, 342.2497, 346.2809, 368.2644, 369.2702, 370.2806, 371.2848, 396.0400, 412.1977, 428.1904, 442.3155, 443.2100, 445.0283, 498.3276, 510.2755, 511.3414, 513.3220, 530.3908, 532.2863, 548.3441, 552.3114, 553.3178, 571.3341, 573.2402, 584.2661, 666.3899, 683.3451, 684.3511, 708.3570, 711.3711, 723.3455, 725.3580, 726.3760, 741.3357 m/z (margin of error: ±0.1 m/z).

The discriminant score comprises a first class discriminant score based on the first class low-mass ions, a second class discriminant score based on the second class low-mass ions, a third class discriminant score based on the third class low-mass ions, and a fourth class discriminant score based on the fourth class low-mass ions, in which

the subject for interpretation is determined to be positive of GC if the first class discriminant score is greater than GS11, and the second class discriminant score is greater than GS21, the third class discriminant score is greater than GS31, and the fourth class discriminant score is greater than GS41,

or the subject for interpretation is determined to be negative of GC if the first class discriminant score is less than GS12, or the second class discriminant score is less than GS22, or the third class discriminant score is less than GS32, or the fourth class discriminant score is less than GS42.

The GS11, GS12, GS21, GS22, GS31, GS32 GS41 and GS42 are 0, respectively.

The discriminant score comprises the first class discriminant score based on the first class low-mass ions and the fifth class discriminant score based on the fifth class low-mass ions, in which

the subject for interpretation is determined to be positive of GC if the first class discriminant score is greater than GS11, and the fifth class discriminant score is greater than GS51,

or the subject for interpretation is determined to be negative of GC if the first class discriminant score is less than GS12, or the fifth class discriminant score is less than GS52.

The GS11, GS12, GS51 and GS52 are 0, respectively.

The first discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the low-mass ion mass spectra of the candidate training set;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score by performing the biostatistical analysis with respect to the scaled peak intensities.

The scaling module performs Pareto scaling.

The discriminant score computing module performs the biostatistical analysis using a principal component analysis-based linear discriminant analysis (PCA-DA).

The discriminant score computing module computes the discriminant score using both the factor loadings acquired by the PCA-DA and the scaled peak intensities.

The factor loading computing means comprises a first training set selecting means which performs biostatistical analysis with respect to the aligned mass spectra and selects training cases that meet a condition for training from among the GC patients and the non-GC subjects based on the result of the biostatistical analysis, and computes the factor loadings based on the first training set.

The first training set selecting means sets the first training set with the GC patients and the non-GC subjects, if the result of the biostatistical analysis indicates that the sensitivity equals to or is greater than a threshold (N1), and the specificity equals to or is greater than a threshold (N2).

The thresholds (N1, N2) are 1, respectively.

The second discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the biological materials for cancer screening;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score based on the scaled peak intensities and the factor loadings.

The scaling module performs Pareto scaling.

The discriminant score computing module computes the discriminant score based on the scaled peak intensities of the low-mass ions for GC screening and the associated factor loadings.

The cancer determining means determines the subject for cancer screening to be GC positive or negative depending on the discriminant score, in which the cancer determining means determines GC positive if the discriminant score of the subject for cancer screening is greater than the threshold (S), or determines GC negative if the discriminant score of the subject for cancer screening is less than the threshold (S).

The threshold(S) is 0.

The cancer determining means determines the GC information of the subject for cancer screening based on an average of a plurality of the discriminant scores which are computed with respect to a plurality of low-mass ion mass spectra obtained as a result of repeatedly measuring the biological sample for cancer screening.

The GC-diagnosing ion selecting means comprises:

a candidate ion set selecting means which selects a candidate ion set with candidate low-mass ions that meet a condition for candidate from the first training set; and

a final ion set selecting means which selects a final ion set with low-mass ions for cancer screening based on individual or combinational discriminating performance of the candidate low-mass ions of the candidate ion set.

The candidate ion set selecting means comprises a first low-mass ion selecting module which selects first low-mass ions for each training case, if a product of multiplying the peak intensity of each low-mass ion by the associated factor loading is greater than a threshold (T1).

The threshold (T1) is 0.1.

The candidate ion set selecting means comprises a candidate ion set pre-selecting module which selects the candidate ion set with second low-mass ions present commonly in cases above a threshold percent (T2) from among the first low-mass ions.

The threshold (T2) is 50.

The candidate ion set selecting means further comprises:

a sensitivity and specificity computing module which computes a discriminant score,

indicative of whether each of the training cases is GC positive or negative using the second low-mass ions, and computes sensitivity and specificity according to the discriminant score; and

a final candidate ion set selecting module which changes at least one from among the thresholds (T1, T2) if the sensitivity is less than a threshold (N3) or the specificity is less than a threshold (N4), and selects the candidate ion set by repeating the processes.

The thresholds (N3 ,N4) are 0.9, respectively.

The criterion to evaluate the discriminating performance in the final ion set selecting means comprises a first criterion according to which a low-mass ion is selected if a sum of the sensitivity and the specificity thereof equals to or is greater than a threshold, or a combination of the candidate low-mass ions is selected if a sum of the sensitivity and the specificity thereof is greater than any other combinations in a comparison group.

The criterion to evaluate the discriminating performance in the final ion set selecting means comprises a second criterion according to which a combination of a least number of low-mass ions is selected from among the combinations of the candidate low-mass ions in a comparison group.

The criterion to evaluate the discriminating performance in the final ion set selecting means comprises a third criterion according to which a combination of the candidate low-mass ions is selected, if a difference between the lowest discriminant score of true positive cases and the highest discriminant score of true negative cases thereof is greater than any other combinations in a comparison group, wherein the discriminant score is computed based on

the scaled peak intensities of the candidate low-mass ions and the associated factor loadings, and indicative of GC positive or negative.

The final ion set selecting means comprises:

an ion classifying module which classifies the candidate low-mass ions into a high sensitivity set {Sns1, Sns2, Sns3 ... SnsI} which includes a high sensitivity low-mass ions with sensitivity exceeding the specificity and arranges the high sensitivity low-mass ions in a descending order of the sum of the sensitivity and the specificity, and a high specificity set {Spc1, Spc2, Spc3 ... SpcJ} which includes a high specificity low-mass ions and arranges the high specificity low-mass ions in a descending order of the sum of the sensitivity and the specificity;

a pre-selecting module which selects a biomarker group with a combination selected from candidate combinations of two or more low-mass ions from

L upper high sensitivity low-mass ions {Sns1, Sns2, Sns3 ... SnsL} and L upper high

specificity low-mass ions {Spc1, Spc2, Spc3 ... SpcL}, if the combination meets one or more of the first, second and third criteria for evaluating the discriminating performance;

a re-selecting module which re-selects the group of low-mass ions with a combination selected from among the group of low-mass ions and candidate combinations in which one or more low-mass ions from M next upper high sensitivity low-mass ions and

M next upper high specificity low-mass ions are added to the group of low-mass ions, if the combination meets one or more of the first, second and third criteria; and

a final group of low-mass ions selecting module which finalizes the selection of the group of low-mass ions after repeating the re-selecting until there are no next upper low-mass ions left

in the high sensitivity set or the high specificity set.

The final ion set selecting means further comprises:

an additional group of low-mass ions selecting module which selects additional groups of low-mass ions by repeating the three processes to select the group of low-mass ions with respect to the candidate ion set excluding the group of low-mass ions finalized by the final group of low-mass ions selecting module, until there are less than L low-mass ions left in the high sensitivity set or the high specificity set; and

a final GC-diagnosing low-mass ion selecting module which selects a combination of low-mass ions of top K groups of low-mass ions in terms of accuracy from among the group of low-mass ions and the additional groups of low-mass ions.

The L is 2, M is 1, K is 1, 2 or 3.

The final ion set selecting means performs a low-mass ion selecting process with respect to a training set enlarged by adding a second training set, independent of the first training set, to the first training set.

[Effects of Invention]

The apparatus for screening cancer according to the present invention provides advantages including economic analysis cost in the case of CRC diagnosis, short analysis time and large-scale analysis. To describe the procedure briefly, mass spectrum of the low-mass ion in blood is measured, peak intensities corresponding to the masses of the low-mass ions for CRC diagnosis are extracted, and through simple calculation, CRC positive/negative information can be provided.

Further, sound and robust discrimination performance is provided, so that with CRC as a target, it is confirmed that all the sensitivity, specificity, positive predictability and

negative predictability exceed 85% with respect to not only training set, but also validation set. Further, by changing the CRC patient and non-cancer subject sets to patients with other diseases and non-cancer subjects, it is possible to advantageously implement the present invention for other various diseases.

Further, in terms of CRC target, compared to the comparison of FOBT with the feces as the analyte, the present invention can use blood as analyte, and thus can be co-conducted with the other analysis. Accordingly, the present invention provides more convenient and efficient CRC information. Compared to the conventional FOBT discrimination performance, the present invention using low-mass ions for the diagnosis of CRC exhibits comparable specificity and markedly increased sensitivity.

The apparatus for screening cancer according to the present invention provides advantages including economic analysis cost in the case of BRC diagnosis, short analysis time and large-scale analysis. To describe the procedure briefly, mass spectrum of the low-mass ion in blood is measured, peak intensities corresponding to the masses of the low-mass ions for BRC diagnosis are extracted, and through simple calculation, BRC positive/negative information can be provided.

Further, sound and robust discrimination performance is provided, so that with BRC as a target, it is confirmed that all the sensitivity, specificity, positive predictability and negative predictability exceed 85% with respect to not only training set, but also validation set. Further, by changing the BRC patient and non-cancer subject sets to patients with other diseases and non-cancer subjects, it is possible to advantageously implement the present invention for other various diseases.

The apparatus for screening cancer according to the present invention provides advantages including economic analysis cost in the case of GC diagnosis, short analysis time and large-scale analysis. To describe the procedure briefly, mass spectrum of the low-mass

ion in blood is measured, peak intensities corresponding to the masses of the low-mass ions for GC diagnosis are extracted, and through simple calculation, BRC positive/negative information can be provided.

Further, sound and robust discrimination performance is provided, so that with GC as a target, it is confirmed that all the sensitivity, specificity, positive predictability and negative predictability exceed approximately 80~90% with respect to not only training set, but also validation set. Further, by changing the GC patient and non-cancer subject sets to patients with other diseases and non-cancer subjects, it is possible to advantageously implement the present invention for other various diseases.

【Brief Description of the Drawings】

FIGS. 1 to 6 are provided to explain a conventional art, in which

FIG. 1 is a flowchart provided to explain a process of determining CRC using low-mass ion mass spectrum according to a conventional art;

FIG. 2 is a graph illustrating a result of interpretation made according to a conventional art with respect to a set consisting of 133 CRC patients and 153 normal controls;

FIG. 3 is a flowchart provided to explain a process of determining BRC using low-mass ion mass spectrum according to a conventional art;

FIG. 4 is a graph illustrating a result of interpretation made according to a conventional art with respect to a set consisting of 54 BRC patients and 49 normal controls;

FIG. 5 is a flowchart provided to explain a process of determining GC using low-mass ion mass spectrum according to a conventional art;

FIG. 6 is a graph illustrating a result of interpretation made according to a conventional art with respect to a set consisting of 49 GC patients and 84 normal controls;

FIGS. 7 to 13 are views provided to explain an apparatus for screening cancer according to a preferred embodiment of the present invention, in which

FIG. 7 is a block diagram of an apparatus for screening cancer according to a preferred embodiment of the present invention;

FIG. 8 is a detailed block diagram of the cancer diagnosing unit of FIG. 7;

FIG. 9 is a detailed block diagram of the first discriminant score computnig means of FIG. 8;

FIG. 10 is a detailed block diagram of the secondt discriminant score computnig means of FIG. 8;

FIG. 11 is a detailed block diagram of the cancer-diagnosing ion selecting means of FIG. 8;

FIG. 12 is a detailed block diagram of the candidate ion set selecting means of FIG. 11;

FIG. 13 is a detailed block diagram of the final ion set selecting means of FIG. 11;

FIGS. 14 to 25 are views provided to explain an apparatus for screening cancer diagnosing CRC according to a preferred embodiment of the present invention, in which

FIG. 14 is a detailed block diagram of the cancer diagnosing unit of FIG. 7 diagnosing CRC according to an embodiment;

FIG. 15 is a flowchart provided to explain a process of selecting a first training set (A_0) with predetermined sensitivity and specificity and calculating a weighting per mass ions, according to an embodiment of the present invention;

FIG. 16 is a flowchart provided to explain a process of applying a discriminant to an analyte;

FIG. 17 is a graph illustrating a result of determining a set A_1 with the weighting per mass ions computed based on the first training set A_{01};

FIG. 18 is a graph illustrating a result of determining a set A_1 with the weighting per mass ions computed based on the first training set A_{02};

FIG. 19 is a flowchart provided to explain a process of constructing a preliminary discriminant according to an embodiment,

FIG. 20 is a graph illustrating a result of determining set A_1 with the first type of preliminary discriminant;

FIG. 21 is a graph presenting the result of discriminating set A_1 with the second type preliminary discriminant;

FIG. 22 is a flowchart provided to explain the process of constructing the final discriminant according to an embodiment of the present invention;

FIG. 23 is a graph presenting a discrimination result obtained by computing discriminant score (DS) according to the final discriminnt with respect to the mass spectrum repeatedly measured five times with respect to set A and obtaining mean DS, according to an embodiment;

FIG. 24 is a graph presenting a discrimination result obtained by computing discriminant score (DS) according to the final discriminnt with respect to the mass spectrum repeatedly measured five times with respect to set B and obtaining mean DS, according to an embodiment;

FIG. 25a is a graph presenting a characterization result of 1465.6184 m/z from among the first type CRC-diagnosing low-mass ion masses as confirmed, according to an embodiment;

FIG. 25b is a graph presenting a characterization result of 2450.9701 m/z from among the first type CRC-diagnosing low-mass ion masses as confirmed, according to an embodiment;

FIGS. 26 to 37 are views provided to explain an apparatus for screening cancer which

diagnoses BRC according to an embodiment, in which

FIG. 26 is a detailed block diagram of the cancer diagnosing unit of FIG. 7 to diagnose BRC according to an embodiment;

FIG. 27 is a flowchart provided to explain a process of selecting a first training set C_0 with predetermined sensitivity and specificity and computing weightings per mass ions, according to an embodiment;

FIG. 28 is a flowchart provided to explain a process of applying a discriminant with respect to the biological materials for screening;

FIG. 29 is a graph presenting a discrimination result of set C_1 obtained by applying the weightings per mass ions computed from the first training set C_{01};

FIG. 30 is a graph presenting a discrimination result of set C_1 obtained by applying the weightings per mass ions computed from the first training set C_{03};

FIG. 31 is a flowchart provided to explain a process of constructing a preliminary discriminant according to an embodiment;

FIG. 32 is a graph presenting a discrimination result of set C_1 with a first type preliminary discriminant;

FIG. 33 is a graph presenting a discrimination result of set C_1 with a second type preliminary discriminant;

FIG. 34 is a graph presenting a discrimination result of set C_1 with a fourth type preliminary discriminant;

FIG. 35 is a flowchart provided to explain a process of constructing a final discriminant according to an embodiment;

FIG. 36 is a graph presenting a discrimination result obtained by computing DS according to the first, or second and third final discriminants with respect to the mass spectra

repeatedly measured with respect to set C five times and obtaining a mean DS, according to an embodiment;

FIG. 37 is a graph presenting a discrimination result obtained by computing mean DS according to the first, or second and third final discriminants, and discriminating set D which is repeatedly measured five times, according to an embodiment;

FIGS. 38 to 54 are views provided to explain an apparatus for screening GC according to an embodiment, in which

FIG. 38 is a detailed block diagram of the cancer diagnosing unit of FIG. 7 to diagnose GC according to an embodiment;

FIG. 39 is a flowchart provided to explain a process of selecting a first training set E_0 with predetermined sensitivity and specificity and computing weightings per mass ions, according to an embodiment;

FIG. 40 is a flowchart provided to explain a process of applying a discriminant with respect to the biological materials for screening;

FIG. 41 is a graph presenting a discrimination result of set E_1 obtained by applying the weightings per mass ions computed from the first training set E_{01};

FIG. 42 is a graph presenting a discrimination result of set E_1 obtained by applying the weightings per mass ions computed from the first training set E_{03};

FIG. 43 is a graph presenting a discrimination result of set E_1 with weightings per mass ions computed from the first training set E_{03};

FIG. 44 is a graph presenting a discrimination result of set E_1 with weightings per mass ions computed from the first training set E_{04};

FIG. 45 is a graph presenting a discrimination result of set E_1 with weightings per mass ions computed from the first training set E_{05};

FIG. 46 is a flowchart provided to explain a process of constructing a preliminary

discriminant according to an embodiment;

FIG. 47 is a graph presenting a discrimination result of set E_1 by the first type preliminary discriminant;

FIG. 48 is a graph presenting a discrimination result of set E_1 by the second type preliminary discriminant;

FIG. 49 is a graph presenting a discrimination result of set E_1 by the third type preliminary discriminant;

FIG. 50 is a graph presenting a discrimination result of set E_1 by the fourth type preliminary discriminant;

FIG. 51 is a graph presenting a discrimination result of set E_1 by the fifth type preliminary discriminant;

FIG. 52 is a flowchart provided to explain a process of constructing a final discriminant according to an embodiment;

FIG. 53 is a graph presenting a discrimination result obtained by computing DS according to the first and fifth final discriminants with respect to the mass spectra repeatedly measured with respect to set E five times and obtaining a mean DS, according to an embodiment;

FIG. 37 is a graph presenting a discrimination result obtained by computing mean DS according to the first and fifth final discriminants, and discriminating set F which is repeatedly measured five times, according to an embodiment;

【Detailed Description of the Invention】

1. Definitions

As used herein, the expression "biological material" encompasses whole blood,

serum, plasma, urine, feces, sputum, saliva, tissue, cells, cell extract, or *in vitro* cell culture, but not limited thereto. In the Examples provided below, the biological materials of serums from patients or non-cancer subjects are used.

As used herein, the expression "peak intensity" refers to values obtained by the MALDI-TOF mass spectrometer, and have correlativity with the amount of mass ions corresponding to the peaks.

As used herein, the expression "normalization" refers to the process of brining data range to agreement with each other or brining data distribution to similar state, in which the normalization may be performed using mean or median, but not limited thereto. That is, various known methods may be adequately implemented. In one embodiment, the normalization involves obtaining partial sums of the peak intensities of the respective samples and averaging the partial sums of the samples, and multiplying the respective peak intensities by the scaling factors of the respective samples so that the partial sums of the peak intensities of the respective samples are brought into agreement with the average. As a result, the partial sums of the peak intensities of the respective samples are identical after the normalization.

As used herein, the "Pareto scaling" refers to the process of subtracting averages of the respective mass ions from the normalized peak intensities and dividing by the square root of the standard deviation. The Pareto-scaling has the advantage because it is possible to avoid amplification of noise by partially maintaining the data size information instead of applying more general method such as autoscaling which completely offsets the data size information by standard deviation.

As used herein, the "weighting factor" refers to a factor which adjusts the numeric data size after multiplication by weighting factor to a proportional relationship with the importance from the statistical viewpoint. One example of the weighting factor includes a

factor loading which is obtained as a result of PCA-DA in the Examples provided below.

As used herein, the term "low-mass ion" refers to ions having mass within 1500 m//z as obtained using MALDI-TOF mass spectrometer, or the like. Although some of the low-mass ions for CRC diagnosis may have mass exceeding the above limit, considering the most low-mass ions are within this limit, all the ions will be collectively called "low-mass ions". Accordingly, the limit as 1500 m/z will be understood as approximate value rather than definite one.

The mass measured by the MALDI-TOF mass spectrometer includes an error range of "±0.05 m/z", considering a slight error that may be generated in the mass measure depending on the environment of experiment. Y way of example, the mass of 1467.5969 m/z as indicated in the appended claims is indeed understood to be within a range between 1467.5469 m/z and 1467.6469 m/z. The error range may be "±0.1 m/z" depending on the environment of experiment.

In one embodiment, the mass measured by the MALDI-TOF mass spectrometry may be acquired in positive mode of the MALDI-TOF mass spectrometry.

In one embodiment, the code of the weighting vector is determined to be positive if the discriminant score is positive number, while it is determined to be negative if the discriminant score is negative number. The factor loading vector in the PCA-DA mathematically corresponds to eigenvector, of which code may be determined arbitrarily. That is, mathematically, the values are considered equal according to the eigenvalue problem, even when the computed factor loading per mass ions are multiplied by -1 and thus change code. However, the negative value of discriminant score is considered to indicate positivity, while the positive value of the discriminant score is considered to indicate negativity. Although the positive discriminant score indicates negativity and the negative discriminant score indicates positivity, the scope of the invention is not limited to the specific example.

Further, as used herein, the term "discriminant score" refers to a value computed by a biostatistical analysis with respect to mass spectrum extracted from a biological material, based on which cancer positivity or negativity may be determined. Simple method of determining whether the computed discriminant score exceeds a specific reference value or not may be implemented, and a function may be used, according to which the computed discriminant score is input and a result of interpretation is output.

Although the specific term "discriminant score" is used in the embodiments of the present invention, the term is not limiting. Accordingly, various other forms of terms such as discriminant level, discriminant value or the like may be adequately used. Accordingly, the term "discriminant score" is not limited to the definition in the dictionary, but rather understood as a term that encompasses various terms such as discriminant level, value or any other similar terms that can indicate the discriminant score as defined by the invention.

Further, as used herein, the term "discrimination performance" refers to numeric representation of the index including, for example, sensitivity, specificity, positive predictability, negative predictability or accuracy. The term "discrimination performance" may also refer to a value computed by the functions of the indexes. For example, sensitivity, specificity, positive predictability, negative predictability and accuracy may each be used as the discrimination performance, or alternatively, the sum of two or more indexes, e.g., the sum of sensitivity and specificity, the sum of sensitivity and positive predictability, or the sum of negative predictability and accuracy, may be used as the discrimination performance.

The invention will be explained in greater detail below with reference to Examples. However, the Examples are given only for illustrative purpose, and accordingly, the scope of the present invention should not be construed as limited by any of specific Examples.

FIGS. 7 to 13 are views provided to explain an apparatus for screening cancer according to a preferred embodiment.

First, FIG. 7 is a block diagram of an apparatus for screening cancer according to a preferred embodiment. Referring to FIG. 7, the apparatus for screening cancer according to one embodiment includes a low-mass ion detector 1000 which detects a mass spectrum of low-mass ions from a plurality of cancer patients and normal cases, a cancer diagnosing unit 2000 which determines cancer diagnosis information by compare-analyzing the mass spectrum of the low-mass ions, and a display 3000 which converts the cancer diagnosis information determined at the cancer diagnosing unit 2000 into a form suitable for output and displays the result.

The low-mass ion detecting unit 1000 may extract the mass spectrum of the low-mass ions by detecting peak intensity of the low-mass ions from the biological material. Further, the low-mass ion detecting unit 1000 may include a mass spectrometer.

The display 3000 may convert the cancer diagnosis information as determined into various forms including text, numbers, or figures and displays the resultant converted information on a device such as monitor screen, or LCD of mobile terminal, or the like.

FIG. 8 is a detailed block diagram of the cancer diagnosing unit of FIG. 7. Referring to FIG. 8, the cancer diagnosing unit 2000 may include a first aligning means 2100 which aligns the low-mass ion mass spectra of the cancer patient and non-cancer patient cases as a training candidate set, a first discriminant score (DS) computnig means 2200 which computes DS by performing biostatistical analysis with respect to the aligned mass spectra, a factor loading computnig means 2300 which computes sensitivity and specificity according to DS, selects a first training set based on the result, and computes factor loading per low-mass ions, a cancer-diagnosing ion selecting means 2400 which selects low-mass ions for the purpose of cancer diagnosis based on the discrimination performance of the candidate low-mass ions that meets condition of candidates, a second aligning means which aligns the low-mass ion mass spectra of the biological biological materials for screening to the first training set, a second

DS computnig means 2600 which computes peak intensity of the low-mass ion of interest and DS based on the factor loading, and a cancer determining means 2700 which determines the object of analysis to be cancer positive or negative depending on the DS.

The factor loading computnig means 2300 may perform biostatistical analysis with respect to the aligned mass spectra and may include a first training set selecting means 2310 which selects a first raining set based on the training cases that meet condition of training based on the biostatistical analysis among the cancer and non-cancer cases. The factor loading computnig means 2300 may compute a factor loading based on the first training set.

The first training set selecting means 2310 may set the cancer and non-cancer cases to be the first training set, if the sensitivity according to the result of biostatistical analysis exceeds a threshold N_1, and the specificity exceeds a threshold N_2. The thresholds N_1 and N_2 may preferably be 1.

The cancer determining means 2700 may determine the subject of interest to be cancer positive or negative depending on the discriminant score, and may determine the subject of interest to be positive if the DS exceeds a reference value S, or negative if the DSC does not exceed the reference value S. The reference value S may preferably be 0.

The cancer determining means 2700 may determine the cancer information of the subjects of interest based on the ge of a plurality of DS which are computed with respect to a plurality of low-mass ion mass spectra detected by repetitive measure of a biological materials for cancer screening.

FIG. 9 is a detailed block diagram of the first DS computnig means of FIG. 8. Referring to FIG. 9, the first DS computnig means 2200 may include a normalizing module 2210 which normalizes the peak intensities of the low-mass ion mass spectra of the training candidate set, a scaling module 2200 which scales the normalized peak intensities, and a DS calculating module 2230 which computes the DS by performing the biostatistical analysis

with respect to the scaled peak intensities.

The scaling module 2200 may perform Pareto-scaling. The DS calculating module 2230 may perform the biostatistical analysis using PCA-DA. The DS calculating module 2230 may compute the DS using the factor loading acquired as a result of PCA-DA and the scaled peak intensities.

FIG. 10 is a detailed block diagram of the second DS computnig means of FIG. 8. Referring to FIG. 10, the second DS computnig means 2600 may include a normalizing module 2610 which normalizes the peak intensities of the low-mass ion mass spectra of the subjects of interest, a scaling module 2620 which scales the normalized peak intensities, and a DS calculating module 2630 which computes the DS based on the scaled peak intensities and the factor loading.

The scaling module 2620 may perform Pareto-scaling. The DS calculating module 2630 may compute the DS based on the scaled peak intensities of the low-mass ions for cancer diagnosis and the factor loading.

FIG. 11 is a detailed block diagram of the cancer-diagnosing ion selecting means of FIG. 8. Referring to FIG. 11, the cancer-diagnosing ion selecting means 2400 may include a candidate ion set selecting means 2410 which selects a candidate ion set based on candidate low-mass ions that meet condition of candidates from the selected first training set, and a final ion set selecting means 2420 which selects a final ion set with the cancer-diagnosing low-mass ions based on the individual or combinational discrimination performance of the candidate low-mass ions of the selected candidate ion set.

The criterion for evaluating the discrimination performance implementable at the final ion set selecting means 2420 may include a first criterion according to which ions, from among the candidate low-mass ions, that have sums of sensitivity and specificity greater than a reference are selected, or a combination of ions, from among the combinations of the

candidate low-mass ions, that has a sum of sensitivity and specificity greater than the counterpart combinations is selected.

The criterion for evaluating the discrimination performance at the final ion set selecting means 2420 may additionally include a second criterion according to which a combination of the ions, from among the combinations of the candidate low-mass ions, that has the least number of the candidate low-mass ions among the counterpart combinations.

The criterion for evaluating the discrimination performance implementable at the final ion set selecting means 2420 may additionally include a third criterion according to which a combination of the candidate low-mass ions, from among the combinations of the candidate low-mass ions, that has the greatest difference between the maximum DS of the true positive case and the maximum DS of the true negative case, in which the DS may be computed based on the scaled peak intensities and the factor loading of the candidate low-mass ions, and indicate cancer positive or negative.

The final ion set selecting means 2420 may perform the operation of selecting low-mass ions with respect to a training set consisting of the first training set added with a second training set, independent from the first training set.

FIG. 12 is a detailed block diagram of the candidate ion set selecting means of FIG. 11. Referring to FIG. 12, the candidate ion set selecting means 2410 may include a first low-mass ion selecting module 2411 which selects the first low-mass ions for the respective training cases, in which, as illustrated in FIG. 12, an absolute product of multiplying the peak intensities of the low-mass ions of the respective training cases by the factor loading per low-mass ions obtained through the biostatistical analysis does not exceed a threshold T_1. The threshold T_1 may preferably be 0.1.

The candidate ion set selecting means 2410 may include a candidate ion set preselecting module 2412 which selects the candidate ion set with the second low-mass ions

which are present commonly in the training cases of the first low-mass ions that exceed the threshold percentage T_2. The threshold percentage T_2 may preferably be 50%.

The candidate ion set selecting means 2410 may include a sensitivity/specificity calculating module 2413 which computes DS representing cancer positive or negative with respect to each training case using the second low-mass ions, and computes sensitivity and specificity based on the DS, and a candidate ion set final selecting module 2414 which changes at least one of T_1 and T_2 and selects the candidate ion set by repeating the above operations, if the sensitivity is less than the threshold N_3 or if the specificity is less than threshold N_4. The thresholds N_3 and N_4 may preferably be 0.9.

FIG. 13 is a detailed block diagram of the final ion set selecting means of FIG. 11. Referring to FIG. 13, the final ion set selecting means 2420 may include an ion dividing module 2421 which divides the candidate low-mass ions included in the candidate ion set into high sensitivity sets $\{Sns_1, Sns_2, Sns_3 \ldots Sns_I\}$ consisting of high sensitivity low-mass ions having greater sensitivity than the specificity in which the high sensitivity low-mass ions are sorted in descending order based on the sum of the sensitivity and the specificity, and high specificity sets $\{Spc_1, Spc_2, Spc_3 \ldots Spc_J\}$ having high specificity low-mass ions with greater specificity than sensitivity in which the high specificity low-mass ions are sorted in a descending order based on the sum of the sensitivity and the specificity; a biomarker group preselecting module 2422 which selects a biomarker group based on combinations that are selected according to the discrimination performance based on at least one of the first, the second and the third criteria from among the candidate combinations consisting of two or more low-mass ions of top L high sensitivity low-mass ions $\{Sns_1, Sns_2, Sns_3 \ldots Sns_L\}$ and top L high specificity low-mass ions $\{Spc_1, Spc_2, Spc_3 \ldots Spc_L\}$; and a biomarker group re-selecting module 2424 which re-selects the biomarker group with a combination which is selected according to the criteria of the discrimination performance by at least one of the first,

the second and third criteria, from among candidate combinations consisting of the biomarker group added with second top M high sensitivity low-mass ions of the high sensitivity set and second top M high specificity low-mass ions of the high specificity set; and a biomarker group final selecting module 2424 which repeats the re-selecting until there is no second top low-mass ions left in the high sensitivity set and the high specificity set and finally selects the biomarker group.

The final ion set selecting means 2420 may include a biomarker group additional selecting module 2425 which repeats the selecting operation of the three biomarker groups with respect to remaining candidate ion set of the candidate ion set except for the low-mass ions in the combinations selected as the biomarker group at the biomarker group final selecting module 2424 to thereby additionally select a biomarker group, and continues additionally selecting the biomarker group as far as there are more than L mass ions left in the high sensitivity set or the high specificity set; and a cancer-diagnosing low-mass ion final selecting module 2426 which selects the low-mass ions in the combination of top K biomarker groups as the low-mass ions for cancer diagnosis in terms of accuracy in determining true positivity or true negativity. The value L may be 2, and M may be 1, and K may be 1, 2 or 3.

The plurality of cancer patent cases may include any of CRC, BRC or GC patient cases.

2. Examples of apparatus for screening CRC

FIG. 14 is a detailed block diagram of the cancer diagnosing unit of FIG. 7 for the diagnosis of CRC according to an embodiment.

Referring to FIG. 14, the cancer diagnosing unit according to one embodiment may include a first aligning means 4100 which aligns a low-mass ion mass spectrum of a

candidate training set consisting of the CRC patient and non-CRC cases; a first DS computing means 4200 which computes DS by conducting biostatistical analysis with respect to the aligned mass spectrum; a factor loading computing means 4300 which computes sensitivity and specificity according to DS and selects a first training set based on the computed result, and computes factor loadings per low-mass ions; a CRC diagnosing ion selecting means 4400 which selects low-mass ions for the purpose of diagnosing CRC in terms of the discrimination performance from among the candidate low-mass ions that meet candidate condition; a second aligning means which aligns the low-mass ion mass spectrum of a biological biological materials for screening to the first training set; a second DS computing means 4600 which computes DS based on peak intensities of the low-mass ions of interest and the factor loadings; and a CRC determining means 4700 which determines the subject of interest to be CRC positive or negative depending on the DS. The CRC diagnosing ion selecting means 4400 may divide the plurality of CRC patient and non-CRC cases into a first type discrimination case consisting of a plurality of CRC patient cases and a plurality of normal cases, a second type discrimination case consisting of the plurality of CRC patient cases and a plurality of cancer patient cases with cancers other than CRC, and executed with respect to the first and second discrimination cases, respectively, to divide the CRC-diagnosing low-mass ions into first type CRC diagnosing low-mass ions with respect to the first type discrimination case and second type CRC-diagnosing low-mass ions with respect to the second type discrimination case.

To the above-mentioned purpose, the low-mass ion detecting unit 1000 extracts mass spectrum of the low-mass ion by detecting peak intensity of the low-mass ions using mass spectrometer with respect to biological materials of a plurality of CRC patient and non-CRC cases.

The detailed components of the cancer diagnosing unit to diagnose the CRC are

identical to those of the apparatus for screening cancer explained above with reference to FIGS. 9 to 13. Accordingly, the like elements will not be explained in detail below for the sake of brevity.

Referring to FIG. 14, the apparatus for screening cancer according to one embodiment may be implemented in a hardware level, or alternatively, in a software level via program structure, and the example of implementation in the software level will be explained below with reference to the flowcharts accompanied hereto, to explain diagnosing CRC with an apparatus for screening cancer according to an embodiment.

(2-1) Sample preparation – collecting serums

Serums were collected from 133 CRC patients (Table 101), 153 normal controls (Table 102), 111 BRC patients (Table 105), 36 non-Hodgkin lymphoma (NHL) patients (Table 106) and 29 GC patients (Table 107), respectively.

【Table 105】

BRC	Sex	Age year	Node	ER	ER%	PR	PR%	HER 2	Tumor Size cm
BRC-A1	F	48	-	5	33-66%	6	33-66%	2	-
BRC-A2	F	35	-	6	33-66%	6	33-66%	1	-
BRC-A3	F	45	pN1a	5	33-66%	5	33-66%	0	1.5
BRC-A4	F	61	-	0	0%	0	0%	2	-
BRC-A5	F	70	pN0(sn)	0	0%	0	0%	1	<0.1
BRC-A6	F	58	ypN0	3	<10%	3	10-33%	3	0.5
BRC-A7	F	49	ypN0(i+)	0	0%	0	0%	2	1.9
BRC-A8	F	49	ypN2a	0	0%	0	0%	1	2.5
BRC-A9	F	39	pN1a	6	33-66%	7	>66%	1	2.2
BRC-A10	F	48	ypN2a	6	33-66%	4	<10%	3	5.8
BRC-A11	F	39	-	0	0%	0	0%	1	-
BRC-A12	F	56	pN1a	6	33-66%	6	33-66%	0	2.8
BRC-	F	59	pN0(sn	6	33-66%	2	<10%	1	2.3

A13			)						
BRC-A14	F	31	pN1a	5	33-66%	4	10-33%	1	2.2
BRC-A15	F	46	pN3a	6	33-66%	6	33-66%	1	3.5
BRC-A16	F	56	-	7	>66%	4	10-33%	1	-
BRC-A17	F	55	-	0	0%	0	0%	2	-
BRC-A18	F	46	pN0	0	0%	0	0%	0	1.5
BRC-A19	F	60	ypN0	0	0%	0	0%	3	1.9
BRC-A20	F	49	pN0(sn)	5	33-66%	2	<10%	2	1.5
BRC-A21	F	55	pN1mi	0	0%	0	0%	3	1.8
BRC-A22	F	65	pN0	6	33-66%	6	33-66%	0	1.7
BRC-A23	F	35	ypN2a	6	66%	4	10-33%	2	2.6
BRC-A24	F	46	pN1a	6	33-66%	6	33-66%	3	2.5
BRC-A25	F	45	pN0(sn)	6	33-66%	6	33-66%	1	0.8
BRC-A26	F	42	pN0(sn)	3	10-33%	6	33-66%	0	1
BRC-A27	F	58	pN0(sn)	6	33-66%	6	33-66%	1	1.5
BRC-A28	F	62	pN1a	0	0%	0	0%	2	2.2
BRC-A29	F	61	-	0	0%	0	0%	1	-
BRC-A30	F	60	-	-	-	-	-	-	-
BRC-A31	F	51	-	-	-	-	-	-	-
BRC-A32	F	42	pN0	7	>66%	7	>66%	2	-
BRC-A33	F	43	pN0(sn)	3	10-33%	4	10-33%	0	2.3
BRC-A34	F	60	pN0(sn)	0	0%	0	0%	1	2.3
BRC-A35	F	61	-	6	33-66%	0	0%	2	-
BRC-A36	F	61	pN0(sn)	0	0%	2	<10%	2	1.8
BRC-	F	49	-	-	-	-	-	-	-

A37									
BRC-A38	F	44	pN0	6	33-66%	7	>66%	1	1.2
BRC-A39	F	72	pN0(sn)	0	0%	0	0%	0	1.8
BRC-A40	F	48	pN0(sn)	5	33-66%	4	10-33%	1	0.8
BRC-A41	F	44	pN0	5	33-66%	7	>66%	1	2
BRC-A42	F	41	pN2a	5	33-66%	6	33-66%	1	4
BRC-A43	F	58	pN0	6	33-66%	0	0%	2	<0.1
BRC-A44	F	42	-	5	33-66%	6	33-66%	2	-
BRC-A45	F	44	pN1a	4	10-33%	2	<10%	2	5.5
BRC-A46	F	62	pN0(sn)	7	>66%	0	0%	0	2
BRC-A47	F	47	pN0	6	33-66%	6	33-66%	2	2.4
BRC-A48	F	52	pN1a	6	33-66%	0	0%	3	1.8
BRC-A49	F	44	pN0(sn)	6	33-66%	0	0%	0	2
BRC-A50	F	49	pN0(sn)	2	<10%	2	<10%	3	0.4
BRC-A51	F	46	pN0(sn)	6	33-66%	5	33-66%	1	0.7
BRC-A52	F	58	pN0(sn)	7	>66%	5	33-66%	1	2.3
BRC-A53	F	64	pN1a	6	33-66%	7	>66%	1	2
BRC-A54	F	47	-	6	33-66%	6	33-66%	2	-
BRC-A55	F	74	pN1a	6	33-66%	6	33-66%	1	1.8
BRC-A56	F	64	pN0(sn)	0	0%	0	0%	1	2.2
BRC-A57	F	40	ypN1a	6	33-66%	6	33-66%	1	3.5
BRC-A58	F	43	pN0	6	33-66%	6	33-66%	2	2.5
BRC-A59	F	43	ypN0	0	0%	0	0%	2	-
BRC-A60	F	42	pN0	0	0%	0	0%	0	2.3
BRC-	F	37	pN0(i+	6	33-66%	6	33-66%	1	1

A61			)						
BRC-A62	F	50	pN1a	6	33-66%	6	33-66%	1	1
BRC-A63	F	57	pN0(sn)	6	33-66%	96	33-66%	1	1.4
BRC-A64	F	38	ypN0	0	0%	0	0%	1	2
BRC-A65	F	67	-	6	33-66%	2	<10%	1	-
BRC-A66	F	42	pN0(sn)	6	33-66%	6	33-66%	2	0.5
BRC-A67	F	46	pN0(sn)	6	33-66%	6	33-66%	1	1
BRC-A68	F	48	pN2a	4	10-33%	4	10-33%	3	2.5
BRC-A69	F	58	pN0	2	<10%	0	0	1	0.5
BRC-A70	F	53	pN0(sn)	0	0%	0	0%	3	<0.1
BRC-A71	F	56	-	0	0%	0	0%	0	-
BRC-A72	F	45	pN0(sn)	6	33-66%	6	33-66%	2	<0.1
BRC-A73	F	59	pN0(sn)	5	33-66%	0	0%	2	1.4
BRC-A74	F	40	ypN1a	2	<10%	0	0%	0	0.3
BRC-A75	F	34	pN0(sn)	2	<10%	0	0%	2	2
BRC-A76	F	69	-	6	33-66%	6	33-66%	1	-
BRC-A77	F	52	-	-	-	-	-	-	-
BRC-A78	F	67	-	-	-	-	-	-	-
BRC-A79	F	61	-	6	33-66%	2	<10%	0	-
BRC-A80	F	38	pN1a	6	33-66%	5	33-66%	1	-
BRC-A81	F	60	pN0	6	33-66%	3	10-33%	1	1
BRC-A82	F	55	pN2a	5	33-66%	0	0%	2	2.2
BRC-A83	F	46	ypN0	5	33-66%	2	<10%	1	1.5
BRC-A84	F	67	pN0	6	33-66%	6	33-66%	1	2.8
BRC-	F	46	pN1a	6	33-66%	6	33-66%	2	0.7

A85									
BRC-A86	F	39	pN1mi	6	33-66%	6	33-66%	2	2.5
BRC-A87	F	50	pN0(sn)	4	10-33%	5	33-66%	0	1
BRC-A88	F	31	pN1mi (sn)	6	33-66%	6	33-66%	1	1
BRC-A89	F	46	pN0	6	33-66%	7	>66%	1	1.2
BRC-A90	F	44	pN0(sn)	6	33-66%	7	>66%	1	2.5
BRC-A91	F	40	pN0	0	0%	0	0%	0	-
BRC-A92	F	40	-	6	33-66%	6	33-66%	1	-
BRC-A93	F	56	-	7	>66%	0	0	0	0.6
BRC-A94	F	48	pN1a	0	0%	0	0%	0	3
BRC-A95	F	39	pN0(sn)	6	33-66%	6	33-66%	1	3.5
BRC-A96	F	40	ypN1a	6	33-66%	4	10-33%	2	3
BRC-A97	F	48	pN0(sn)	6	33-66%	6	33-66%	0	2.5
BRC-A98	F	59	-	7	>66%	2	<10%	1	-
BRC-A99	F	46	-	0	0%	0	0%	2	-
BRC-A100	F	37	pN3a	6	33-66%	6	33-66%	2	0.6
BRC-A101	F	38	pN0(sn)	6	33-66%	6	33-66%	2	0.3
BRC-A102	F	66	pN1a	6	33-66%	6	33-66%	0	1.5
BRC-A103	F	58	pN0(sn)	0	0%	0	0%	2	1.7
BRC-A104	F	42	pN3a	5	33-66%	6	33-66%	0	1.8
BRC-A105	F	52	pN0	6	33-66%	6	33-66%	0	0.7
BRC-A106	F	46	pN0(sn)	0	0%	2	<10%	1	1.5
BRC-A107	F	42	pN0(sn)	4	10-33%	6	33-66%	1	0.6
BRC-A108	F	48	-	-	-	-	-	-	-
BRC-	F	47	pN0	6	33-66%	2	<10%	2	3

A109									
BRC-A110	F	59	pN1a	6	33-66%	4	10-33%	1	1.8
BRC-A111	F	56	-	0	0%	0	0%	3	-

【Table 106】

NHL	Sex	Age year	Stage	Involved Site	Subtype	IPI
NHL-A1	M	65	3	multiple	DLBL	3
NHL-A2	M	63	2	stomach	DLBL	1
NHL-A3	M	65	3	multiple	DLBL	3
NHL-A4	M	65	3	multiple	Follicular L	2
NHL-A5	M	64	2	stomach	DLBL	2
NHL-A6	M	52	3	multiple	DLBL	2
NHL-A7	M	52	2	spleen, pancreatic LN	DLBL	1
NHL-A8	M	52	3	multiple	DLBL	2
NHL-A9	M	42	2	multiple	DLBL	2
NHL-A10	M	44	1	stomach	DLBL	1
NHL-A11	M	44	2	cervical LN, tonsil	DLBL	0
NHL-A12	M	40	4	multiple	DLBL	3
NHL-A13	M	39	1	nasal cavity	NK/T cell L	1
NHL-A14	M	41	1	inguinal LN	ALCL	0
NHL-A15	F	57	4	multiple	DLBL	3
NHL-A16	F	38	2	tonsil, neck LN	DLBL	0
NHL-A17	F	56	1	breast	DLBL	0
NHL-A18	M	71	4	multiple	Mantle cell L	3
NHL-A19	M	70	2	neck area LN	DLBL	1
NHL-A20	M	80	2	stomach	PTCL	1
NHL-A21	F	39	2	tonsil, neck LN	DLBL	0
NHL-A22	F	38	4	multiple	DLBL	3
NHL-A23	F	38	1	stomach	DLBL	0
NHL-A24	M	67	4	multiple	DLBL	2
NHL-A25	M	67	3	multiple	Burkitt's L	3
NHL-A26	F	73	1	nasal cavity	DLBL	2
NHL-A27	F	73	3	multiple	DLBL	2
NHL-A28	F	41	1	0	DLBL	0
NHL-A29	M	49	3	multiple	DLBL	3
NHL-A30	M	31	2	neck	DLBL	0
NHL-A31	M	46	2	nasopharynx, tonsil	DLBL	0
NHL-A32	M	71	-	stomach	r/o Lymphoma	-

NHL-A33	M	73	1	nasal cavity	DLBL	1
NHL-A34	M	73	4	tibia, leg(skin)	DLBL	3
NHL-A35	M	72	2	stomach	DLBL	1
NHL-A36	M	79	1	nasal cavity	malignant L	2

【Table 107】

GC	Sex	Age year	CEA ng/mL	Stage	GC	Sex	Age year	CEA ng/mL	Stage
GC-A1	F	52	3.36	IV	GC-A16	F	51	0.51	IV
GC-A2	M	65	0.99	IV	GC-A17	M	63	27.18	IV
GC-A3	M	41	-[a]	IV	GC-A18	M	51	1.93	IV
GC-A4	M	78	4.93	IV	GC-A19	M	64	2.41	IV
GC-A5	M	79	1.11	IV	GC-A20	M	62	2.72	IV
GC-A6	M	76	2.37	IV	GC-A21	M	71	8.46	IV
GC-A7	M	54	117.13	IV	GC-A22	M	46	2.67	IV
GC-A8	M	58	2.24	IV	GC-A23	M	68	24.93	IV
GC-A9	M	67	>1500	IV	GC-A24	M	68	3.23	IV
GC-A10	F	71	1.92	IV	GC-A25	M	57	41.32	IV
GC-A11	F	42	<0.4	IV	GC-A26	M	71	2.8	IV
GC-A12	M	49	104.73	IV	GC-A27	F	43	1.62	IV
GC-A13	M	65	1.69	IV	GC-A28	M	58	6.6	IV
GC-A14	F	57	6.98	IV	GC-A29	M	73	-	IV
GC-A15	M	55	2.03	IV					

With respect to set A_1 consisting of 462 cases, subset A_0 was constructed into the first training set. The weightings (factor loadings) per mass ions were computed by the biostatistical analysis, and the preliminary discriminant was acquired. Further, the training set was enlarged to include the second training set A_2 consisting of the 144 CRC patients of Table 108, 50 normal controls of Table 109, 25 BRC patients of Table 110, 15 NHL patients of Table 111 and 57 GC patients of Table 112. That is, to analyze CRC-diagnosing low-mass ions according to the method explained below with respect to the preliminary candidate groups of the low-mass ions constructing the preliminary discriminant, the set A, i.e., union of set A_1 and set A_2, which are independent from each other, was used as the training set.

【Table 108】

CRC	Sex	Age year	Stage	Location	Cell Type	CEA ng/mL
CRC-A134	M	49	I	Rectum	AC	6.6
CRC-A135	F	60	III	A-colon	AC	30.4
CRC-A136	M	69	IV	A-colon	AC	33.5
CRC-A137	M	43	III	A-colon	MAC	77.6
CRC-A138	F	69	III	Rectum	AC	1.0
CRC-A139	M	72	III	A-colon	AC	2.4
CRC-A140	M	54	II	Rectum	AC	4.6
CRC-A141	M	58	II	S-colon	AC	2.9
CRC-A142	F	52	III	S-colon	AC	9.2
CRC-A143	M	52	III	S-colon	AC	3.2
CRC-A144	M	78	IV	Rectum	AC	4.1
CRC-A145	F	55	III	Rectum	AC	0.9
CRC-A146	M	65	II	S-colon	AC	1.7
CRC-A147	F	46	I	S-colon	AC	1.4
CRC-A148	M	77	III	S-colon	AC	2.5
CRC-A149	F	52	II	S-colon	AC	<0.5
CRC-A150	F	47	III	S-colon	AC	1.5
CRC-A151	M	48	III	S-colon	AC	1.7
CRC-A152	F	76	II	S-colon	AC	2.2
CRC-A153	M	51	II	S-colon	ASC	8.6
CRC-A154	M	61	I	Rectum	AC	1.4
CRC-A155	M	56	II	Rectum	AC	3
CRC-A156	F	70	III	S-colon	MAC	36.0
CRC-A157	M	64	III	A-colon	AC	2.2
CRC-A158	F	54	III	Rectum	AC	5.5
CRC-A159	F	77	II	Rectum	AC	6.2
CRC-A160	M	53	III	Rectum	AC	1.4
CRC-A161	M	43	I	Rectum	AC	0.5
CRC-A162	M	81	III	A-colon	MAC	10.9
CRC-A163	F	52	III	A-colon	AC	1.2
CRC-A164	F	71	III	A-colon	AC	2.8
CRC-A165	M	84	III	Rectum	AC	15.0
CRC-A166	F	33	III	D-colon	AC	4.7
CRC-A167	F	68	III	Rectum	AC	3.3
CRC-A168	M	69	III	Rectum	AC	3.5
CRC-A169	F	61	III	A-colon	AC	2.8
CRC-A170	M	44	II	T-colon	AC	1.8
CRC-A171	F	82	II	A-colon	AC	2.8
CRC-A172	M	38	IV	Rectum	AC	2.1
CRC-A173	M	73	III	Rectum	AC	11.1
CRC-A174	M	64	III	D-colon	AC	8.2
CRC-A175	M	67	II	A-colon	AC	20.1
CRC-A176	M	72	II	A-colon	AC	3.4
CRC-A177	M	59	II	S-colon	AC	2.1

CRC-A178	M	53	I	Rectum	AC	3.5
CRC-A179	M	70	II	Rectum	AC	1.3
CRC-A180	M	55	II	Rectum	AC	22.0
CRC-A181	M	62	II	Rectum	AC	6.1
CRC-A182	M	64	III	Rectum	AC	4.8
CRC-A183	M	62	IV	Rectum	AC	25.3
CRC-A184	M	51	III	Rectum	AC	149.3
CRC-A185	F	45	II	Rectum	AC	2.7
CRC-A186	F	49	II	Rectum	AC	2.1
CRC-A187	F	45	0	Rectum	AC	0.9
CRC-A188	M	62	III	Rectum	AC	2.4
CRC-A189	M	54	0	Rectum	AC	6.9
CRC-A190	M	45	0	Rectum	AC	7.4
CRC-A191	F	54	0	Rectum	AC	3.6
CRC-A192	M	69	II	Rectum	AC	24.0
CRC-A193	M	51	I	Rectum	AC	2.7
CRC-A194	M	45	I	Rectum	AC	3.2
CRC-A195	M	67	I	Rectum	AC	2.9
CRC-A196	M	60	I	Rectum	AC	1.5
CRC-A197	M	49	0	Rectum	AC	0.8
CRC-A198	M	71	I	Rectum	AC	9.8
CRC-A199	M	62	III	Rectum	AC	2.5
CRC-A200	M	54	II	Rectum	AC	4.6
CRC-A201	M	56	II	Rectum	AC	3.0
CRC-A202	F	71	III	Rectum	AC	6.7
CRC-A203	M	73	0	Rectum	AC	61.5
CRC-A204	F	50	III	Rectum	AC	2.2
CRC-A205	F	49	0	Rectum	AC	1.6
CRC-A206	F	42	III	Rectum	AC	9.9
CRC-A207	M	61	III	Rectum	AC	68.1
CRC-A208	F	72	II	Rectum	AC	8
CRC-A209	F	69	III	Rectum	AC	11.3
CRC-A210	M	58	II	Rectum	AC	5.3
CRC-A211	M	56	I	Rectum	AC	24.8
CRC-A212	M	72	III	Rectum	AC	1.4
CRC-A213	M	62	III	Rectum	AC	1.6
CRC-A214	M	55	II	Rectum	AC	2.4
CRC-A215	F	71	III	Rectum	AC	1.3
CRC-A216	M	59	III	Rectum	AC	2.8
CRC-A217	M	52	II	Rectum	AC	4.0
CRC-A218	M	47	III	Rectum	AC	2.3
CRC-A219	M	58	II	Rectum	AC	1.1
CRC-A220	M	60	0	Rectum	AC	2.0
CRC-A221	M	64	I	Rectum	AC	2.0
CRC-A222	M	41	III	Rectum	AC	1.6
CRC-A223	M	48	I	Rectum	AC	0.8
CRC-A224	M	58	II	Rectum	AC	1.1
CRC-A225	M	61	I	Rectum	AC	2.6

CRC-A226	M	63	I	Rectum	AC	1.3
CRC-A227	F	52	II	Rectum	AC	1.6
CRC-A228	M	53	II	Rectum	AC	2.0
CRC-A229	M	64	I	Rectum	AC	2.0
CRC-A230	M	73	II	Rectum	AC	5.6
CRC-A231	M	41	III	Rectum	AC	1.6
CRC-A232	M	57	III	Rectum	AC	2.0
CRC-A233	M	48	I	Rectum	AC	0.8
CRC-A234	M	72	III	Rectum	AC	6.1
CRC-A235	F	67	0	Rectum	AC	4.4
CRC-A236	F	66	II	Rectum	AC	4.8
CRC-A237	M	47	III	S-colon	AC	3.7
CRC-A238	M	40	III	A-colon	AC	1.2
CRC-A239	M	55	II	D-colon	AC	6.0
CRC-A240	F	73	I	D-colon, T-colon	AC	2.0
CRC-A241	F	69	I	A-colon	AC	5.0
CRC-A242	F	69	I	A-colon	AC	5.7
CRC-A243	F	74	II	D-colon	AC	12.5
CRC-A244	M	61	II	S-colon	MAC	1.9
CRC-A245	M	37	III	Rectum	AC	6.0
CRC-A246	M	60	III	S-colon	AC	5.4
CRC-A247	M	70	II	S-colon	AC	2.6
CRC-A248	M	68	III	Rectum	AC	13.2
CRC-A249	M	73	I	Rectum	AC	1.7
CRC-A250	M	82	III	T-colon	AC	2.1
CRC-A251	F	75	II	Rectum	AC	0.9
CRC-A252	F	57	I	A-colon	AC	1.5
CRC-A253	F	62	III	S-colon	AC	4.4
CRC-A254	M	73	II	Rectum	AC	15.5
CRC-A255	M	59	I	S-colon	AC	1.1
CRC-A256	F	74	III	Rectum	AC	31.0
CRC-A257	F	70	I	A-colon	AC	2.5
CRC-A258	M	74	II	S-colon	AC	15.4
CRC-A259	M	69	II	Rectum	AC	2.1
CRC-A260	M	61	II	A-colon, T-colon	AC	2.3
CRC-A261	M	73	I	Rectum	AC	1.9
CRC-A262	M	64	I	Rectum	AC	2.8
CRC-A263	M	69	II	D-colon	AC	5.0
CRC-A264	M	58	III	Rectum	AC	1.6
CRC-A265	M	73	II	T-colon	AC	2.6
CRC-A266	M	70	II	A-colon	AC	20.8
CRC-A267	M	56	IV	Rectum	AC	29.9
CRC-A268	F	70	II	A-colon	AC	5.9
CRC-A269	M	71	III	S-colon	AC	110.1
CRC-A270	M	47	III	Rectum	AC	13.7
CRC-A271	M	61	III	Rectum	AC	2.8

CRC-A272	F	77	II	S-colon	AC	1.5
CRC-A273	F	62	III	Rectum	AC	13.7
CRC-A274	M	61	II	S-colon	AC	2.3
CRC-A275	M	66	II	S-colon	AC	1.7
CRC-A276	M	64	III	A-colon	AC	1.0
CRC-A277	M	69	II	S-colon	AC	23.0

ASC: Adenosquamous carcinoma

【Table 109】

Control	Sex	Age year	CEA ng/mL	Control	Sex	Age year	CEA ng/mL
CONT-A154	F	51	1.7	CONT-A179	F	63	1.8
CONT-A155	F	62	1.3	CONT-A180	F	65	1.1
CONT-A156	M	54	4.2	CONT-A181	M	64	1.4
CONT-A157	F	63	1.6	CONT-A182	F	55	4.8
CONT-A158	F	60	1.9	CONT-A183	M	63	2.6
CONT-A159	F	68	1.4	CONT-A184	F	52	4.1
CONT-A160	F	62	1.9	CONT-A185	M	51	4.0
CONT-A161	F	68	5.6	CONT-A186	M	59	2.0
CONT-A162	M	63	4.5	CONT-A187	M	68	4.6
CONT-A163	M	50	2.1	CONT-A188	M	50	5.0
CONT-A164	F	53	2.3	CONT-A189	F	64	<0.5
CONT-A165	M	60	3.3	CONT-A190	F	63	2.2
CONT-A166	M	64	1.8	CONT-A191	M	64	1.7
CONT-A167	M	63	3.4	CONT-A192	M	51	2.3
CONT-A168	F	63	1.1	CONT-A193	F	62	1.1
CONT-A169	M	53	2.0	CONT-A194	M	54	2.5
CONT-A170	F	51	2.0	CONT-A195	F	53	0.7
CONT-A171	M	57	3.3	CONT-A196	F	65	3.8
CONT-A172	M	61	2.8	CONT-A197	F	64	1.5
CONT-A173	F	68	1.4	CONT-A198	F	53	1.0
CONT-A174	F	52	1.5	CONT-A199	M	50	1.1
CONT-A175	M	60	4.6	CONT-A200	F	66	1.7
CONT-A176	M	55	2.2	CONT-A201	F	50	1.0
CONT-A177	M	55	1.8	CONT-A202	F	50	1.9
CONT-A178	M	56	2.2	CONT-A203	M	61	1.5

【Table 110】

BRC	Sex	Age year	Node	ER	ER%	PR	PR%	HER2	Tumor Size cm
BRC-A112	F	61	pN0(i+0)	7	> 95%	0	0%	0	4
BRC-A113	F	53	pN0	7	80%	5	25%	0	0.6
BRC-A114	F	49	pN0	3	20%	7	60%	0	0.3
BRC-A115	F	57	pN0	0	0%	0	0%	0	0.8
BRC-A116	F	68	pN0	0	0%	3	1%	3	1.2
BRC-A117	F	58	pN0	8	95%	4	40%	0	0.8
BRC-A118	F	40	-	8	95%	8	95%	0	-
BRC-A119	F	29	pN0	8	95%	8	95%	1	1.2
BRC-A120	F	40	-	-	-	-	-	-	-
BRC-A121	F	61	pN0(i+0)	7	> 95%	0	0%	0	4
BRC-A122	F	40	-	8	95%	8	95%	0	-
BRC-A123	F	43	pN0	0	0%	0	0%	3	0.7
BRC-A124	F	59	pN0	8	95%	8	95%	0	1.2
BRC-A125	F	45	PN2	7	95%	8	95%	1	2.1
BRC-A126	F	55	pN0	0	0%	0	0%	3	1.8
BRC-A127	F	52	pN0	7	80-90%	8	80-90%	0	0.3
BRC-A128	F	59	pN0	8	95%	5	2~3%	1	1.3
BRC-A129	F	39	-	7	> 95%	7	70-80%	0	-
BRC-A130	F	39	pN0	0	0%	0	0%	3	1.1
BRC-A131	F	40	pN0	5	50-60%	5	20-30%	0	0.8
BRC-A132	F	46	pN0	7	95%	8	95%	0	4.9
BRC-A133	F	51	pN0	0	<1%	0	0%	0	0.9
BRC-A134	F	61	pN0	7	90%	8	90%	0	1.3
BRC-A135	F	48	pN0	0	0%	0	0%	0	0.6
BRC-A136	F	47	pN0	8	> 95%	8	95%	0	0.7

【Table 111】

NHL	Sex	Age year	Stage	Involved Site	Subtype	IPI
NHL-A37	F	69	3	multiple	ATCL	3
NHL-A38	F	72	1	stomach	DLBL	2
NHL-A39	M	24	4	multiple	DLBL	3
NHL-A40	F	41	2	stomach	DLBL	1
NHL-A41	F	48	4	multiple	DLBL	3

NHL-A42	F	66	2	gum, submandibular	DLBL	1
NHL-A43	F	61	2	stomach	DLBL	3
NHL-A44	M	38	4	multiple	Hodgkin L	-
NHL-A45	M	70	4	multiple	DLBL	3
NHL-A46	M	37	1	cervical LN	DLBL	0
NHL-A47	M	64	4	multiple	DLBL	4
NHL-A48	F	76	2	stomach	DLBL	1
NHL-A49	M	34	2	neck, SCN	DLBL	1
NHL-A50	M	25	4	multiple	PTCL	2
NHL-A51	M	70	2	stomach	DLBL	1

【Table 112】

GC	Sex	Age year	CEA ng/mL	Stage	GC	Sex	Age year	CEA ng/mL	Stage
GC-A30	M	70	1.26	III	GC-A59	M	62	-	II
GC-A31	M	62	5.41	I	GC-A60	M	67	-	II
GC-A32	M	58	-	I	GC-A61	F	64	-	II
GC-A33	M	62	1.34	I	GC-A62	F	40	-	II
GC-A34	M	32	-	I	GC-A63	M	64	-	II
GC-A35	M	71	3.54	I	GC-A64	M	68	-	II
GC-A36	M	56	2.83	I	GC-A65	M	54	-	II
GC-A37	M	69	21.71	II	GC-A66	F	52	-	II
GC-A38	F	62	-	I	GC-A67	M	59	-	II
GC-A39	M	52	1.86	I	GC-A68	F	81	-	II
GC-A40	F	64	4.16	I	GC-A69	M	46	-	III
GC-A41	M	59	-	II	GC-A70	M	62	-	III
GC-A42	M	61	10.41	IV	GC-A71	M	51	-	III
GC-A43	F	68	5.56	III	GC-A72	M	42	-	III
GC-A44	M	48	1.44	III	GC-A73	M	81	-	III
GC-A45	F	80	-	III	GC-A74	F	81	-	III
GC-A46	M	66	-	IV	GC-A75	M	70	-	III
GC-A47	F	57	2.46	IV	GC-A76	M	51	-	III
GC-A48	M	46	1.68	III	GC-A77	M	68	-	IV
GC-A49	M	79	-	I	GC-A78	M	68	-	IV
GC-A50	M	81	-	I	GC-A79	F	33	-	IV
GC-A51	M	52	-	I	GC-A80	M	31	-	IV
GC-A52	M	53	-	I	GC-A81	M	52	-	IV
GC-A53	M	67	-	I	GC-A82	M	59	-	IV
GC-A54	M	61	-	I	GC-A83	M	56	-	IV
GC-A55	F	77	-	I	GC-A84	M	82	-	IV
GC-A56	F	74	-	I	GC-A85	F	52	-	IV
GC-A57	F	81	-	I	GC-A86	M	82	-	IV

GC-A58	F	55	-	I	

Further, validation set was constructed with set A and set B consisting of 143 CRC patients of Table 113, 50 normal controls of Table 114, 25 BRC patients of Table 115, 15 NHL patients of Table 116, 55 GC patents of Table 117, 25 ovarian cancer (OVC) patients of Table 118, 19 Tis or Advanced Adenoma (TA) patients of Table 119. The OVC patients and TA patients were not reflected at all when obtaining weighting per mass ions or investigating CRC-diagnosing low-mass ions, and included to see how these particular patient groups are discriminated with the discriminant constructed according to the present invention.

【Table 113】

CRC	Sex	Age year	Stage	Location	Cell Type	CEA ng/mL
CRC-B1	F	51	II	Rectum	AC	6.7
CRC-B2	M	71	I	Rectum	AC	9.8
CRC-B3	F	47	I	Rectum	AC	3.9
CRC-B4	F	50	IV	Rectum	AC	62.0
CRC-B5	M	79	II	S-colon	AC	6.2
CRC-B6	F	54	I	Rectum	AC	1.6
CRC-B7	F	52	III	S-colon	AC	22.1
CRC-B8	M	61	III	Rectum	AC	128.1
CRC-B9	F	47	III	S-colon	AC	1.2
CRC-B10	M	73	I	S-colon	AC	7.1
CRC-B11	F	74	I	S-colon	AC	2.3
CRC-B12	M	71	III	A-colon	AC	8.2
CRC-B13	M	57	IV	Rectum	AC	6.4
CRC-B14	M	57	IV	S-colon	AC	41.7
CRC-B15	M	52	III	S-colon	AC	4.1
CRC-B16	F	64	III	S-colon	AC	6.8
CRC-B17	M	48	IV	A-colon	AC	59.4
CRC-B18	F	51	III	S-colon	AC	1.2
CRC-B19	M	67	IV	Rectum	AC	16.2
CRC-B20	M	71	I	Rectum	AC	83.7
CRC-B21	M	59	I	S-colon	AC	3.0
CRC-B22	F	66	IV	S-colon	AC	18.5
CRC-B23	F	78	IV	A-colon	AC	12.6

CRC-B24	M	55	III	A-colon	AC	1.2
CRC-B25	M	62	III	Rectum	AC	2.5
CRC-B26	M	38	III	Rectum	AC	6.1
CRC-B27	F	65	III	D-colon	AC	3.5
CRC-B28	M	49	III	S-colon, T-colon	AC	3.8
CRC-B29	F	59	II	A-colon	AC	1
CRC-B30	M	62	II	S-colon	AC	-
CRC-B31	F	54	IV	S-colon	AC	27.9
CRC-B32	M	66	III	S-colon	AC	10.7
CRC-B33	M	84	II	S-colon	AC	11.3
CRC-B34	F	54	III	S-colon	AC	8.8
CRC-B35	M	68	II	Rectum	AC	5.8
CRC-B36	M	54	II	A-colon	AC	1.1
CRC-B37	M	62	III	S-colon	AC	10.8
CRC-B38	F	60	III	S-colon, A-colon	AC	28.5
CRC-B39	F	51	II	D-colon	AC	5.9
CRC-B40	F	73	III	Rectum	AC	3.7
CRC-B41	F	54	III	D-colon	AC	1122.2
CRC-B42	M	64	I	Rectum	AC	2.5
CRC-B43	F	69	II	S-colon, A-colon	AC	5.1
CRC-B44	M	39	II	S-colon	AC	2.9
CRC-B45	M	74	II	Rectum	AC	7.9
CRC-B46	F	59	III	Rectum	AC	1.4
CRC-B47	M	56	I	Rectum	AC	2.6
CRC-B48	M	69	II	Rectum	AC	14.0
CRC-B49	M	58	II	Rectum	AC	10.2
CRC-B50	F	75	II	Rectum	AC	2.4
CRC-B51	M	47	II	Rectum	AC	3.2
CRC-B52	F	68	II	Rectum	AC	0.7
CRC-B53	M	52	III	Rectum	AC	2.9
CRC-B54	M	68	I	Rectum	AC	7.0
CRC-B55	M	51	II	Rectum	AC	1.4
CRC-B56	M	66	0	Rectum	AC	1.2
CRC-B57	M	74	0	Rectum	AC	4.5
CRC-B58	M	43	II	Rectum	AC	12.3
CRC-B59	M	68	III	Rectum	AC	2.5
CRC-B60	M	68	III	Rectum	AC	19.4
CRC-B61	F	56	I	Rectum	AC	2.3
CRC-B62	M	63	0	Rectum	AC	1.3
CRC-B63	M	65	II	Rectum	AC	2.1
CRC-B64	M	60	II	Rectum	AC	4.6
CRC-B65	M	51	II	Rectum	AC	1.3
CRC-B66	M	44	0	Rectum	AC	2.2
CRC-B67	M	61	II	Rectum	AC	2.0
CRC-B68	M	57	III	Rectum	AC	2.2

CRC-B69	M	41	II	Rectum	AC	3.1
CRC-B70	M	50	I	Rectum	AC	4.9
CRC-B71	F	56	III	Rectum	AC	1.0
CRC-B72	M	54	III	Rectum	AC	1.7
CRC-B73	F	69	I	Rectum	AC	1.5
CRC-B74	M	54	I	Rectum	AC	2.6
CRC-B75	M	61	II	Rectum	AC	3.7
CRC-B76	M	72	III	Rectum	AC	3.0
CRC-B77	F	71	III	Rectum	AC	1.8
CRC-B78	M	54	II	Rectum	AC	3.0
CRC-B79	M	77	II	Rectum	AC	1.6
CRC-B80	M	67	III	Rectum	AC	1.1
CRC-B81	M	59	II	Rectum	AC	7.2
CRC-B82	M	56	III	Rectum	AC	9.0
CRC-B83	F	51	I	Rectum	AC	1.5
CRC-B84	F	67	III	Rectum	AC	3.4
CRC-B85	F	76	III	Rectum	AC	1.0
CRC-B86	F	38	III	Rectum	AC	0.7
CRC-B87	M	53	II	Rectum	AC	3.3
CRC-B88	M	58	III	Rectum	AC	1.6
CRC-B89	M	69	III	Rectum	AC	6.4
CRC-B90	F	60	I	Rectum	AC	1.2
CRC-B91	M	52	II	Rectum	AC	4.0
CRC-B92	M	59	III	Rectum	AC	2.8
CRC-B93	F	56	III	Rectum	AC	2.3
CRC-B94	F	68	I	Rectum	AC	2.0
CRC-B95	M	65	I	Rectum	AC	1.6
CRC-B96	M	33	II	Rectum	AC	1.9
CRC-B97	M	61	III	Rectum	AC	3.2
CRC-B98	F	41	III	Rectum	AC	1.5
CRC-B99	M	61	I	Rectum	AC	1.6
CRC-B100	F	34	III	Rectum	AC	5.2
CRC-B101	M	47	III	Rectum	AC	2.3
CRC-B102	F	61	III	A-colon	AC	30.4
CRC-B103	M	71	IV	A-colon	AC	33.5
CRC-B104	M	44	III	A-colon	MAC	77.6
CRC-B105	F	71	III	Rectum	AC	1.0
CRC-B106	M	59	II	S-colon	AC	2.9
CRC-B107	M	79	IV	Rectum	AC	4.1
CRC-B108	M	66	II	S-colon	AC	1.7
CRC-B109	M	78	III	S-colon	AC	2.5
CRC-B110	F	53	II	S-colon	AC	1.3
CRC-B111	M	50	III	S-colon	AC	1.7
CRC-B112	F	77	II	S-colon	AC	2.2
CRC-B113	M	53	II	S-colon	ASC	8.6
CRC-B114	M	63	I	Rectum	AC	1.4
CRC-B115	F	71	III	S-colon	MAC	36.0
CRC-B116	F	79	II	Rectum	AC	6.2

CRC-B117	M	83	III	A-colon	MAC	10.9
CRC-B118	F	53	III	A-colon	AC	1.2
CRC-B119	F	72	III	A-colon	AC	2.8
CRC-B120	F	34	III	D-colon	AC	4.7
CRC-B121	M	70	III	Rectum	AC	3.5
CRC-B122	F	62	III	A-colon	AC	2.8
CRC-B123	M	45	II	T-colon	AC	1.8
CRC-B124	F	84	II	A-colon	AC	2.8
CRC-B125	M	74	III	Rectum	AC	11.1
CRC-B126	M	65	III	D-colon	AC	8.2
CRC-B127	M	69	II	A-colon	AC	20.1
CRC-B128	M	73	II	A-colon	AC	2.3
CRC-B129	M	61	II	S-colon	AC	2.1
CRC-B130	F	71	II	S-colon	AC	15.3
CRC-B131	F	56	I	S-colon	AC	0.7
CRC-B132	F	70	II	S-colon	AC	1.4
CRC-B133	F	62	III	Rectum	AC	235.4
CRC-B134	M	61	III	S-colon	AC	11.2
CRC-B135	F	52	III	S-colon	AC	6.4
CRC-B136	M	62	II	S-colon	AC	4.9
CRC-B137	F	61	III	T-colon	AC	13.9
CRC-B138	F	88	II	A-colon	AC	3.0
CRC-B139	M	73	II	S-colon	AC	16.5
CRC-B140	M	69	III	A-colon	AC	1.7
CRC-B141	M	71	III	A-colon	MAC	2.4
CRC-B142	F	45	0	Rectum	AC	-
CRC-B143	M	66	0	Rectum	AC	58.4

【Table 114】

Control	Sex	Age year	CEA ng/mL	Control	Sex	Age year	CEA ng/mL
CONT-B1	M	64	2.4	CONT-B26	F	56	1.7
CONT-B2	M	53	3.3	CONT-B27	F	52	1.7
CONT-B3	M	63	0.9	CONT-B28	M	63	1.0
CONT-B4	M	57	1.5	CONT-B29	F	60	1.8
CONT-B5	F	66	1.6	CONT-B30	F	58	0.7
CONT-B6	M	60	1.5	CONT-B31	M	65	4.1
CONT-B7	M	57	2.2	CONT-B32	M	52	2.2
CONT-B8	M	53	1.9	CONT-B33	F	58	3.1
CONT-B9	M	60	0.8	CONT-B34	M	65	2.8
CONT-B10	F	50	2.6	CONT-B35	M	66	0.8
CONT-B11	F	53	2.6	CONT-B36	M	69	2.1
CONT-B12	M	64	1.5	CONT-B37	F	54	1.6
CONT-B13	F	60	3.7	CONT-B38	M	50	1.9

CONT-B14	M	58	1.2	CONT-B39	F	60	1.1
CONT-B15	F	66	1.1	CONT-B40	F	55	8.8
CONT-B16	M	57	2.9	CONT-B41	M	62	0.9
CONT-B17	F	68	5.5	CONT-B42	F	51	2.0
CONT-B18	M	56	1.7	CONT-B43	M	65	2.3
CONT-B19	M	51	3.4	CONT-B44	M	52	2.4
CONT-B20	F	56	1.3	CONT-B45	F	64	1.7
CONT-B21	M	57	1.5	CONT-B46	M	57	0.8
CONT-B22	M	61	4.2	CONT-B47	F	54	<0.5
CONT-B23	F	51	1.9	CONT-B48	F	59	0.8
CONT-B24	F	51	1.6	CONT-B49	F	65	1.6
CONT-B25	F	52	1.4	CONT-B50	F	68	1.6

【Table 115】

BRC	Sex	Age year	Node	ER	ER%	PR	PR%	HER2	Tumor Size cm
BRC-B1	F	45	ypN0	0	0%	0	0%	0	0.9
BRC-B2	F	59	pN0	0	0%	0	0%	3	1.1
BRC-B3	F	43	pN1	0	0%	0	0%	0	1.5
BRC-B4	F	46	pN1	8	100%	8	100%	0	1.3
BRC-B5	F	48	pN0	6	50-60%	5	10-20%	3	1.3
BRC-B6	F	39	pN0	0	0%	0	0%	0	2.2
BRC-B7	F	66	pN0	8	95%	8	95%	0	1.7
BRC-B8	F	39	ypN0	0	0%	0	0%	0	DCIS
BRC-B9	F	37	pN0	7	70-80%	8	80%	3	1.5
BRC-B10	F	64	pN0	8	95%	8	95%	0	0.5
BRC-B11	F	44	ypN1	7	90%	8	95%	0	2
BRC-B12	F	50	pN2	8	95%	8	100%	0	1.1
BRC-B13	F	47	pN0	7	70%	7	50-60%	1	0.5
BRC-B14	F	44	pN1	8	90%	8	95%	1	0.6
BRC-B15	F	50	pN0	0	0%	0	0%	2	2.2
BRC-B16	F	53	pN0	7	95%	8	95%	0	1.1
BRC-B17	F	65	pN0	8	95%	7	40%	0	1.5
BRC-B18	F	39	pN1	7	> 95%	3	< 10%	0	2.2
BRC-B19	F	54	pN0(i+)	7	95%	5	10-30%	1	1.7
BRC-B20	F	48	pN3a	7	90%	8	90%	0	3.2
BRC-B21	F	54	pN0	0	0%	0	0%	0	3
BRC-B22	F	43	pN0	7	50-	7	50-	3	2.3

					60%		60%		
BRC-B23	F	61	pN0	8	95%	8	95%	0	1.6
BRC-B24	F	54	-	0	0%	0	0%	3	-
BRC-B25	F	46	pN0	7	80%	8	95%	0	2.2

【Table 116】

NHL	Sex	Age year	Stage	Involved Site	Subtype	IPI
NHL-B1	M	58	3	multiple	DLBL	2
NHL-B2	F	24	4	multiple	DLBL	4
NHL-B3	M	56	4	multiple	DLBL	3
NHL-B4	M	54	2	stomach	DLBL	1
NHL-B5	F	76	4	multiple	DLBL	3
NHL-B6	F	69	4	multiple	Mantle cell L	4
NHL-B7	F	49	1	mandibular area	DLBL	0
NHL-B8	F	64	4	multiple	DLBL	5
NHL-B9	M	44	4	multiple	DLBL	2
NHL-B10	F	70	4	multiple	DLBL	3
NHL-B11	M	25	4	multiple	NK/T cell L	3
NHL-B12	F	48	1	neck, submandibular	DLBL	0
NHL-B13	F	48	1	breast	DLBL	1
NHL-B14	M	48	4	multiple	DLBL	3
NHL-B15	M	67	4	multiple	MZBCL	2

【Table 117】

GC	Sex	Age year	CEA ng/mL	Stage	GC	Sex	Age year	CEA ng/mL	Stage
GC-B1	F	62	8.30	III	GC-B29	F	57	-	II
GC-B2	M	64	-	III	GC-B30	M	78	-	II
GC-B3	M	58	6.89	III	GC-B31	M	75	-	II
GC-B4	M	34	3.57	IV	GC-B32	F	67	-	II
GC-B5	M	69	1.39	IV	GC-B33	M	50	-	II
GC-B6	M	49	1.67	IV	GC-B34	F	60	-	II
GC-B7	F	34	13.44	IV	GC-B35	F	47	-	II
GC-B8	F	47	2.86	III	GC-B36	M	69	-	II
GC-B9	F	40	0.64	IV	GC-B37	M	72	-	II
GC-B10	F	60	1.20	II	GC-B38	F	49	-	II
GC-B11	M	66	11.68	IV	GC-B39	F	55	-	III
GC-B12	M	73	-	II	GC-B40	F	46	-	III

GC-B13	M	53	1.00	III	GC-B41	M	64	-	III
GC-B14	M	51	5.60	IV	GC-B42	M	53	-	III
GC-B15	M	42	0.69	III	GC-B43	M	61	-	III
GC-B16	M	81	-	III	GC-B44	F	81	-	III
GC-B17	M	72	-	II	GC-B45	F	36	-	III
GC-B18	M	66	1.22	IV	GC-B46	M	50	-	IV
GC-B19	F	49	-	II	GC-B47	M	55	-	IV
GC-B20	M	48	-	I	GC-B48	M	66	-	IV
GC-B21	M	51	-	I	GC-B49	F	40	-	IV
GC-B22	M	44	-	I	GC-B50	M	61	-	IV
GC-B23	F	44	-	I	GC-B51	M	70	-	IV
GC-B24	M	61	-	I	GC-B52	M	39	-	IV
GC-B25	M	76	-	I	GC-B53	M	70	-	IV
GC-B26	M	51	-	I	GC-B54	F	71	-	IV
GC-B27	F	40	-	I	GC-B55	F	52	-	IV
GC-B28	M	62		I					

【Table 118】

OVC	Age year	Stage	Histology
OVC-B1	56	IIIc	Clear cell carcinoma
OVC-B2	52	IIa	Endometrioid adenocarcinoma
OVC-B3	63	IV	Papillary serous adenocarcinoma
OVC-B4	55	Ia	Malignant Brenner tumor
OVC-B5	47	IIIc	Papillary serous adenocarcinoma
OVC-B6	50	Ic	Clear cell carcinoma
OVC-B7	68	Ib	Serous adenocarcinoma
OVC-B8	74	IIIc	Papillary serous adenocarcinoma
OVC-B9	43	Ic	Mucinous adenocarcinoma
OVC-B10	44	IIIc	Papillary serous adenocarcinoma
OVC-B11	54	IIIc	Papillary serous adenocarcinoma
OVC-B12	55	IV	Serous adenocarcinoma
OVC-B13	72	IIIc	Serous adenocarcinoma
OVC-B14	58	IIIc	Mucinous adenocarcinoma
OVC-B15	44	IIIc	Papillary serous adenocarcinoma
OVC-B16	57	IV	Serous adenocarcinoma
OVC-B17	54	IIIc	Papillary serous adenocarcinoma
OVC-B18	73	IIIc	Serous adenocarcinoma
OVC-B19	47	IIIc	Papillary serous adenocarcinoma
OVC-B20	40	Ic	Papillary serous adenocarcinoma
OVC-B21	74	IIb	Transitional cell carcinoma
OVC-B22	65	IIIc	Papillary serous adenocarcinoma
OVC-B23	47	IV	Serous adenocarcinoma
OVC-B24	58	IIc	Serous adenocarcinoma

OVC-B25	57	Ib	Mixed cell adenocarcinoma

【Table 119】

TA	Sex	Age year	FOBT	CEA ng/mL
TA-B1	M	70	Negative	2.0
TA-B2	M	58	Negative	2.0
TA-B3	M	52	Negative	0.6
TA-B4	M	48	-[a]	2.6
TA-B5	F	59	Negative	5.8
TA-B6	M	77	Negative	5.1
TA-B7	F	53	Negative	3.2
TA-B8	M	63	Negative	-
TA-B9	F	68	-	-
TA-B10	M	54	Negative	79.4
TA-B11	M	69	-	1.1
TA-B12	M	56	-	0.5
TA-B13	M	53	-	2.0
TA-B14	F	76	Negative	2.7
TA-B15	M	63	Positive	3.2
TA-B16	F	54	Negative	0.7
TA-B17	F	62	-	1.1
TA-B18	F	64	Negative	1.6
TA-B19	F	46	Positive	1.2

(2-2) Sample preparation – preparing serum and measuring mass spectrum

4X volume of methanol/chloroform (2:1, v/v) was mixed with 25$\mu\ell$ serum violently and incubated at room temperature for 10 min. The mixture was centrifuged at 4℃, 10 min, 6000 × g. The supernatant was completely dried for 1 h in the concentrator, and dissolved in the vortexer in 30$\mu\ell$ of 50% acetonitrile/0.1% trifluoroacetic acid (TFA).

Methanol/chloroform extract was mixed with a-cyano-4-hydroxycinnamic acid solution in 50% acetonitrile/0.1% TFA (1:12, v/v), and 1$\mu\ell$ mixture was placed on MALDI-target plate. The mass spectra of the serum extracts from the CRC patients and normal

subjects were measured using the Proteomics Analyzer (Applied Biosystems, Foster City, CA, USA).

The mass spectrum data for one sample is extracted based on the average of spectrum which was repeatedly measured 20 times. The mass region of the entire individual samples was adjusted so that the maximum mass was set at approximately 2500 m/z. To minimize experimental error, various factors including focus mass, laser intensity, target plate, data acquisition time were taken into consideration.

The focus mass and the laser intensity were fixed at preferable levels, i.e., 500 m/z and 5000, respectively. In addition to the fixed focus mass and the laser intensity, the entire samples were repeatedly measured at least five times under viewpoint of other extraction and other data collection. The set A_1, from which weightings per mass ions were computed, was measured one more time.

Accordingly, the low-mass ion detecting means 4000 extracted the low-mass ion mass spectrum from the serum sample via the processes explained above, using the MALDI-TOF.

(2-3) Discrimination strategy

In order for the constructed discriminant to be CRC specific, the discriminant is required to discriminate the CRC patient group from not only the normal control, but also the patient groups with other cancer types. In one embodiment, the patient groups with other cancer types include BRC patients, NHL patients and GC patients. Table 120 provides the result of implementing the conventional PCA-DA to investigate whether one discriminant can discriminate the CRC patient group from the non-CRC group (normal controls, BRC patient group, NHL patient group and GC patient group). To be specific, the specificity of the normal controls is as low as 69.28%. This reveals the fact that one discriminant cannot

discriminate the CRC patient group from all the non-CRC groups.

【Table 120】

						Sensitivity		99.25%
Set A_1	True CRC	True Non-CRC				Specificity	CONT	69.28%
		CONT	BRC	NHL	GC		BRC	97.30%
Predicted CRC	132	47	3	1	0		NHL	97.22%
Predicted Non-CRC	1	106	108	35	29		GC	100.0%

Referring to FIG. 2 and Table 104, considering the superior discrimination result of the CRC patient group from the normal controls, it was also investigated if the CRC patient group was discriminated from the patient groups with other cancer types, and the result is provided by Table 121. Except for the specificity (83.33%) of the NHL patient group which is relatively lower than the other cancer groups, the result is good overall.

【Table 121】

					Sensitivity		99.25%
Set A_1	True CRC	True Non-CRC			Specificity	BRC	99.10%
		BRC	NHL	GC		NHL	83.33%
Predicted CRC	132	1	6	1		GC	96.55%
Predicted Non-CRC	1	110	30	28		Total	95.45%

Accordingly, discriminating the CRC patient group from the non-CRC patient groups may include implementing a first type discriminant to discriminate CRC patient group from

normal controls and a second discriminant to discriminate CRC patient group from the patient groups with other cancer types, in which the CRC patient is determined if both the discriminants indicate CRC, while the non-CRC patient is determined if any of the two discriminants indicates non-CRC patient.

(2-4) Selecting first training set A_0 and computing weightings per mass ions

Although the result of discrimination of Tables 104 and 121 are good, the sensitivity and the specificity are not always 100%. In one embodiment of the present invention, the first training set A_0 with predetermined sensitivity and specificity is selected, and weightings per mass ions of the first training set A_0 were computed, in which the predetermined sensitivity and specificity were both 100%.

A method for selecting the first training set A_0 with the predetermined sensitivity and specificity will be explained below with reference to FIG. 15.

The first DS computing means 4200 aligned and imported the low-mass ion mass spectra of the CRC patient group and the normal control group of set A_1 (D111), normalized the imported peak intensities (D112), Pareto-scaled the normalized peak intensities (D113), and computed DS by performing biostatistical analysis with respect to the Pareto-scaled peak intensities (D114).

Among a variety of biostatistical analyzing methods that can be implemented to compute DS, in one embodiment, the PCA-DA was performed. Sensitivity and specificity were computed based on the DS (D115) and the result is shown in FIG. 2 and Table 104.

Next, sensitivity threshold CN_1 and specificity threshold CN_2 were set (D116), and false positive or false negative cases were excluded when the sensitivity or the specificity was less than the corresponding threshold (D117).

In one embodiment, both the sensitivity threshold CN_1 and the specificity threshold

CN_2 were set to 1, to thus find the first training set A_0 with both the sensitivity and the specificity being 100%. That is, steps D111 to D115 were performed again with respect to the set from which two false positive cases and two false negative cases in Table 104 were excluded. The sensitivity and the specificity did not directly reach 100% when the steps D111 to D115 were repeated with respect to the set excluding the false positive and false negative cases. That is, the first training set A_0 with both the sensitivity and the specificity being 100% was found after the steps D111 to D117 were repeated predetermined number of times (D118).

The first type discriminant to discriminate CRC patient group from the normal controls reached discrimination result with 100% sensitivity and specificity when 8 false negative and 9 false positive cases were excluded, and the second type discriminant reached discrimination result with 100% sensitivity and specificity when 5 false negative and 10 false positive cases (1 BRC, 8 NHL, and 1 GC) were excluded. Through this process, it is possible to derive factor loadings per mass ions which provide discrimination result with both 100% sensitivity and specificity (D119).

The series of the processes explained above may be performed at the factor loading computing means 4300.

(2-5) Implementing a discriminant

The process of implementing the constructed discriminant on the sample of interest will be explained below.

First, MarkerView™ supports the function that can be used for the similar purpose. That is, it is possible to apply the PCA-DA on only the part of the imported sample data, and discriminate the rest samples using the discriminant constructed as a result. According to this function, it is possible to select only the first training set after the import of the first training

set and the other samples for analysis so that only the first training set undergoes the PCA-DA to show how the samples for analysis are interpreted.

Meanwhile, the peak alignment function to align the peaks is performed in the import process of MarkerView™. Because there is no function to align the peaks of the samples of interest based on the first training set, the peak table (matrix of m/z rows and rows of peak intensities per samples) obtained when only the first training set is imported, does not match the first training set of the peak table which is generated when the first training set is imported together with the samples of interest. The peak intensity matrices are difference, and the m/z values corresponding to the same peak intensity column also do not always appear the same. Accordingly, in order to compute DS by implementing the discriminant constructed from the first training set on the samples of interest, a realignment operation to realign the peak table, generated when the first training set is imported together with the samples of interest, to the peak table generated when only the first training set is imported.

The misalignment becomes more serious, if several samples of interests are imported together with the first training set. Accordingly, in one embodiment, with respect to the entire samples of interest, one sample of interest is added to the first training set to be imported, realigned, normalized and Pareto-scaled.

The embodiment will be explained in greater detail below with reference to FIG. 16.

First, the low-mass ion mass spectra of the samples of interest were aligned with the first training set and imported (D211).

Meanwhile, since MarkerView™ in one embodiment does not support the function of aligning and importing the sample of interest to the first training set, as explained above, a program may be designed to realign the peak table generated after importing the low-mass ion mass spectrum of the sample of interest together with the first training set to the peak table which is generated after importing the first training set only, so that the low-mass ion

mess spectrum of the sample of interest aligned with the first training set is extracted. However, it is more preferable that the sample of interest is directly aligned and imported to the first training set without having realigning process and this is implementable by designing a program.

Next, the imported peak intensities were normalized (D212), and the normalized peak intensities were Pareto-scaled (D213).

Next, discriminant score was computed using the Pareto-scaled peak intensities of the low-mass ions and the factor loadings per mass ions acquired by the PCA-DA (D214).

It is determined whether or not the computed DS exceeds a reference CS (D215), and if so, it is interpreted positive (D216), while it is interpreted negative if the computed DS is less than the reference CS (D217). In one embodiment, the reference DS may preferably be 0.

The series of processes explained above may be performed at the second aligning means 4500, the second DS computing means 4600 and a CRC determining means 4700.

The DS was computed by applying factor loadings per mass ions computed at Clause (2-4) with respect to the 8 CRC patient samples and 9 normal control samples which were excluded when constructing the first training set A_{01} from the set A_1 to construct the first type discriminant, and the 5 CRC patient samples, 1 BRC patient sample, 8 NHL patient samples and 1 GC patient sample which were excluded when constructing the first training set A_{02} from the set A_1 to construct the second type discriminant. Considering that the cases were excluded when constructing the first training sets A_{01} and A_{02}, it was expected that the cases would be discriminated to be false positive or false negative, and they were discriminated to be false positive or false negative as expected when the computation was done. The result of discrimination of the set A_1 by applying the factor loadings per mass ions computed at Clause (2-4) is presented in FIGS. 17 and 18, in which FIG. 17 shows the result of the first type

discriminant and FIG. 18 shows the result of the second discriminant.

(2-6) Constructing preliminary discriminant

Conventionally, DS is computed using the entire mass ions that are taken into consideration in the PCA-DA and the CRC patient was determined according to the computed DS. In one embodiment of the present invention, a preliminary discriminant is constructed, which uses only the mass ions that contribute considerably to the DS, in order to derive a discriminant with robust discrimination performance. As used herein, the term "preliminary discriminant" refers to an intermediate form of a discriminant which is obtained before the final discriminant is obtained, and the low-mass ions constructing the discriminant are the "preliminary candidate group" of the CRC-diagnosing low-mass ions to construct the final discriminant.

Through the process of FIG. 17, predetermined mass ions were selected, which give considerable influence on the DS, from among 10,000 mass ions. In one embodiment, 278 mass ions were selected by the first type discriminant, while 383 mass ions were selected by the second discriminant.

As explained above with reference to Table 103, because the maximum number of the peaks under the import condition is set to 10,000 and sufficient samples are imported, the discriminant constructed by the PCA-DA of MarkerView^{TM} consists of 10,000 terms. However, not all the 10,000 terms have the equal importance particularly in distinguishing CRC patients and non-CRC patients. Accordingly, the mass ions that give considerable influence on the DS were selected from among the 10,000 mass ions by two steps according to the process of FIG. 19. This particular step is employed to remove unnecessary mass ions in distinguishing CRC patients from non-CRC patients from the 10,000 mass ions.

The mass ions were preliminarily selected under corresponding case categories, if the

absolute product obtained by multiplying the peak intensities by the factor loadings per mass ions exceeds the threshold CT_1 (D121). In one embodiment, the threshold CT_1 may preferably be 0.1.

Next, the mass ions were again selected from among the preliminarily-selected mass ions under each case category, if the mass ions appear commonly in the cases exceeding the threshold percentage CT_2 (D122). In one embodiment, the threshold percentage CT_2 may preferably be 50. That is, take the first type discriminant for example, only the mass ions that appear commonly in at least 135 cases from among the 269 cases of the first training set were used to construct the preliminary discriminant.

The DS was again computed exclusively with the mass ions that were selected as explained above, and the sensitivity and the specificity were computed accordingly (D123). Again, the sensitivity threshold CN_3 and the specificity threshold CN_4 were set (D124), so that if the sensitivity or the specificity is less than the corresponding threshold, the threshold CT_1 used at step D121 and/or the threshold CT_2 used at step D122 was changed (D125) and the steps from D121 to D124 were repeated. In one embodiment, the sensitivity threshold CN_3 and the specificity threshold CN_4 may preferably be 0.9, respectively.

The preliminary candidate group of the CRC-diagnosing low-mass ions was constructed with the mass ions that were selected as explained above (D126), and in one embodiment, 278 mass ions were selected by the first type discriminant or 383 mass ions were selected by the second type discriminant from among the 10,000 mass ions. Tables 122 and 123 provides the results of discriminating the first training sets A_{01} and A_{02} with the first and second type preliminary discriminants, according to which the discrimination performance including the sensitivity and the specificity was slightly degraded from 100%, but still the result of computing with less than 3~4% of the total mass ions was certainly as good as the result obtained by using the entire mass ions.

Further, FIGS. 20 and 21 provide the result of discriminating the set A_1 with the preliminary discriminant, in which FIG. 20 shows the result by the first type preliminary discriminant and FIG. 21 shows the result by the second type discriminant. Compared to the sharp reduction in the number of mass ions used for the computation, the range of DS was not so influenced. This suggests that not all 10,000 mass ions are necessary to distinguish CRC patients from non-CRC patients.

【Table 122】

				Sensitivity	99.20%
Set A_{01}	True CRC	True CONT		Specificity	97.92%
Predicted CRC	124	3		PPV	97.64%
Predicted CONT	1	141		NPV	99.30%

【Table 123】

Set A_{02}	True CRC	True Non-CRC					
		BRC	NHL	GC		Sensitivity	98.44%
						Specificity	98.19%
Predicted CRC	126	2	1	0		PPV	97.67%
Predicted Non-CRC	2	108	27	28		NPV	98.79%

The series of processes explained above may be performed at the CRC-diagnosing ion selecting means 4400 which includes the candidate ion set selecting means.

(2-7) Constructing a final discriminant

The mass ions were extracted from among the 10,000 mass ions imported in the

process of constructing the preliminary discriminant, as those that contribute considerably to the numerical aspect of the DS. Considering that the selected mass ions include the mass ions that do not generate a problem in the first training set A_0, but can potentially deteriorate the discrimination performance in the discrimination with the mass spectrum that was re-measured with respect to the same CRC patient samples and non-CRC samples or in the discrimination of new CRC patient group and non-CRC patient group, additional step is necessary, which can actively remove the presence of such mass ions. The process of constructing a final discriminant includes such step before finally determining CRC-diagnosing low-mass ions.

To validate robustness of a discriminant, repeated measure experiment was conducted with respect to the set A_1 5 times, and the repeated measure experiment was also performed 5 times with respect to the sets A_2 and B which were independent from the set A_1 and also independent from each other. It is hardly possible to confirm that the repeated measure of the mass spectrum is always conducted under the exactly same conditions in the processes like vaporization using laser beam, desorption, ionization, or the like, in addition to the process of freezing and thawing the serums and mixing the serums with methanol/chloroform to obtain extract, and it is also hard to rule out introduction of disturbances due to various causes. In other words, the DS with respect to the repeatedly-measured individual mass spectrum may have a predetermined deviation, and considering this, interpretation in one embodiment was made by computing an average DS with respect to the sample which was repeatedly measured 5 times.

Table 124 provides the result of discriminating the sets A and B with the discriminant of 10,000 terms as a result of the conventional technology, i.e., PCA-DA by MarkerView™, and Table 125 shows the result of discriminating the sets A and B with the first type preliminary discriminant with 278 terms and the second type preliminary discriminant with

383 terms. Referring to the table, CRC LOME 1 (colorectal cancer low mass ion discriminant equation) refers to the first type discriminant, and CRC LOME 2 refers to the second type discriminant, and the following numbers indicate the number of low-mass ions included in the discriminant. Further, Table 126 shows the discrimination performance with respect to the validation set only, i.e., to the set B, in which the numbers in parenthesis refers to the discrimination performance when TA patient group is included in the CRC patient group. Considering that TA patients have high risk of developing CRC, discriminating the TA patient group is considered to be rather advantageous result for the purpose of early detection of the diagnosis.

【Table 124】

CRC LOME 1-10000						CRC LOME 1-10000							
Set A	True CRC	True Non-CRC				Set B	True CRC	True Non-CRC					
		CONT	BRC	NHL	GC			CONT	BRC	NHL	GC	OVC	TA
Predicted CRC	131	18	26	36	36	Predicted CRC	68	0	7	4	23	6	13
Predicted Non-CRC	146	185	110	15	50	Predicted Non-CRC	75	50	18	11	32	19	6
CRC LOME 2-10000						CRC LOME 2-10000							
Set A	True CRC	True Non-CRC				Set B	True CRC	True Non-CRC					
		CONT	BRC	NHL	GC			CONT	BRC	NHL	GC	OVC	TA
Predicted CRC	109	120	21	3	2	Predicted CRC	43	0	4	0	0	0	9
Predicted Non-CRC	168	83	115	48	84	Predicted Non-CRC	100	50	21	15	55	25	10
CRC LOMEs 1 & 2						CRC LOMEs 1 & 2							
Set A	True CRC	True Non-CRC				Set B	True CRC	True Non-CRC					
		CON	BRC	NHL	GC			CON	BRC	NHL	GC	OVC	TA

		T						T					
Predicted CRC	80	17	3	3	1	Predicted CRC	39	0	1	0	0	0	8
Predicted Non-CRC	197	186	133	48	85	Predicted Non-CRC	104	50	24	15	55	25	11

【Table 125】

CRC LOME 1-278						CRC LOME 1-278							
Set A	True CRC	True Non-CRC				Set B	True CRC	True Non-CRC					
		CONT	BRC	NHL	GC			CONT	BRC	NHL	GC	OVC	TA
Predicted CRC	136	14	26	36	35	Predicted CRC	70	0	5	4	24	7	13
Predicted Non-CRC	141	189	110	15	51	Predicted Non-CRC	73	50	20	11	31	18	6
CRC LOME 2-383						CRC LOME 2-383							
Set A	True CRC	True Non-CRC				Set B	True CRC	True Non-CRC					
		CONT	BRC	NHL	GC			CONT	BRC	NHL	GC	OVC	TA
Predicted CRC	106	121	21	3	4	Predicted CRC	43	0	3	0	0	0	9
Predicted Non-CRC	171	82	115	48	82	Predicted Non-CRC	100	50	22	15	55	25	10
CRC LOMEs 1 & 2						CRC LOMEs 1 & 2							
Set A	True CRC	True Non-CRC				Set B	True CRC	True Non-CRC					
		CONT	BRC	NHL	GC			CONT	BRC	NHL	GC	OVC	TA
Predicted CRC	75	13	3	3	1	Predicted CRC	39	0	1	0	0	0	8
Predicted Non-CRC	202	190	133	48	85	Predicted Non-CRC	104	50	24	15	55	25	11

【Table 126】

Set B	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
CRC LOME 1-10000 & CRC LOME 2-10000	27.27 (29.01)	95.24 (99.41)	81.25 (97.92)	63.38 (59.51)
CRC LOME 1-278 & CRC LOME 2-383	27.27 (29.01)	95.24 (99.41)	81.25 (97.92)	63.38 (59.51)
CRC LOME 1-104 & CRC LOME 2-23	94.41 (93.21)	88.36 (96.47)	85.99 (96.18)	95.43 (93.71)

The discriminant consisting of 10,000 mass ions exhibits perfect discrimination performance with respect to the first training set A_0, but with reference to Table 126, the sensitivity is particularly low with respect to set B. Both the first and second preliminary discriminants exhibited very good discrimination performance (Tables 122, 123) with respect to the first training set A_0, but the discrimination result with respect to set B is far from satisfaction.

Accordingly, in one embodiment of the present invention, steps illustrated in FIG. 22 were performed to improve the preliminary discriminant to more robust discriminant.

First, the mass ions of the preliminary candidate group were divided into high sensitivity set and high specificity set (D131). As used herein, the mass ions of the high sensitivity set have higher sensitivity per mass ions than specificity, while the mass ions of the high specificity set have higher specificity per mass ions than sensitivity.

Next, the mass ions of the high sensitivity set and the mass ions of the high specificity set were sorted in a descending order $\{Sns_1, Sns_2, Sns_3 \ldots Sns_I\}\{Spc_1, Spc_2, Spc_3 \ldots Spc_J\}$ in terms of the sum of the sensitivity and specificity per mass ions, and two top mass ions of the respective sets were taken $\{Sns_1, Sns_2, Spc_1, Spc_2\}$, and a biomarker group was selected with

a combination of the best performance from among 11 combinations that are possibly made with the two or more mass ions of the four mass ions (D132).

The criteria to determine whether a combination has the best performance or not may be selected objectively and universally from among the following criteria which are listed in the order of importance:

Criterion 1) The combination with greater sum of sensitivity and specificity has better performance;

Criterion 2) The combination with less mass ions has better performance; and

Criterion 3) The combination with a greater difference between minimum DS of the true positive case and the maximum DS of true negative case has better performance.

Next, one more mass ion, i.e., the second top mass ion {Sns_3, Spc_3} was additionally taken from each of the high sensitivity set and the high specificity, so that a set with the best performance was re-selected as a biomarker group from among the four sets {biomarker group}, {biomarker group, Sns_3}, {biomarker group, Spc_3}, {biomarker group, Sns_3, Spc_3} which are the combinations of the additionally-taken mass ions {Sns_3, Spc_3} (D133).

The process repeated until the high sensitivity set and the high specificity set had no further mass ion to add (D134).

In other words, the process (D133) repeats as long as both the high sensitivity set and the high specificity set have mass ions to add, and when any of the high sensitivity set and the high specificity set has no further mass ion left to add, the next top mass ion {Sns_i or Spc_j} in the set having mass ions is additionally taken, so that a biomarker group is selected with a set of the best performance among the two sets {biomarker group}, {biomarker group, Sns_i or Spc_j} which are combinations of the additionally-taken mass ion {Sns_i or Spc_j}.

The process repeats as long as the high sensitivity set or the high specificity set is out of the mass ion, and the biomarker group that is selected when there is no mass ion left in the

high sensitivity set and high specificity set becomes the biomarker group 1 (CG) (D135).

The biomarker group 1 (CG) was removed from the preliminary candidate group (D136), the high sensitivity set and the high specificity set were constructed with the remaining mass ions, and the above-explained process repeats. The process repeats until any of the high sensitivity set and the high specificity has less than two mass ions therein (D137).

CK number of biomarker groups were combined with the biomarker groups 1, 2, ... which were obtained by the repeated process explained above, in the order of accuracy, to form a final biomarker group. As used herein, the "accuracy" refers to a proportion of true positive and true negative cases in the entire cases. In one embodiment, CK may preferably be 1, 2, or 3 (D138).

Accordingly, the mass ions of the final biomarker group were determined to be the CRC-diagnosing low-mass ions (D139).

The preliminary candidate group of the mass ions was selected from the set A_1, and more specifically, from the subset A_0, and to avoid overfitting problem, the set A_2 which was independent from the set A_1 was added to enlarge the training set when the final biomarker group was determined from the preliminary candidate group.

As a result of performing the process explained above with respect to the samples to distinguish CRC patient group from the normal controls, 104 mass ions were selected as the first type CRC-diagnosing low-mass ions. Further, as a result of performing the process explained above with respect to the samples to distinguish CRC patient group from the patient group with other cancer types, 23 mass ions were selected as the second type CRC-diagnosing low-mass ions. The masses of the first and second type CRC-diagnosing low-mass ions are listed in Tables 127 and 128. The low-mass ions explained above are referred to as the "first type CRC-diagnosing low-mass ions" and the "second type CRC-diagnosing low-mass ions", and the discriminant according to the present invention which is finally

obtained using the same are referred to as the "first type CRC-diagnosing final discriminant" and the "second type CRC-diagnosing final discriminant", respectively.

【Table 127】

18.0260	190.0849	317.2311	401.0531	508.3407	548.2856	1206.5305
22.9797	191.0848	335.1862	423.0313	510.3265	566.8375	1207.5571
74.0948	191.3324	340.2241	428.1878	512.3119	581.1957	1465.6184
76.0763	195.0785	343.2451	454.2090	513.3177	582.1888	1466.6096
102.0916	212.3195	345.2583	465.3014	518.2931	583.2242	1467.5969
105.1078	231.0667	357.0666	466.1923	518.8555	656.0270	2450.9701
106.0899	235.0053	357.2784	468.1851	519.2967	667.3291	2451.9662
107.0477	256.0939	366.2310	469.2831	519.8598	709.3519	2452.9546
118.0822	266.9557	368.2551	477.1721	525.3449	710.3581	
123.0395	267.9501	369.3302	478.1678	534.2739	711.3617	
137.0423	288.2033	377.0570	480.1715	537.2800	712.3683	
137.0729	291.0997	379.1438	482.3220	538.3306	713.3798	
147.0573	295.0663	379.4765	483.3258	540.2629	991.6196	
147.1058	300.1297	383.0529	496.8683	540.8144	992.6209	
169.0653	301.1269	384.1745	497.7636	542.8457	1016.6113	
181.0656	316.2288	388.2688	503.8719	544.8692	1020.4817	

Referring to Table 127, 1465.6184, 1466.6096, 1467.5969, 2450.9701, 2451.9662, 2452.9546 m/z were characterized into fibrinogen alpha chain and transthyretin.

【Table 128】

60.0476	179.1451	280.2642	332.3224	486.6356	566.8737
138.0540	191.1277	281.1440	333.3324	488.6882	707.3475
172.6653	279.0855	296.2574	369.3406	544.8908	733.3569
173.1158	280.0895	312.3248	465.3161	551.3287	

The series of the processes explained above may be performed at the CRC-diagnosing ion selecting means 4400 which includes the final ion set selecting means.

(2-8) Implementation of the final discriminant & Analysis

The interpretation is available when the first and second type CRC-diagnosing final discriminants using the first and second type CRC-diagnosing low-mass ions are implemented on the set B according to the method of FIG. 16.

The result of interpretation obtained by the final discriminant is shown in FIGS. 23 and 24 and Tables 126 and 129. FIGS. 23 and 24 illustrate the result of interpretation based on the average DS of the DS of five rounds, in which FIG. 23 shows the result of interpretation on set A and FIG. 24 shows the result of interpretation on set B.

【Table 129】

CRC LOME 1-104						CRC LOME 1-104							
Set A	True CRC	True Non-CRC				Set B	True CRC	True Non-CRC					
		CONT	BRC	NHL	GC			CONT	BRC	NHL	GC	OVC	TA
Predicted CRC	258	2	67	44	69	Predicted CRC	141	3	23	10	45	19	17
Predicted Non-CRC	19	201	69	7	17	Predicted Non-CRC	2	47	2	5	10	6	2
CRC LOME 2-23						CRC LOME 2-23							
Set A	True CRC	True Non-CRC				Set B	True CRC	True Non-CRC					
		CONT	BRC	NHL	GC			CONT	BRC	NHL	GC	OVC	TA
Predicted CRC	273	113	0	2	7	Predicted CRC	137	39	1	0	2	2	18
Predicted Non-CRC	4	90	136	49	79	Predicted Non-CRC	6	11	24	15	53	23	1
CRC LOMEs 1 & 2						CRC LOMEs 1 & 2							
Set A	True CRC	True Non-CRC				Set B	True CRC	True Non-CRC					
		CONT	BRC	NHL	GC			CONT	BRC	NHL	GC	OVC	TA

Predicted CRC	254	0	0	2	5	Predicted CRC	135	1	1	0	2	2	16
Predicted Non-CRC	23	203	136	49	81	Predicted Non-CRC	8	49	24	15	53	23	3

The validation set (set B) exhibits all the sensitivity, specificity, positive predictability and negative predictability exceeding 85%. Further, if TA patient group is added into CRC patient group, the discrimination performance exceeds 90% which is quite satisfactory.

Table 130 shows the discrimination performance of the conventional FOBT conducted with respect to the analyte, in comparison with the discrimination performance according to the present invention. Among the validation sets, the FOBT result exhibits 100% of specificity, but low sensitivity at 50% with respect to the 96 CRC patient samples and 49 normal control samples.

The sensitivity is less than 60~85% which is generally accepted sensitivity of the FOBT. That is, in comparison with the discrimination performance of the general conventional FOBT, the present invention provides comparable performance in terms of the specificity, and provides distinguishing result in terms of the sensitivity. Therefore, the present invention provides superior discrimination performance. The similar result is displayed in the training set. Table 131 lists the results of discrimination by FOBT and the present invention with respect to both the training set and the validation set.

【Table 130】

Set B	CRC LOME 1-104		CRC LOME 1-104 & CRC LOME 2-23		FOBT				
	True CRC	True CONT	True CRC	True CONT	True CRC	True CONT			
Predicted CRC	94	3	91	1	48	0			

Predicted Non-CRC	2	46	5	48	48	49			
Set B	Sensitivity (%)		Specificity (%)		PPV (%)			NPV (%)	
CRC LOME 1-104	97.92		93.88		96.91			95.83	
CRC LOME 1-104 & CRC LOME 2-23	94.79		97.96		98.91			90.57	
FOBT	50.00		100.0		100.0			50.52	

【Table 131】

Control	FOBT	Prediction		Control	FOBT	Prediction	
CRC-B61	Positive	CRC CRC LOME 1-104	CRC CRC LOME 1-104 & CRC LOME 2-23	CRC-B133	-	CRC CRC LOME 1-104	CRC CRC LOME 1-104 & CRC LOME 2-23
CRC-A68	Negative	CRC	CRC	CRC-A207	Positive	CRC	CRC
CONT-A1	-	Non-CRC	Non-CRC	CONT-A103	Negative	Non-CRC	Non-CRC
CRC-B62	Positive	CRC	CRC	CRC-B134	Positive	CRC	CRC
CONT-A2	Negative	Non-CRC	Non-CRC	CONT-A104	-	Non-CRC	Non-CRC
CRC-A69	Positive	CRC	CRC	CRC-A208	Negative	CRC	CRC
CONT-A3	Negative	Non-CRC	Non-CRC	CONT-A105	Negative	Non-CRC	Non-CRC
CRC-B63	Negative	CRC	CRC	CRC-B135	-	CRC	CRC

CONT-A4	Negative	Non-CRC	Non-CRC	CONT-A106	-	Non-CRC	Non-CRC
CRC-A70	Positive	CRC	CRC	CRC-A209	-	CRC	CRC
CONT-A5	Negative	Non-CRC	Non-CRC	CONT-A107	Negative	Non-CRC	Non-CRC
CRC-B64	Negative	CRC	CRC	CRC-B136	-	CRC	CRC
CONT-A6	Negative	Non-CRC	Non-CRC	CONT-A108	Negative	Non-CRC	Non-CRC
CRC-A71	Positive	CRC	CRC	CRC-A210	Negative	CRC	CRC
CONT-A7	Negative	Non-CRC	Non-CRC	CONT-A109	Negative	Non-CRC	Non-CRC
CRC-B65	Negative	CRC	CRC	CRC-B137	Positive	CRC	CRC
CONT-A8	Negative	Non-CRC	Non-CRC	CONT-A110	Negative	Non-CRC	Non-CRC
CRC-A72	Positive	Non-CRC	Non-CRC	CRC-A211	-	CRC	CRC
CONT-A9	Negative	Non-CRC	Non-CRC	CONT-A111	Negative	Non-CRC	Non-CRC
CRC-B66	Positive	CRC	CRC	CRC-B138	Positive	CRC	CRC
CONT-A10	Negative	Non-CRC	Non-CRC	CONT-A112	Negative	Non-CRC	Non-CRC
CRC-A73	-	CRC	CRC	CRC-A212	-	CRC	CRC
CONT-A11	Negative	Non-CRC	Non-CRC	CONT-A113	Negative	Non-CRC	Non-CRC
CRC-B67	Negative	CRC	CRC	CRC-B139	Positive	CRC	CRC

CONT-A12	Negative	Non-CRC	Non-CRC	CONT-A114	Negative	Non-CRC	Non-CRC
CRC-A74	-	CRC	CRC	CRC-A213	-	CRC	CRC
CONT-A13	Negative	Non-CRC	Non-CRC	CONT-A115	Negative	Non-CRC	Non-CRC
CRC-B68	Negative	CRC	CRC	CRC-B140	-	CRC	CRC
CONT-A14	Negative	Non-CRC	Non-CRC	CONT-A116	Negative	Non-CRC	Non-CRC
CRC-A75	-	Non-CRC	Non-CRC	CRC-A214	-	CRC	CRC
CONT-A15	Negative	Non-CRC	Non-CRC	CONT-A117	Negative	Non-CRC	Non-CRC
CRC-B69	-	CRC	CRC	CRC-B141	Negative	CRC	CRC
CONT-A16	Negative	Non-CRC	Non-CRC	CONT-A118	Negative	Non-CRC	Non-CRC
CRC-A76	Positive	CRC	CRC	CRC-A215	Negative	CRC	CRC
CONT-A17	Negative	Non-CRC	Non-CRC	CONT-A119	Negative	Non-CRC	Non-CRC
CRC-B70	Positive	CRC	CRC	CRC-B142	Positive	CRC	CRC
CONT-A18	Negative	Non-CRC	Non-CRC	CONT-A120	-	Non-CRC	Non-CRC
CRC-A77	-	CRC	CRC	CRC-A216	Positive	CRC	CRC
CONT-A19	-	Non-CRC	Non-CRC	CONT-A121	-	Non-CRC	Non-CRC
CRC-B71	-	CRC	CRC	CRC-B143	-	CRC	CRC

CONT-A20	Negative	Non-CRC	Non-CRC	CONT-A122	Negative	Non-CRC	Non-CRC
CRC-A78	Positive	CRC	CRC	CRC-A217	-	CRC	CRC
CONT-A21	Negative	Non-CRC	Non-CRC	CONT-A123	Negative	Non-CRC	Non-CRC
CRC-B72	Negative	CRC	CRC				
CONT-A22	Negative	Non-CRC	Non-CRC	CONT-A124	Negative	Non-CRC	Non-CRC
CRC-A79	Positive	Non-CRC	Non-CRC	CRC-A218	-	CRC	CRC
CONT-A23	Negative	Non-CRC	Non-CRC	CONT-A125	Negative	Non-CRC	Non-CRC
CONT-A24	Negative	Non-CRC	Non-CRC	CONT-A126	Negative	Non-CRC	Non-CRC
CRC-A80	Positive	CRC	CRC	CRC-A219	Negative	CRC	CRC
CONT-A25	Negative	Non-CRC	Non-CRC	CONT-A127	Negative	Non-CRC	Non-CRC
CONT-A26	Negative	Non-CRC	Non-CRC	CONT-A128	Negative	Non-CRC	Non-CRC
CRC-A81	Positive	Non-CRC	Non-CRC	CRC-A220	-	CRC	CRC
CONT-A27	Negative	Non-CRC	Non-CRC	CONT-A129	Negative	Non-CRC	Non-CRC
CONT-A28	Negative	Non-CRC	Non-CRC	CONT-A130	-	Non-CRC	Non-CRC
CRC-A82	-	CRC	CRC	CRC-A221	-	CRC	CRC
CONT-A29	Negative	Non-CRC	Non-CRC	CONT-A131	Negative	Non-CRC	Non-CRC
CONT-A30	Negative	Non-CRC	Non-CRC	CONT-A132	Negative	Non-CRC	Non-CRC
CONT-A31	Negative	Non-CRC	Non-CRC	CONT-A133	Negative	Non-CRC	Non-CRC
CRC-A83	Positive	CRC	CRC	CRC-	Negative	CRC	CRC

				A222			
CONT-A32	Negative	Non-CRC	Non-CRC	CONT-A134	-	Non-CRC	Non-CRC
CONT-A33	Negative	Non-CRC	Non-CRC	CONT-A135	-	Non-CRC	Non-CRC
CRC-A84	Positive	CRC	CRC	CRC-A223	-	CRC	CRC
CONT-A34	Negative	Non-CRC	Non-CRC	CONT-A136	Negative	Non-CRC	Non-CRC
CONT-A35	Negative	Non-CRC	Non-CRC	CONT-A137	Negative	Non-CRC	Non-CRC
CRC-A85	Positive	CRC	CRC	CRC-A224	Negative	CRC	CRC
CONT-A36	Negative	Non-CRC	Non-CRC	CONT-A138	Negative	Non-CRC	Non-CRC
CONT-A37	Negative	Non-CRC	Non-CRC	CONT-A139	Negative	Non-CRC	Non-CRC
CRC-A86	Positive	CRC	CRC	CRC-A225	-	CRC	CRC
CONT-A38	Negative	Non-CRC	Non-CRC	CONT-A140	Negative	Non-CRC	Non-CRC
CONT-A39	Negative	Non-CRC	Non-CRC	CONT-A141	Negative	Non-CRC	Non-CRC
CRC-A87	-	CRC	CRC	CRC-A226	-	CRC	CRC
CONT-A40	-	Non-CRC	Non-CRC	CONT-A142	Negative	Non-CRC	Non-CRC
CONT-A41	Negative	Non-CRC	Non-CRC	CONT-A143	Negative	Non-CRC	Non-CRC
CRC-A88	Negative	CRC	CRC	CRC-A227	-	CRC	CRC
CONT-A42	Negative	Non-CRC	Non-CRC	CONT-A144	Negative	Non-CRC	Non-CRC
CONT-A43	Negative	Non-CRC	Non-CRC	CONT-A145	Negative	Non-CRC	Non-CRC
CRC-A89	-	CRC	CRC	CRC-	-	CRC	CRC

				A228			
CONT-A44	-	Non-CRC	Non-CRC	CONT-A146	-	Non-CRC	Non-CRC
CONT-A45	Negative	Non-CRC	Non-CRC	CONT-A147	-	Non-CRC	Non-CRC
CRC-A90	Positive	CRC	CRC	CRC-A229	Positive	CRC	CRC
CONT-A46	Negative	Non-CRC	Non-CRC	CONT-A148	Negative	Non-CRC	Non-CRC
CONT-A47	Negative	Non-CRC	Non-CRC	CONT-A149	-	Non-CRC	Non-CRC
CRC-A91	Negative	CRC	CRC	CRC-A230	Negative	CRC	CRC
CONT-A48	Negative	Non-CRC	Non-CRC	CONT-A150	Negative	Non-CRC	Non-CRC
CONT-A49	Negative	Non-CRC	Non-CRC	CONT-A151	Negative	Non-CRC	Non-CRC
CRC-A92	Positive	CRC	CRC	CRC-A231	Negative	CRC	CRC
CONT-A50	Negative	Non-CRC	Non-CRC	CONT-A152	Negative	Non-CRC	Non-CRC
CONT-A51	Negative	Non-CRC	Non-CRC	CONT-A153	-	Non-CRC	Non-CRC
CRC-A93	Negative	CRC	CRC	CRC-A232	-	CRC	CRC
CONT-A52	Negative	Non-CRC	Non-CRC	CONT-A154	Negative	Non-CRC	Non-CRC
CONT-A53	Negative	Non-CRC	Non-CRC	CONT-A155	Negative	Non-CRC	Non-CRC
CRC-A94	-	CRC	CRC	CRC-A233	Positive	CRC	CRC
CONT-A54	Negative	Non-CRC	Non-CRC	CONT-A156	Negative	Non-CRC	Non-CRC
CONT-A55	Negative	Non-CRC	Non-CRC	CONT-A157	Positive	Non-CRC	Non-CRC
CRC-A95	-	CRC	CRC	CRC-	Positive	CRC	CRC

				A234			
CONT-A56	Negative	Non-CRC	Non-CRC	CONT-A158	Negative	Non-CRC	Non-CRC
CONT-A57	Negative	Non-CRC	Non-CRC	CONT-A159	Negative	Non-CRC	Non-CRC
CRC-A96	Positive	CRC	CRC	CRC-A235	-	CRC	CRC
CONT-A58	Negative	Non-CRC	Non-CRC	CONT-A160	Negative	Non-CRC	Non-CRC
CONT-A59	Negative	Non-CRC	Non-CRC	CONT-A161	Negative	Non-CRC	Non-CRC
CRC-A97	Positive	CRC	CRC	CRC-A236	Positive	CRC	CRC
CONT-A60	Negative	Non-CRC	Non-CRC	CONT-A162	Negative	Non-CRC	Non-CRC
CONT-A61	Negative	Non-CRC	Non-CRC	CONT-A163	Negative	Non-CRC	Non-CRC
CRC-A98	Positive	CRC	CRC	CRC-A237	Positive	CRC	CRC
CONT-A62	Negative	Non-CRC	Non-CRC	CONT-A164	-	Non-CRC	Non-CRC
CONT-A63	Negative	Non-CRC	Non-CRC	CONT-A165	Negative	Non-CRC	Non-CRC
CRC-A99	Positive	CRC	CRC	CRC-A238	Negative	CRC	CRC
CONT-A64	Negative	Non-CRC	Non-CRC	CONT-A166	Negative	Non-CRC	Non-CRC
CONT-A65	Negative	Non-CRC	Non-CRC	CONT-A167	Negative	Non-CRC	Non-CRC
CRC-A100	Negative	CRC	CRC	CRC-A239	Negative	Non-CRC	Non-CRC
CONT-A66	Negative	Non-CRC	Non-CRC	CONT-A168	Negative	Non-CRC	Non-CRC
CONT-A67	Negative	Non-CRC	Non-CRC	CONT-A169	Negative	Non-CRC	Non-CRC
CRC-A101	-	Non-CRC	Non-CRC	CRC-	Negative	CRC	CRC

				A240			
CONT-A68	Negative	Non-CRC	Non-CRC	CONT-A170	Negative	Non-CRC	Non-CRC
CONT-A69	Negative	Non-CRC	Non-CRC	CONT-A171	Negative	Non-CRC	Non-CRC
CRC-A102	Negative	CRC	CRC	CRC-A241	Negative	CRC	CRC
CONT-A70	Negative	Non-CRC	Non-CRC	CONT-A172	Negative	Non-CRC	Non-CRC
CONT-A71	Negative	Non-CRC	Non-CRC	CONT-A173	Negative	Non-CRC	Non-CRC
CRC-A103	Positive	CRC	CRC	CRC-A242	-	CRC	CRC
CONT-A72	Negative	Non-CRC	Non-CRC	CONT-A174	Negative	Non-CRC	Non-CRC
CONT-A73	Negative	Non-CRC	Non-CRC	CONT-A175	Negative	Non-CRC	Non-CRC
CRC-A104	Positive	CRC	CRC	CRC-A243	-	CRC	CRC
CONT-A74	Negative	Non-CRC	Non-CRC	CONT-A176	-	Non-CRC	Non-CRC
CONT-A75	Negative	Non-CRC	Non-CRC	CONT-A177	Negative	Non-CRC	Non-CRC
CRC-A105	Positive	CRC	CRC	CRC-A244	Positive	CRC	Non-CRC
CONT-A76	Negative	Non-CRC	Non-CRC	CONT-A178	Negative	Non-CRC	Non-CRC
CONT-A77	Negative	Non-CRC	Non-CRC	CONT-A179	Negative	Non-CRC	Non-CRC
CRC-A106	Negative	CRC	CRC	CRC-A245	-	CRC	CRC
CONT-A78	Negative	Non-CRC	Non-CRC	CONT-A180	Negative	Non-CRC	Non-CRC
CONT-A79	Negative	Non-CRC	Non-CRC	CONT-A181	Negative	Non-CRC	Non-CRC
CRC-A107	Positive	CRC	CRC	CRC-	-	CRC	CRC

				A246			
CONT-A80	Negative	Non-CRC	Non-CRC	CONT-A182	Negative	Non-CRC	Non-CRC
CONT-A81	Negative	Non-CRC	Non-CRC	CONT-A183	Negative	Non-CRC	Non-CRC
CRC-A108	Positive	CRC	CRC	CRC-A247	Negative	CRC	CRC
CONT-A82	Negative	Non-CRC	Non-CRC	CONT-A184	Negative	Non-CRC	Non-CRC
CONT-A83	Negative	CRC	Non-CRC	CONT-A185	Negative	Non-CRC	Non-CRC
CRC-A109	Positive	CRC	CRC	CRC-A248	-	Non-CRC	Non-CRC
CONT-A84	Negative	Non-CRC	Non-CRC	CONT-A186	Negative	Non-CRC	Non-CRC
CONT-A85	Negative	Non-CRC	Non-CRC	CONT-A187	Negative	Non-CRC	Non-CRC
CRC-A110	Positive	CRC	CRC	CRC-A249	-	CRC	CRC
CONT-A86	Negative	Non-CRC	Non-CRC	CONT-A188	-	Non-CRC	Non-CRC
CONT-A87	Negative	Non-CRC	Non-CRC	CONT-A189	Negative	Non-CRC	Non-CRC
CRC-A111	Positive	CRC	CRC	CRC-A250	Negative	CRC	CRC
CONT-A88	Negative	Non-CRC	Non-CRC	CONT-A190	Negative	Non-CRC	Non-CRC
CONT-A89	Negative	Non-CRC	Non-CRC	CONT-A191	Negative	Non-CRC	Non-CRC
CRC-A112	-	CRC	CRC	CRC-A251	Positive	CRC	CRC
CONT-A90	Negative	Non-CRC	Non-CRC	CONT-A192	Negative	Non-CRC	Non-CRC
CONT-A91	Negative	Non-CRC	Non-CRC	CONT-A193	Negative	Non-CRC	Non-CRC
CRC-A113	Positive	CRC	CRC	CRC-	Negative	CRC	CRC

				A252			
CONT-A92	Negative	Non-CRC	Non-CRC	CONT-A194	Negative	Non-CRC	Non-CRC
CONT-A93	Negative	Non-CRC	Non-CRC	CONT-A195	Negative	Non-CRC	Non-CRC
CRC-A114	-	CRC	CRC	CRC-A253	Positive	CRC	CRC
CONT-A94	Negative	Non-CRC	Non-CRC	CONT-A196	Negative	Non-CRC	Non-CRC
CONT-A95	-	Non-CRC	Non-CRC	CONT-A197	Negative	Non-CRC	Non-CRC
CRC-A115	Positive	CRC	CRC	CRC-A254	Positive	CRC	CRC
CONT-A96	Negative	Non-CRC	Non-CRC	CONT-A198	Negative	Non-CRC	Non-CRC
CONT-A97	Negative	Non-CRC	Non-CRC	CONT-A199	Negative	Non-CRC	Non-CRC
CRC-A116	-	CRC	CRC	CRC-A255	Negative	Non-CRC	Non-CRC
CONT-A98	Negative	Non-CRC	Non-CRC	CONT-A200	Negative	Non-CRC	Non-CRC
CONT-A99	Negative	Non-CRC	Non-CRC	CONT-A201	Negative	CRC	Non-CRC
CRC-A117	Positive	CRC	CRC	CRC-A256	Negative	Non-CRC	Non-CRC
CONT-A100	Negative	Non-CRC	Non-CRC	CONT-A202	Negative	Non-CRC	Non-CRC
CONT-A101	Negative	Non-CRC	Non-CRC	CONT-A203	Negative	Non-CRC	Non-CRC
CRC-A118	Positive	CRC	CRC	CRC-A257	Negative	CRC	CRC
CONT-A102	Negative	Non-CRC	Non-CRC				
CONT-B1	Negative	Non-CRC	Non-CRC	CONT-B26	Negative	Non-CRC	Non-CRC
CRC-	Negative	CRC	CRC	CRC	Positive	CRC	CRC

A119				- A258			
CONT-B2	Negative	Non-CRC	Non-CRC	CONT-B27	Negative	Non-CRC	Non-CRC
CONT-B3	Negative	Non-CRC	Non-CRC	CONT-B28	Negative	Non-CRC	Non-CRC
CONT-B4	Negative	Non-CRC	Non-CRC	CONT-B29	Negative	Non-CRC	Non-CRC
CONT-B5	Negative	Non-CRC	Non-CRC	CONT-B30	Negative	Non-CRC	Non-CRC
CRC-A120	-	CRC	CRC	CRC-A259	Positive	CRC	CRC
CONT-B6	Negative	Non-CRC	Non-CRC	CONT-B31	Negative	Non-CRC	Non-CRC
CONT-B7	Negative	Non-CRC	Non-CRC	CONT-B32	-	Non-CRC	Non-CRC
CONT-B8	Negative	Non-CRC	Non-CRC	CONT-B33	Negative	CRC	CRC
CONT-B9	Negative	Non-CRC	Non-CRC	CONT-B34	Negative	CRC	Non-CRC
CONT-B10	Negative	Non-CRC	Non-CRC	CONT-B35	Negative	Non-CRC	Non-CRC
CRC-A121	-	CRC	CRC	CRC-A260	-	CRC	CRC
CONT-B11	Negative	Non-CRC	Non-CRC	CONT-B36	Negative	Non-CRC	Non-CRC
CONT-B12	Negative	Non-CRC	Non-CRC	CONT-B37	Negative	Non-CRC	Non-CRC
CONT-B13	Negative	Non-CRC	Non-CRC	CONT-B38	Negative	Non-CRC	Non-CRC
CONT-B14	Negative	Non-CRC	Non-CRC	CONT-B39	Negative	Non-CRC	Non-CRC
CRC-A122	Positive	CRC	Non-CRC	CRC-A261	Negative	Non-CRC	Non-CRC
CONT-B15	Negative	Non-CRC	Non-CRC	CONT-B40	Negative	Non-CRC	Non-CRC
CONT-B16	Negative	Non-CRC	Non-CRC	CONT-B41	Negative	Non-CRC	Non-CRC
CONT-B17	Negative	Non-CRC	Non-CRC	CONT-B42	Negative	Non-CRC	Non-CRC
CONT-	Negative	Non-CRC	Non-CRC	CONT-	Negative	Non-CRC	Non-CRC

B18				B43			
CRC-A123	Positive	CRC	CRC	CRC-A262	Negative	Non-CRC	Non-CRC
CONT-B19	Negative	Non-CRC	Non-CRC	CONT-B44	Negative	Non-CRC	Non-CRC
CONT-B20	Negative	Non-CRC	Non-CRC	CONT-B45	Negative	Non-CRC	Non-CRC
CONT-B21	Negative	Non-CRC	Non-CRC	CONT-B46	Negative	Non-CRC	Non-CRC
CONT-B22	Negative	Non-CRC	Non-CRC	CONT-B47	Negative	Non-CRC	Non-CRC
CRC-A124	Positive	CRC	CRC	CRC-A263	Negative	Non-CRC	Non-CRC
CONT-B23	Negative	CRC	Non-CRC	CONT-B48	Negative	Non-CRC	Non-CRC
CONT-B24	Negative	Non-CRC	Non-CRC	CONT-B49	Negative	Non-CRC	Non-CRC
CONT-B25	Negative	Non-CRC	Non-CRC	CONT-B50	Negative	Non-CRC	Non-CRC
CRC-A125	Positive	CRC	CRC	CRC-A264	Positive	CRC	CRC
CRC	FOBT	Prediction		CRC	FOBT	Prediction	
		CRC LOME 1-104	CRC LOME 1-104 & CRC LOME 2-23			CRC LOME 1-104	CRC LOME 1-104 & CRC LOME 2-23
CRC-A126	Negative	CRC	CRC	CRC-A265	Positive	CRC	CRC
CRC-A1	Negative	CRC	CRC	CRC-A140	-	CRC	CRC
CRC-A127	Positive	Non-CRC	Non-CRC	CRC-A266	Positive	CRC	CRC
CRC-A2	-	CRC	CRC	CRC-A141	Positive	CRC	CRC

CRC-A128	Positive	CRC	CRC	CRC-A267	-	CRC	CRC
CRC-A3	Negative	CRC	CRC	CRC-A142	Negative	CRC	CRC
CRC-A129	-	CRC	CRC	CRC-A268	Positive	CRC	CRC
CRC-A4	Negative	CRC	CRC	CRC-A143	-	CRC	CRC

To investigate the reproductibility of the discrimination result according to the present invention, the same process was repeated with respect to some of the validation sets, i.e., 13 normal controls, 35 CRC patients, 7 BRC patients, 14 GCpatients, 7 OVC patients, and 5 TA patients and the result is shown in Table 132. TA patient group has most reversal of the interpretation. The clinical category of Tis of TA is sometimes confusing between cancer and non-cancer, and the discrimination result according to the present invention reflect such confusion. Except for the TA patent group, reproducibility exceeds 90% which is indicative of good discrimination performance of the present invention.

【Table 132】

	Prediction after 1st 5 times repeated Low mass ion measurements	Prediction after 2nd 5 times repeated Low mass ion measurements		Prediction after 1st 5 times repeated Low mass ion measurements	Prediction after 2nd 5 times repeated Low mass ion measurements
	CRC LOME 1-104 & CRC LOME 2-23	CRC LOME 1-104 & CRC LOME 2-23		CRC LOME 1-104 & CRC LOME 2-23	CRC LOME 1-104 & CRC LOME 2-23
CONT-B1	Non-CRC	Non-CRC	CRC-B1	CRC	CRC

CONT-B5	Non-CRC	Non-CRC	CRC-B2	CRC	CRC
CONT-B9	Non-CRC	Non-CRC	CRC-B3	CRC	CRC
CONT-B13	Non-CRC	Non-CRC	CRC-B4	CRC	CRC
CONT-B17	Non-CRC	Non-CRC	CRC-B5	Non-CRC	Non-CRC
CONT-B21	Non-CRC	Non-CRC	CRC-B7	Non-CRC	CRC
CONT-B26	Non-CRC	Non-CRC	CRC-B8	CRC	CRC
CONT-B29	Non-CRC	Non-CRC	CRC-B9	CRC	CRC
CONT-B33	CRC	Non-CRC	CRC-B10	Non-CRC	CRC
CONT-B36	Non-CRC	Non-CRC	CRC-B11	CRC	CRC
CONT-B41	Non-CRC	Non-CRC	CRC-B12	CRC	CRC
CONT-B47	Non-CRC	Non-CRC	CRC-B13	CRC	CRC
CONT-B49	Non-CRC	Non-CRC	CRC-B15	CRC	CRC
BRC-B1	Non-CRC	Non-CRC	CRC-B16	CRC	CRC
BRC-B5	Non-CRC	Non-CRC	CRC-B18	CRC	CRC
BRC-B9	Non-CRC	Non-CRC	CRC-B19	Non-CRC	CRC
BRC-B13	Non-CRC	Non-CRC	CRC-B20	CRC	CRC
BRC-B17	Non-CRC	Non-CRC	CRC-B22	CRC	CRC
BRC-B21	Non-CRC	Non-CRC	CRC-B24	CRC	CRC
BRC-B25	Non-CRC	Non-CRC	CRC-B25	CRC	CRC
GC-B1	Non-CRC	Non-CRC	CRC-B26	CRC	CRC
GC-B5	Non-CRC	Non-CRC	CRC-B28	CRC	CRC
GC-B9	Non-CRC	Non-CRC	CRC-B29	CRC	CRC
GC-B13	Non-CRC	Non-CRC	CRC-B32	CRC	CRC
GC-B17	Non-CRC	Non-CRC	CRC-B33	CRC	CRC
GC-B21	Non-CRC	Non-CRC	CRC-B34	CRC	CRC
GC-B25	CRC	Non-CRC	CRC-B35	CRC	Non-CRC
GC-B29	Non-CRC	Non-CRC	CRC-B36	CRC	CRC
GC-B33	Non-CRC	Non-CRC	CRC-B37	CRC	CRC
GC-B37	Non-CRC	Non-CRC	CRC-B38	Non-CRC	Non-CRC
GC-B41	Non-CRC	Non-CRC	CRC-B39	CRC	CRC
GC-B45	Non-CRC	Non-CRC	CRC-B40	CRC	CRC
GC-B49	Non-CRC	Non-CRC	CRC-B41	Non-CRC	CRC
GC-B53	Non-CRC	Non-CRC	CRC-B42	CRC	CRC
OVC-B1	Non-CRC	Non-CRC	CRC-B43	CRC	CRC
OVC-B5	Non-CRC	Non-CRC	TA-B1	CRC	Non-CRC
OVC-B9	CRC	CRC	TA-B5	CRC	Non-CRC
OVC-B13	Non-CRC	Non-CRC	TA-B8	CRC	Non-CRC
OVC-B17	Non-CRC	Non-CRC	TA-B14	CRC	Non-CRC

OVC-B21	Non-CRC	Non-CRC	TA-B18	Non-CRC	Non-CRC
OVC-B25	Non-CRC	Non-CRC	Reproducibility 90.79% (86.42%, when TA was included)		

FIGS. 25a and 25b present the result of characterizing 1465.6184 m/z and 2450.9701 m/z among the first type CRC-diagnosing low-mass ions. The two low-mass ions both exhibit the same material mass peak group which has a mass difference of approximately 1 m/z depending on the number of constituent isotopes. This is typical mass peaks of protein or peptide appearing in the mass spectrometer.

The left-upper sides of FIGS. 25a and 25b represent mass spectra of the two low-mass ions. The spectrum in red represents peak intensity of the CRC patient group serum extract, and the spectrum in blue represents the peak intensity of the normal control. 1465.6184 m/z shows higher peak intensity in CRC patient group, while, on the contrary, 2450.9701 m/z shows lower peak intensity in the CRC patient group. The right-upper parts of FIGS. 25a and 25b represent MS/MS spectra of the two low-mass ions, and the table of FIGS. 25a and 25b and left-lower parts thereof show that 1465.6184 m/z and 2450.9701 m/z ion materials are characterized by the MS/MS analysis into fibrinogen alpha chain and transthyretin, respectively.

Corresponding to the qualitative result that indicates higher peak intensity of the low-mass ion 1465.6184 m/z corresponding to the fibrinogen alpha chain in the CRC patient group, the quantitative measure indicates that the level of fibrinogen in blood of the CRC patient is higher than the normal counter part, and higher according to the progress of the stage (Table 133).

【Table 133】

	Number	Plasma fibrinogen level (mg/dL),	p-value

		mean ± standard deviation	
Healthy control	37	274.51 ± 93.22	<0.001
Colorectal adenoma	29	279.59 ± 58.03	1.000
Stage I CRC	148	298.93 ± 69.40	0.685
Stage II CRC	340	351.14 ± 96.65	<0.001
Stage III CRC	507	345.19 ± 95.25	<0.001
Stage IV CRC	57	365.33 ± 91.37	<0.001

On the contrary, corresponding to the qualitative result that indicates lower peak intensity of the low-mass ion 2450.9701 m/z corresponding to transthyretin in the CRC patient group, the quantitative measure indicates that the level of transthyretin in blood of the CRC patient is lower than that of the normal counterpart (Table 134). To summarize in the form of average ± standard deviation, the CRC patient group has 160.39 ± 62.41 ng/mL, and the normal control indicates 171.19 ± 30.86 ng/mL.

【Table 134】

	Level of Transthyretin (ng/mL)		Level of Transthyretin (ng/mL)
CRC-A134	194.4053871	CRC-B25	163.7544561
CRC-A135	160.3388216	CRC-B26	103.763308
CRC-A137	45.31734887	CRC-B27	272.5678515
CRC-A139	154.2433081	CRC-B28	146.0108407
CRC-A140	201.5848401	CRC-B29	157.6719758
CRC-A141	181.6259276	CRC-B30	34.24514756
CRC-A142	181.8730938	CRC-B32	209.2664543
CRC-A143	209.4562651	CRC-B33	14.23188743
CRC-A144	204.9015183	CRC-B34	170.7668514
CRC-A145	204.8086556	CRC-B35	240.8403292
CRC-A146	151.7466189	CRC-B46	314.1906603
CRC-A147	155.5422654	CRC-B47	24.56925637
CRC-A148	241.4415416	CRC-B48	201.2652628
CRC-A149	232.1575272	CONT-B2	131.7631966
CRC-A150	178.8075456	CONT-B3	185.5791386
CRC-A151	150.5475887	CONT-B4	118.2875787
CRC-A152	150.3770739	CONT-B5	134.204582
CRC-A153	140.3009368	CONT-B6	122.8785828
CRC-A154	146.5080959	CONT-B7	163.1616804
CRC-A155	20.11742957	CONT-B8	155.4717726
CRC-A156	148.9523525	CONT-B9	234.9631822

CRC-B2	107.8883621	CONT-B10	162.5710506
CRC-B4	176.2724527	CONT-B11	162.7922858
CRC-B5	39.91544623	CONT-B12	159.0358497
CRC-B6	156.5325266	CONT-B14	251.1537438
CRC-B7	199.4036008	CONT-B15	160.8484111
CRC-B10	145.7793662	CONT-B16	157.2437136
CRC-B11	181.4202125	CONT-B18	187.9070482
CRC-B12	158.8557207	CONT-B19	158.4960747
CRC-B13	176.0328979	CONT-B20	184.9911989
CRC-B14	209.6462481	CONT-B22	177.2741119
CRC-B16	142.1897289	CONT-B23	151.5403947
CRC-B18	224.0415149	CONT-B24	203.7437549
CRC-B19	212.08369	CONT-B27	179.7828571
CRC-B20	179.8236103	CONT-B32	199.8560708
CRC-B21	154.8387737	CONT-B34	185.7895696
CRC-B22	156.8521618	CONT-B35	163.8658411
CRC-B23	89.36660383	CONT-B48	158.9637736
CRC-B24	120.9443976	CONT-B50	198.7268159

According to the present invention, it is possible to interpret the low-mass ion mass spectrum of the serum as CRC patient and non-CRC patent with high level of discrimination performance.

3. Example of an apparatus for screening breast cancer (BRC)

FIG. 26 is a detailed block diagram of the cancer diagnosing unit of FIG. 7 to diagnose BRC according to an embodiment of the present invention.

Referring to FIG. 26, the cancer diagnosing unit according to one embodiment may include a first aligning means 5100 which aligns a low-mass ion mass spectrum of a candidate training set consisting of the BRC patient and non-BRC cases; a first DS computing means 5200 which computes DS by conducting biostatistical analysis with respect to the aligned mass spectrum; a factor loading computing means 5300 which computes sensitivity and specificity according to DS and selects a first training set based on the computed result, and computes factor loadings per low-mass ions; a BRC diagnosing ion

selecting means 5400 which selects low-mass ions for the purpose of diagnosing BRC in terms of the discrimination performance from among the candidate low-mass ions that meet candidate condition; a second aligning means which aligns the low-mass ion mass spectrum of a biological sample of interest to the first training set; a second DS computing means 5600 which computes DS based on peak intensities of the low-mass ions of interest and the factor loadings; and a BRC determining means 5700 which determines the subject of interest to be BRC positive or negative depending on the DS. The BRC diagnosing ion selecting means 5400 may divide the plurality of BRC patient and non-BRC cases into a first type discrimination case consisting of a plurality of BRC patient cases and a plurality of normal cases, a second type discrimination case consisting of the plurality of BRC patient cases and a plurality of cancer patient cases with cancers other than BRC, and executed with respect to the first and second discrimination cases, respectively, to divide the BRC-diagnosing low-mass ions into first type BRC diagnosing low-mass ions with respect to the first type discrimination case and second type BRC-diagnosing low-mass ions with respect to the second type discrimination case.

To the above-mentioned purpose, the low-mass ion detecting unit 1000 extracts mass spectrum of the low-mass ion by detecting peak intensity of the low-mass ions using mass spectrometer with respect to biological samples of a plurality of BRC patient and non-BRC cases.

The detailed components of the cancer diagnosing unit to diagnose the BRC are identical to those of the apparatus for screening cancer explained above with reference to FIGS. 9 to 13. Accordingly, the like elements will not be explained in detail below for the sake of brevity.

Referring to FIG. 26, the apparatus for screening cancer according to one embodiment may be implemented in a hardware level, or alternatively, in a software level via program

structure, and the example of implementation in the software level will be explained below with reference to the flowcharts accompanied hereto, to explain diagnosing BRC with an apparatus for screening cancer according to an embodiment.

(3-1) Sample preparation – collecting serums

Serums were collected from 54 BRC patients (Table 201), 49 normal controls (Table 202), 34 CRC patients (Table 205), 16 GC patients (Table 206), and 12 non-Hodgkin lymphoma (NHL) patients (Table 207) and, respectively.

【Table 205】

CRC	Sex	Age year	Stage	Location	Cell Type	CEA ng/mL
CRC-C1	F	47	I	S-colon	AC	0.7
CRC-C2	F	82	I	A-colon	AC	1.1
CRC-C3	F	47	I	Rectum	AC	3.9
CRC-C4	F	54	I	Rectum	AC	1.6
CRC-C5	F	81	II	S-colon	AC	4.1
CRC-C6	F	76	II	Rectum	AC	25.3
CRC-C7	F	71	II	A-colon	AC	1.6
CRC-C8	F	82	II	S-colon	AC	1.8
CRC-C9	F	68	II	D-colon	AC	1.7
CRC-C10	F	67	II	A-colon	AC	1.9
CRC-C11	F	51	II	Rectum	AC	6.7
CRC-C12	F	59	II	A-colon	AC	1
CRC-C13	F	51	II	D-colon	AC	5.9
CRC-C14	F	56	III	S-colon	AC	1.2
CRC-C15	F	59	III	S-colon	AC	1.7
CRC-C16	F	73	III	S-colon	AC	5.7
CRC-C17	F	55	III	Rectum	AC	2.1
CRC-C18	F	61	III	A-colon	AC	12.7
CRC-C19	F	50	III	S-colon	AC	4.8
CRC-C20	F	51	III	S-colon	AC	7
CRC-C21	F	74	III	T-colon	AC	2.5
CRC-C22	F	79	III	Rectum	AC	14.1
CRC-C23	F	52	III	S-colon	AC	22.1
CRC-C24	F	47	III	S-colon	AC	1.2
CRC-C25	F	64	III	S-colon	AC	6.8
CRC-C26	F	51	III	S-colon	AC	1.2
CRC-C27	F	65	III	D-colon	AC	3.5
CRC-C28	F	54	III	S-colon	AC	8.8
CRC-C29	F	60	III	S-colon, A-colon	AC	28.5
CRC-C30	F	70	IV	Rectum	AC	3.9
CRC-C31	F	63	IV	D-colon	AC	12.3

CRC-C32	F	63	IV	A-colon	AC	1.4
CRC-C33	F	50	IV	Rectum	AC	62
CRC-C34	F	66	IV	S-colon	AC	18.5

AC: Adenocarcinoma

【Table 206】

GC	Sex	Age year	CEA ng/mL	Stage
GC-C1	F	62	-	I
GC-C2	F	44	-	I
GC-C3	F	40	-	I
GC-C4	F	60	1.2	II
GC-C5	F	57	-	II
GC-C6	F	67	-	II
GC-C7	F	60	-	II
GC-C8	F	62	8.3	III
GC-C9	F	47	2.86	III
GC-C10	F	55	-	III
GC-C11	F	46	-	III
GC-C12	F	52	3.36	IV
GC-C13	F	71	1.92	IV
GC-C14	F	34	13.44	IV
GC-C15	F	40	-	IV
GC-C16	F	71	-	IV

【Table 207】

NHL	Sex	Age year	Stage	Involved Site	Subtype	IPI
NHL-C1	F	56	1	breast	DLBL	0
NHL-C2	F	38	1	stomach	DLBL	0
NHL-C3	F	49	1	mandibular area	DLBL	0
NHL-C4	F	48	1	neck, submandibular	DLBL	0
NHL-C5	F	38	2	tonsil, neck LN	DLBL	0
NHL-C6	F	41	2	stomach	DLBL	1
NHL-C7	F	66	2	gum, submandibular	DLBL	1
NHL-C8	F	73	3	multiple	DLBL	2
NHL-C9	F	69	3	multiple	ATCL	3
NHL-C10	F	57	4	multiple	DLBL	3
NHL-C11	F	24	4	multiple	DLBL	4
NHL-C12	F	76	4	multiple	DLBL	3

With respect to set C_1 consisting of 165 cases, subset C_0 was constructed into the first training set. The weightings (factor loadings) per mass ions were computed by the

biostatistical analysis, and the preliminary discriminant was acquired. Further, the training set was enlarged to include the second training set C_2 consisting of the 54 BRC patients of Table 208, 46 normal controls of Table 209, 29 CRC patients of Table 210, 15 GC patients of Table 211 and 7 NHL patients of Table 212. That is, to analyze BRC-diagnosing low-mass ions according to the method explained below with respect to the preliminary candidate groups of the low-mass ions constructing the preliminary discriminant, the set C, i.e., union of set C_1 and set C_2, which are independent from each other, was used as the training set.

【Table 208】

BRC	Sex	Age year	Node	ER	ER%	PR	PR%	HER2	Tumor Size cm
BRC-C55	F	44	pN0	6	33-66%	7	>66%	1	1.2
BRC-C56	F	72	pN0(sn)	0	0%	0	0%	0	1.8
BRC-C57	F	48	pN0(sn)	5	33-66%	4	10-33%	1	0.8
BRC-C58	F	44	pN0	5	33-66%	7	>66%	1	2
BRC-C59	F	41	pN2a	5	33-66%	6	33-66%	1	4
BRC-C60	F	58	pN0	6	33-66%	0	0%	2	<0.1
BRC-C61	F	42	-	5	33-66%	6	33-66%	2	-
BRC-C62	F	44	pN1a	4	10-33%	2	<10%	2	5.5
BRC-C63	F	62	pN0(sn)	7	>66%	0	0%	0	2
BRC-C64	F	47	pN0	6	33-66%	6	33-66%	2	2.4
BRC-C65	F	52	pN1a	6	33-66%	0	0%	3	1.8
BRC-C66	F	44	pN0(sn)	6	33-66%	0	0%	0	2
BRC-C67	F	49	pN0(sn)	2	<10%	2	<10%	3	0.4
BRC-C68	F	46	pN0(sn)	6	33-66%	5	33-66%	1	0.7
BRC-C69	F	58	pN0(sn)	7	>66%	5	33-66%	1	2.3
BRC-C70	F	64	pN1a	6	33-66%	7	>66%	1	2
BRC-C71	F	47	-	6	33-66%	6	33-66%	2	-
BRC-C72	F	74	pN1a	6	33-66%	6	33-66%	1	1.8
BRC-C73	F	64	pN0(sn)	0	0%	0	0%	1	2.2
BRC-C74	F	40	ypN1a	6	33-66%	6	33-66%	1	3.5
BRC-C75	F	43	pN0	6	33-66%	6	33-66%	2	2.5
BRC-C76	F	43	ypN0	0	0%	0	0%	2	-
BRC-C77	F	42	pN0	0	0%	0	0%	0	2.3
BRC-C78	F	37	pN0(i+)	6	33-66%	6	33-66%	1	1
BRC-C79	F	50	pN1a	6	33-66%	6	33-66%	1	1
BRC-C80	F	57	pN0(sn)	6	33-66%	96	33-66%	1	1.4
BRC-C81	F	38	ypN0	0	0%	0	0%	1	2
BRC-C82	F	67	-	6	33-66%	2	<10%	1	-
BRC-C83	F	42	pN0(sn)	6	33-66%	6	33-66%	2	0.5
BRC-C84	F	46	pN0(sn)	6	33-66%	6	33-66%	1	1
BRC-C85	F	48	pN2a	4	10-33%	4	10-33%	3	2.5
BRC-C86	F	58	pN0	2	<10%	0	0	1	0.5

BRC-C87	F	53	pN0(sn)	0	0%	0	0%	3	<0.1
BRC-C88	F	56	-	0	0%	0	0%	0	-
BRC-C89	F	45	pN0(sn)	6	33-66%	6	33-66%	2	<0.1
BRC-C90	F	59	pN0(sn)	5	33-66%	0	0%	2	1.4
BRC-C91	F	40	ypN1a	2	<10%	0	0%	0	0.3
BRC-C92	F	39	pN1	7	>95%	3	<10%	0	2.2
BRC-C93	F	54	pN0(i+)	7	95%	5	10-30%	1	1.7
BRC-C94	F	48	pN3a	7	90%	8	90%	0	3.2
BRC-C95	F	54	pN0	0	0%	0	0%	0	3
BRC-C96	F	43	pN0	7	50-60%	7	50-60%	3	2.3
BRC-C97	F	61	pN0	8	95%	8	95%	0	1.6
BRC-C98	F	54	-	0	0%	0	0%	3	-
BRC-C99	F	46	pN0	7	80%	8	95%	0	2.2
BRC-C100	F	61	pN0(i+0)	7	>95%	0	0%	0	4
BRC-C101	F	53	pN0	7	80%	5	25%	0	0.6
BRC-C102	F	49	pN0	3	20%	7	60%	0	0.3
BRC-C103	F	57	pN0	0	0%	0	0%	0	0.8
BRC-C104	F	68	pN0	0	0%	3	1%	3	1.2
BRC-C105	F	58	pN0	8	95%	4	40%	0	0.8
BRC-C106	F	40	-	8	95%	8	95%	0	-
BRC-C107	F	29	pN0	8	95%	8	95%	1	1.2
BRC-C108	F	40	-	-	-	-	-	-	-

【Table 209】

Control	Sex	Age year	CEA ng/mL
CONT-C50	F	40	1.5
CONT-C51	F	50	1.9
CONT-C52	F	64	2.9
CONT-C53	F	52	1.9
CONT-C54	F	37	2.1
CONT-C55	F	49	2.6
CONT-C56	F	30	<0.5
CONT-C57	F	50	1.2
CONT-C58	F	49	2.1
CONT-C59	F	38	0.6
CONT-C60	F	59	1.6
CONT-C61	F	41	1.8
CONT-C62	F	48	1.2
CONT-C63	F	39	0.5
CONT-C64	F	51	1.1
CONT-C65	F	44	1.5
CONT-C66	F	38	1.5
CONT-C67	F	48	1.9
CONT-C68	F	70	4.8
CONT-C69	F	38	2.8
CONT-C70	F	50	1.1
CONT-C71	F	54	1.8
CONT-C72	F	38	0.9

CONT-C73	F	55	8.8
CONT-C74	F	51	2
CONT-C75	F	64	1.7
CONT-C76	F	54	<0.5
CONT-C77	F	59	0.8
CONT-C78	F	65	1.6
CONT-C79	F	68	1.6
CONT-C80	F	51	1.7
CONT-C81	F	62	1.3
CONT-C82	F	63	1.6
CONT-C83	F	60	1.9
CONT-C84	F	68	1.4
CONT-C85	F	62	1.9
CONT-C86	F	68	5.6
CONT-C87	F	53	2.3
CONT-C88	F	63	1.1
CONT-C89	F	46	leiomyoma
CONT-C90	F	39	myoma
CONT-C91	F	46	leiomyoma
CONT-C92	F	46	leiomyoma
CONT-C93	F	23	leiomyoma
CONT-C94	F	38	leiomyoma
CONT-C95	F	40	leiomyoma

【Table 210】

CRC	Sex	Age year	Stage	Location	Cell Type	CEA ng/mL
CRC-C35	F	78	I	Rectum	AC	2.6
CRC-C36	F	50	I	Rectum	AC	1.6
CRC-C37	F	74	I	S-colon	AC	2.3
CRC-C38	F	65	II	S-colon	AC	2.1
CRC-C39	F	66	II	Rectum	AC	4.3
CRC-C40	F	49	II	A-colon	AC	1.6
CRC-C41	F	79	II	A-colon	AC	2.9
CRC-C42	F	67	II	A-colon	AC	1.4
CRC-C43	F	69	II	S-colon, A-colon	AC	5.1
CRC-C44	F	52	II	S-colon	AC	<0.5
CRC-C45	F	76	II	S-colon	AC	2.2
CRC-C46	F	44	III	S-colon	AC	1.4
CRC-C47	F	42	III	S-colon	AC	0.8
CRC-C48	F	43	III	A-colon	AC	4.7
CRC-C49	F	81	III	Rectum	AC	8.4
CRC-C50	F	73	III	S-colon	AC	1.7
CRC-C51	F	58	III	Rectum	AC	21.3
CRC-C52	F	42	III	Rectum	AC	0.7
CRC-C53	F	50	III	D-colon	AC	6.4
CRC-C54	F	73	III	Rectum	AC	3.7
CRC-C55	F	54	III	D-colon	AC	1122.2

CRC-C56	F	60	III	A-colon	AC	30.4
CRC-C57	F	69	III	Rectum	AC	1
CRC-C58	F	52	III	S-colon	AC	9.2
CRC-C59	F	55	III	Rectum	AC	0.9
CRC-C60	F	47	III	S-colon	AC	1.5
CRC-C61	F	72	IV	A-colon	AC	73.4
CRC-C62	F	69	IV	A-colon	AC	49
CRC-C63	F	78	IV	A-colon	AC	12.6

【Table 211】

GC	Sex	Age year	CEA ng/mL	Stage
GC-C17	F	64	4.16	I
GC-C18	F	77	-	I
GC-C19	F	74	-	I
GC-C20	F	49	-	II
GC-C21	F	47	-	II
GC-C22	F	49	-	II
GC-C23	F	64	-	II
GC-C24	F	68	5.56	III
GC-C25	F	81	-	III
GC-C26	F	36	-	III
GC-C27	F	42	<0.4	IV
GC-C28	F	57	6.98	IV
GC-C29	F	40	0.64	IV
GC-C30	F	52	-	IV
GC-C31	F	33	-	IV

【Table 212】

NHL	Sex	Age year	Stage	Involved Site	Subtype	IPI
NHL-C13	F	73	1	nasal cavity	DLBL	2
NHL-C14	F	48	1	breast	DLBL	1
NHL-C15	F	39	2	tonsil, neck LN	DLBL	0
NHL-C16	F	61	2	stomach	DLBL	3
NHL-C17	F	38	4	multiple	DLBL	3
NHL-C18	F	69	4	multiple	Mantle cell L	4
NHL-C19	F	64	4	multiple	DLBL	5

Further, validation set was constructed with set A and set B consisting of 53 BRC patients of Table 213, 46 normal controls of Table 214, 88 CRC patients of Table 215, 11 GC patients of Table 216, 5 NHL patents of Table 217, and 25 ovarian cancer (OVC) patients of

Table 218. The OVC patients were not reflected at all when obtaining weighting per mass ions or investigating BRC-diagnosing low-mass ions, and included to see how these particular patient group IS discriminated with the discriminant constructed according to the present invention.

【Table 213】

BRC	Sex	Age year	Node	ER	ER%	PR	PR%	HER2	Tumor Size cm
BRC-D1	F	34	pN0(sn)	2	<10%	0	0%	2	2
BRC-D2	F	69	-	6	33-66%	6	33-66%	1	-
BRC-D3	F	52	-	-	-	-	-	-	-
BRC-D4	F	67	-	-	-	-	-	-	-
BRC-D5	F	61	-	6	33-66%	2	<10%	0	-
BRC-D6	F	38	pN1a	6	33-66%	5	33-66%	1	-
BRC-D7	F	60	pN0	6	33-66%	3	10-33%	1	1
BRC-D8	F	55	pN2a	5	33-66%	0	0%	2	2.2
BRC-D9	F	46	ypN0	5	33-66%	2	<10%	1	1.5
BRC-D10	F	67	pN0	6	33-66%	6	33-66%	1	2.8
BRC-D11	F	46	pN1a	6	33-66%	6	33-66%	2	0.7
BRC-D12	F	39	pN1mi	6	33-66%	6	33-66%	2	2.5
BRC-D13	F	50	pN0(sn)	4	10-33%	5	33-66%	0	1
BRC-D14	F	31	pN1mi(sn)	6	33-66%	6	33-66%	1	1
BRC-D15	F	46	pN0	6	33-66%	7	>66%	1	1.2
BRC-D16	F	44	pN0(sn)	6	33-66%	7	>66%	1	2.5
BRC-D17	F	40	pN0	0	0%	0	0%	0	-
BRC-D18	F	40	-	6	33-66%	6	33-66%	1	-
BRC-D19	F	56	-	7	>66%	0	0	0	0.6
BRC-D20	F	48	pN1a	0	0%	0	0%	0	3
BRC-D21	F	39	pN0(sn)	6	33-66%	6	33-66%	1	3.5
BRC-D22	F	40	ypN1a	6	33-66%	4	10-33%	2	3
BRC-D23	F	48	pN0(sn)	6	33-66%	6	33-66%	0	2.5
BRC-D24	F	59	-	7	>66%	2	<10%	1	-
BRC-D25	F	46	-	0	0%	0	0%	2	-
BRC-D26	F	37	pN3a	6	33-66%	6	33-66%	2	0.6
BRC-D27	F	38	pN0(sn)	6	33-66%	6	33-66%	2	0.3
BRC-D28	F	66	pN1a	6	33-66%	6	33-66%	0	1.5
BRC-D29	F	58	pN0(sn)	0	0%	0	0%	2	1.7
BRC-D30	F	42	pN3a	5	33-66%	6	33-66%	0	1.8
BRC-D31	F	52	pN0	6	33-66%	6	33-66%	0	0.7
BRC-D32	F	46	pN0(sn)	0	0%	2	<10%	1	1.5
BRC-D33	F	42	pN0(sn)	4	10-33%	6	33-66%	1	0.6
BRC-D34	F	48	-	-	-	-	-	-	-
BRC-D35	F	47	pN0	6	33-66%	2	<10%	2	3
BRC-D36	F	59	pN1a	6	33-66%	4	10-33%	1	1.8
BRC-D37	F	56	-	0	0%	0	0%	3	-
BRC-D38	F	61	pN0(i+0)	7	>95%	0	0%	0	4

BRC-D39	F	40	-	8	95%	8	95%	0	-
BRC-D40	F	43	pN0	0	0%	0	0%	3	0.7
BRC-D41	F	59	pN0	8	95%	8	95%	0	1.2
BRC-D42	F	45	PN2	7	95%	8	95%	1	2.1
BRC-D43	F	55	pN0	0	0%	0	0%	3	1.8
BRC-D44	F	52	pN0	7	80-90%	8	80-90%	0	0.3
BRC-D45	F	59	pN0	8	95%	5	2~3%	1	1.3
BRC-D46	F	39	-	7	>95%	7	70-80%	0	-
BRC-D47	F	39	pN0	0	0%	0	0%	3	1.1
BRC-D48	F	40	pN0	5	50-60%	5	20-30%	0	0.8
BRC-D49	F	46	pN0	7	95%	8	95%	0	4.9
BRC-D50	F	51	pN0	0	<1%	0	0%	0	0.9
BRC-D51	F	61	pN0	7	90%	8	90%	0	1.3
BRC-D52	F	48	pN0	0	0%	0	0%	0	0.6
BRC-D53	F	47	pN0	8	>95%	8	95%	0	0.7

【Table 214】

Control	Sex	Age year	CEA ng/mL	Control	Sex	Age year	CEA ng/mL
CONT-D1	F	44	-	CONT-D24	F	51	2
CONT-D2	F	45	-	CONT-D25	F	68	1.4
CONT-D3	F	54	-	CONT-D26	F	52	1.5
CONT-D4	F	51	3.1	CONT-D27	F	63	1.8
CONT-D5	F	55	<0.5	CONT-D28	F	65	1.1
CONT-D6	F	46	<0.5	CONT-D29	F	55	4.8
CONT-D7	F	34	0.6	CONT-D30	F	52	4.1
CONT-D8	F	58	1.5	CONT-D31	F	64	<0.5
CONT-D9	F	54	-	CONT-D32	F	63	2.2
CONT-D10	F	34	<0.5	CONT-D33	F	62	1.1
CONT-D11	F	45	0.8	CONT-D34	F	53	0.7
CONT-D12	F	44	-	CONT-D35	F	65	3.8
CONT-D13	F	46	-	CONT-D36	F	64	1.5
CONT-D14	F	54	2.3	CONT-D37	F	53	1
CONT-D15	F	39	1.3	CONT-D38	F	66	1.7
CONT-D16	F	55	1.3	CONT-D39	F	50	1.9
CONT-D17	F	46	-	CONT-D40	F	70	pelic organ prolapse
CONT-D18	F	45	-	CONT-D41	F	44	leiomyoma
CONT-D19	F	63	-	CONT-D42	F	70	pelic organ prolapse
CONT-D20	F	51	-	CONT-D43	F	53	leiomyoma
CONT-D21	F	52	-	CONT-D44	F	34	leiomyoma
CONT-D22	F	52	-	CONT-D45	F	44	leiomyoma
CONT-D23	F	70	-	CONT-D46	F	41	leiomyoma, adenomyosis

【Table 215】

CRC	Sex	Age	Stage	Location	Cell	CEA

		year			Type	ng/mL
CRC-D1	F	59	I	Rectum	AC	1.6
CRC-D2	F	46	I	S-colon	AC	1.4
CRC-D3	F	67	II	A-colon	AC	7.3
CRC-D4	F	75	II	Rectum	AC	12.6
CRC-D5	F	60	II	S-colon	AC	3.3
CRC-D6	F	66	II	S-colon	AC	4.2
CRC-D7	F	81	II	S-colon	AC	2.4
CRC-D8	F	77	II	Rectum	AC	6.2
CRC-D9	F	82	II	A-colon	AC	2.8
CRC-D10	F	58	III	S-colon	AC	2.1
CRC-D11	F	65	III	S-colon	MAC	2.7
CRC-D12	F	51	III	Rectum	AC	1.4
CRC-D13	F	48	III	A-colon	AC	0.9
CRC-D14	F	54	III	A-colon	AC	1.7
CRC-D15	F	49	III	S-colon	AC	1
CRC-D16	F	63	III	A-colon	AC	58.2
CRC-D17	F	54	III	T-colon	AC	2.2
CRC-D18	F	70	III	S-colon	MAC	36
CRC-D19	F	54	III	Rectum	AC	5.5
CRC-D20	F	52	III	A-colon	AC	1.2
CRC-D21	F	71	III	A-colon	AC	2.8
CRC-D22	F	33	III	D-colon	AC	4.7
CRC-D23	F	68	III	Rectum	AC	3.3
CRC-D24	F	61	III	A-colon	AC	2.8
CRC-D25	F	54	IV	S-colon	AC	29.8
CRC-D26	F	52	IV	A-colon	MAC	9
CRC-D27	F	54	IV	S-colon	AC	27.9
CRC-D28	F	59	III	Rectum	AC	1.4
CRC-D29	F	75	II	Rectum	AC	2.4
CRC-D30	F	68	II	Rectum	AC	0.7
CRC-D31	F	56	I	Rectum	AC	2.3
CRC-D32	F	45	II	Rectum	AC	2.7
CRC-D33	F	49	II	Rectum	AC	2.1
CRC-D34	F	45	0	Rectum	AC	0.9
CRC-D35	F	54	0	Rectum	AC	3.6
CRC-D36	F	71	III	Rectum	AC	6.7
CRC-D37	F	56	III	Rectum	AC	1
CRC-D38	F	69	I	Rectum	AC	1.5
CRC-D39	F	71	III	Rectum	AC	1.8
CRC-D40	F	51	I	Rectum	AC	1.5
CRC-D41	F	67	III	Rectum	AC	3.4
CRC-D42	F	76	III	Rectum	AC	1
CRC-D43	F	38	III	Rectum	AC	0.7
CRC-D44	F	50	III	Rectum	AC	2.2
CRC-D45	F	49	0	Rectum	AC	1.6
CRC-D46	F	42	III	Rectum	AC	9.9
CRC-D47	F	72	II	Rectum	AC	8
CRC-D48	F	69	III	Rectum	AC	11.3
CRC-D49	F	71	III	Rectum	AC	1.3
CRC-D50	F	60	I	Rectum	AC	1.2

CRC-D51	F	56	III	Rectum	AC	2.3
CRC-D52	F	68	I	Rectum	AC	2
CRC-D53	F	41	III	Rectum	AC	1.5
CRC-D54	F	34	III	Rectum	AC	5.2
CRC-D55	F	52	II	Rectum	AC	1.6
CRC-D56	F	67	0	Rectum	AC	4.4
CRC-D57	F	66	II	Rectum	AC	4.8
CRC-D58	F	61	III	A-colon	AC	30.4
CRC-D59	F	71	III	Rectum	AC	1
CRC-D60	F	53	II	S-colon	AC	1.3
CRC-D61	F	77	II	S-colon	AC	2.2
CRC-D62	F	71	III	S-colon	MAC	36
CRC-D63	F	79	II	Rectum	AC	6.2
CRC-D64	F	53	III	A-colon	AC	1.2
CRC-D65	F	72	III	A-colon	AC	2.8
CRC-D66	F	34	III	D-colon	AC	4.7
CRC-D67	F	62	III	A-colon	AC	2.8
CRC-D68	F	84	II	A-colon	AC	2.8
CRC-D69	F	71	II	S-colon	AC	15.3
CRC-D70	F	56	I	S-colon	AC	0.7
CRC-D71	F	70	II	S-colon	AC	1.4
CRC-D72	F	62	III	Rectum	AC	235.4
CRC-D73	F	52	III	S-colon	AC	6.4
CRC-D74	F	61	III	T-colon	AC	13.9
CRC-D75	F	88	II	A-colon	AC	3
CRC-D76	F	73	I	D-colon, T-colon	AC	2
CRC-D77	F	69	I	A-colon	AC	5
CRC-D78	F	69	I	A-colon	AC	5.7
CRC-D79	F	74	II	D-colon	AC	12.5
CRC-D80	F	75	II	Rectum	AC	0.9
CRC-D81	F	57	I	A-colon	AC	1.5
CRC-D82	F	62	III	S-colon	AC	4.4
CRC-D83	F	74	III	Rectum	AC	31
CRC-D84	F	70	I	A-colon	AC	2.5
CRC-D85	F	70	II	A-colon	AC	5.9
CRC-D86	F	77	II	S-colon	AC	1.5
CRC-D87	F	62	III	Rectum	AC	13.7
CRC-D88	F	45	0	Rectum	AC	-

MAC: Mucinous adenocarcinoma

【Table 216】

GC	Sex	Age year	CEA ng/mL	Stage	GC	Sex	Age year	CEA ng/mL	Stage
GC-D1	F	81	-	I	GC-D7	F	81	-	III
GC-D2	F	55	-	I	GC-D8	F	51	0.51	IV
GC-D3	F	40	-	II	GC-D9	F	43	1.62	IV
GC-D4	F	52	-	II	GC-D10	F	57	2.46	IV
GC-D5	F	81	-	II	GC-D11	F	52	-	IV

GC-D6	F	80	-	III	

【Table 217】

NHL	Sex	Age year	Stage	Involved Site	Subtype	IPI
NHL-D1	F	41	1	0	DLBL	0
NHL-D2	F	72	1	stomach	DLBL	2
NHL-D3	F	76	2	stomach	DLBL	1
NHL-D4	F	70	4	multiple	DLBL	3
NHL-D5	F	48	4	multiple	DLBL	3

【Table 218】

OVC	Age year	Histology	Stage
OVC-D1	56	IIIc	Clear cell carcinoma
OVC-D2	52	IIa	Endometrioid adenocarcinoma
OVC-D3	63	IV	Papillary serous adenocarcinoma
OVC-D4	55	Ia	Malignant Brenner tumor
OVC-D5	47	IIIc	Papillary serous adenocarcinoma
OVC-D6	50	Ic	Clear cell carcinoma
OVC-D7	68	Ib	Serous adenocarcinoma
OVC-D8	74	IIIc	Papillary serous adenocarcinoma
OVC-D9	43	Ic	Mucinous adenocarcinoma
OVC-D10	44	IIIc	Papillary serous adenocarcinoma
OVC-D11	54	IIIc	Papillary serous adenocarcinoma
OVC-D12	55	IV	Serous adenocarcinoma
OVC-D13	72	IIIc	Serous adenocarcinoma
OVC-D14	58	IIIc	Mucinous adenocarcinoma
OVC-D15	44	IIIc	Papillary serous adenocarcinoma
OVC-D16	57	IV	Serous adenocarcinoma
OVC-D17	54	IIIc	Papillary serous adenocarcinoma
OVC-D18	73	IIIc	Serous adenocarcinoma
OVC-D19	47	IIIc	Papillary serous adenocarcinoma
OVC-D20	40	Ic	Papillary serous adenocarcinoma
OVC-D21	74	IIb	Transitional cell carcinoma
OVC-D22	65	IIIc	Papillary serous adenocarcinoma
OVC-D23	47	IV	Serous adenocarcinoma
OVC-D24	58	IIc	Serous adenocarcinoma
OVC-D25	57	Ib	Mixed cell adenocarcinoma

(3-2) Sample preparation – preparing serum and measuring mass spectrum

4X volume of methanol/chloroform (2:1, v/v) was mixed with 25$\mu\ell$ serum violently and incubated at room temperature for 10 min. The mixture was centrifuged at 4℃, 10 min,

6000 × g. The supernatant was completely dried for 1 h in the concentrator, and dissolved in the vortexer in 30㎕ of 50% acetonitrile/0.1% trifluoroacetic acid (TFA).

Methanol/chloroform extract was mixed with a-cyano-4-hydroxycinnamic acid solution in 50% acetonitrile/0.1% TFA (1:12, v/v), and 1㎕ mixture was placed on MALDI-target plate. The mass spectra of the serum extracts from the BRC patients and normal subjects were measured using the Proteomics Analyzer (Applied Biosystems, Foster City, CA, USA).

The mass spectrum data for one sample is extracted based on the average of spectrum which was repeatedly measured 20 times. The mass region of the entire individual samples was adjusted so that the maximum mass was set at approximately 2500 m/z. To minimize experimental error, various factors including focus mass, laser intensity, target plate, data acquisition time were taken into consideration.

The focus mass and the laser intensity were fixed at preferable levels, i.e., 500 m/z and 5000, respectively. In addition to the fixed focus mass and the laser intensity, the entire samples were repeatedly measured at least five times under viewpoint of other extraction and other data collection. The set C_1, from which weightings per mass ions were computed, was measured one more time.

Accordingly, the low-mass ion detecting means 5000 extracted the low-mass ion mass spectrum from the serum sample via the processes explained above, using the MALDI-TOF.

(3-3) Discrimination strategy

In order for the constructed discriminant to be BRC specific, the discriminant is required to discriminate the BRC patient group from not only the normal control, but also the

patient groups with other cancer types. In one embodiment, the patient groups with other cancer types include CRC patients, GC patients and NHL patients. Table 219 provides the result of implementing the conventional PCA-DA to investigate whether one discriminant can discriminate the BRC patient group from the non-BRC group (normal controls, CRC patient group, GC patient group and NHL patient group). Although the result of discrimination was not as perfect as that of Table 204, the discrimination performance was generally as high as 80% or above. This reveals the fact that one discriminant can discriminate the BRC patient group from all the non-BRC groups.

【Table 219】

						Sensitivity		100.0%
Set C_1	True BRC	True Non-BRC				Specificity	CONT	89.80%
		CONT	CRC	GC	NHL		CRC	91.18%
Predicted BRC	54	5	3	2	2		GC	87.50%
Predicted Non-BRC	0	44	31	14	10		NHL	83.33%

Referring to FIG. 4 and Table 204, considering the perfect discrimination result of the BRC patient group from the normal controls, it was also investigated if the BRC patient group was discriminated from the patient groups with other cancer types, and the result is provided by Table 220. The discrimination result was good overall, considering that no presence of false negative case and presence of only one false positive case.

【Table 220】

					Sensitivity		100.0%
Set C_1	True BRC	True Non-BRC			Specificity	CRC	100.0%
		CRC	GC	NHL		GC	93.75%
Predicted	54	0	1	0		NHL	100.0%

BRC								
Predicted Non-BRC	0	34	15	12			Total	98.39%

Accordingly, discriminating the BRC patient group from the non-BRC patient groups may implement one discriminant or two discriminants as explained detail in the Examples provided below. A first type discriminant may be used to discriminate BRC patient group from non-patient group. A second discriminant may be used to discriminate the BRC patient group from the normal controls, with a third discriminant which may be used to discriminate the BRC patient group from non-BRC patient groups with other types of cancers, in which the BRC patient is determined if both discriminants indicate BRC, while the non-BRC patient is determined if any of the two discriminants indicates non-BRC patient.

(3-4) Selecting first training set C_0 and computing weightings per mass ions

Although the result of discrimination of Tables 219 and 220 are good, the sensitivity and the specificity are not always 100%. In one embodiment of the present invention, the first training set C_0 with predetermined sensitivity and specificity is selected, and weightings per mass ions of the first training set C_0 were computed, in which the predetermined sensitivity and specificity were both 100%.

A method for selecting the first training set C_0 with the predetermined sensitivity and specificity will be explained below with reference to FIG. 27.

The first DS computing means 5200 aligned and imported the low-mass ion mass spectra of the BRC patient group and the normal control group of set C_1 (E111), normalized the imported peak intensities (E112), Pareto-scaled the normalized peak intensities (E113), and computed DS by performing biostatistical analysis with respect to the Pareto-scaled peak intensities (E114).

Among a variety of biostatistical analyzing methods that can be implemented to

compute DS, in one embodiment, the PCA-DA was performed. Sensitivity and specificity were computed based on the DS (E115) and the result is shown in Table 219.

Next, sensitivity threshold BN_1 and specificity threshold BN_2 were set (E116), and false positive or false negative cases were excluded when the sensitivity or the specificity was less than the corresponding threshold (E117).

In one embodiment, both the sensitivity threshold BN_1 and the specificity threshold BN_2 were set to 1, to thus find the first training set C_{01} with both the sensitivity and the specificity being 100%. That is, steps E111 to E115 were performed again with respect to the set from which 12 false positive cases and 12 false negative cases in Table 219 were excluded. The sensitivity and the specificity did not directly reach 100% when the steps E111 to E115 were repeated with respect to the set excluding the false positive and false negative cases. That is, the first training set C_{01} with both the sensitivity and the specificity being 100% was found after the steps E111 to E117 were repeated predetermined number of times (E118).

The first type discriminant to discriminate BRC patient group from the normal controls reached the first training set C_{01} when 15 false positive cases (7 CONT, 3 CRC, 2 GC, 3 NHL) were excluded, and the third type discriminant to discriminate BRC patient group from the patient groups with other types of cancer reached the first training set C_{03} when 1 false positive case (1 GC) was excluded, with both the sensitivity and specificity reaching 100%.

The training set C_{02} was used as is, i.e., without excluding cases, because the second type discriminant to distinguish BRC patient group from the normal controls already provides 100% sensitivity and specificity. Through this process, it is possible to derive factor loadings per mass ions which provide discrimination result with both 100% sensitivity and specificity (E119).

The series of the processes explained above may be performed at the factor loading

computing means 5300.

(3-5) Implementing a discriminant

The process of implementing the constructed discriminant on the sample of interest will be explained below.

First, MarkerView™ supports the function that can be used for the similar purpose. That is, it is possible to apply the PCA-DA on only the part of the imported sample data, and discriminate the rest samples using the discriminant constructed as a result. According to this function, it is possible to select only the first training set after the import of the first training set and the other samples for analysis so that only the first training set undergoes the PCA-DA to show how the samples for analysis are interpreted.

Meanwhile, the peak alignment function to align the peaks is performed in the import process of MarkerView™. Because there is no function to align the peaks of the samples of interest based on the first training set, the peak table (matrix of m/z rows and rows of peak intensities per samples) obtained when only the first training set is imported, does not match the first training set of the peak table which is generated when the first training set is imported together with the samples of interest. The peak intensity matrices are difference, and the m/z values corresponding to the same peak intensity column also do not always appear the same. Accordingly, in order to compute DS by implementing the discriminant constructed from the first training set on the samples of interest, a realignment operation to realign the peak table, generated when the first training set is imported together with the samples of interest, to the peak table generated when only the first training set is imported.

The misalignment becomes more serious, if several samples of interests are imported together with the first training set. Accordingly, in one embodiment, with respect to the entire samples of interest, one sample of interest is added to the first training set to be imported,

realigned, normalized and Pareto-scaled.

The embodiment will be explained in greater detail below with reference to FIG. 28.

First, the low-mass ion mass spectra of the samples of interest were aligned with the first training set and imported (E211).

Meanwhile, since MarkerView™ in one embodiment does not support the function of aligning and importing the sample of interest to the first training set, as explained above, a program may be designed to realign the peak table generated after importing the low-mass ion mass spectrum of the sample of interest together with the first training set to the peak table which is generated after importing the first training set only, so that the low-mass ion mess spectrum of the sample of interest aligned with the first training set is extracted. However, it is more preferable that the sample of interest is directly aligned and imported to the first training set without having realigning process and this is implementable by designing a program.

Next, the imported peak intensities were normalized (E212), and the normalized peak intensities were Pareto-scaled (E213).

Next, discriminant score was computed using the Pareto-scaled peak intensities of the low-mass ions and the factor loadings per mass ions acquired by the PCA-DA (E214).

It is determined whether or not the computed DS exceeds a reference BS (E215), and if so, it is interpreted positive (E216), while it is interpreted negative if the computed DS is less than the reference BS (E217). In one embodiment, the reference BS may preferably be 0.

The series of processes explained above may be performed at the second aligning means 5500, the second DS computing means 5600 and a BRC determining means 5700.

The DS was computed by applying factor loadings per mass ions computed at Clause (3-4) with respect to the 15 non-BRC patient samples which were excluded when

constructing the first training set C_{01} from the set C_1 to construct the first type discriminant, and the 1 GC patient sample which was excluded when constructing the first training set C_{03} from the set C_1 to construct the third type discriminant. Considering that the cases were excluded when constructing the first training sets C_{01} and C_{03}, it was expected that the cases would be discriminated to be false positive or false negative, and they were determined to be the false positive or false negative cases as expected when the computation was done, except for one case of the normal control group related to the first type discriminant which was determined to be true negative. The result of discrimination of the set C_1 by applying the factor loadings per mass ions computed at Clause (3-4) is presented in FIGS. 29 and 30, in which FIG. 29 shows the result of the first type discriminant and FIG. 30 shows the result of the third discriminant.

(3-6) Constructing preliminary discriminant

Conventionally, DS is computed using the entire mass ions that are taken into consideration in the PCA-DA and the BRC patient was determined according to the computed DS. In one embodiment of the present invention, a preliminary discriminant is constructed, which uses only the mass ions that contribute considerably to the DS, in order to derive a discriminant with robust discrimination performance. As used herein, the term "preliminary discriminant" refers to an intermediate form of a discriminant which is obtained before the final discriminant is obtained, and the low-mass ions constructing the discriminant are the "preliminary candidate group" of the CRC-diagnosing low-mass ions to construct the final discriminant.

Through the process of FIG. 31, predetermined mass ions were selected, which give considerable influence on the DS, from among 10,000 mass ions. In one embodiment, 376 mass ions were selected by the first type discriminant, 353 mass ions were selected by the

second discriminant, and 345 mass ions were selected by the third type discriminant.

As explained above with reference to Table 203, because the maximum number of the peaks under the import condition is set to 10,000 and sufficient samples are imported, the discriminant constructed by the PCA-DA of MarkerView™ consists of 10,000 terms. However, not all the 10,000 terms have the equal importance particularly in distinguishing BRC patients and non-BRC patients. Accordingly, the mass ions that give considerable influence on the DS were selected from among the 10,000 mass ions by two steps according to the process of FIG. 31. This particular step is employed to remove unnecessary mass ions in distinguishing BRC patients from non-BRC patients from the 10,000 mass ions.

The mass ions were preliminarily selected under corresponding case categories, if the absolute product obtained by multiplying the peak intensities by the factor loadings per mass ions exceeds the threshold BT_1 (E121). In one embodiment, the threshold BT_1 may preferably be 0.1.

Next, the mass ions were secondarily selected from among the preliminarily-selected mass ions under each case category, if the mass ions appear commonly in the cases exceeding the threshold percentage BT_2 (E122). In one embodiment, the threshold percentage BT_2 may preferably be 50. That is, take the second type discriminant for example, only the mass ions that appear commonly in at least 52 cases from among the 103 cases of the first training set were used to construct the preliminary discriminant.

The DS was again computed exclusively with the mass ions that were selected as explained above, and the sensitivity and the specificity were computed accordingly (E123). Again, the sensitivity threshold BN_3 and the specificity threshold BN_4 were set (E124), so that if the sensitivity or the specificity is less than the corresponding threshold, the threshold BT_1 used at step E121 and/or the threshold BT_2 used at step E122 was changed (E125) and the steps from E121 to E124 were repeated. In one embodiment, the sensitivity threshold

BN_3 and the specificity threshold BN_4 may preferably be 0.9, respectively.

The preliminary candidate group of the BRC-diagnosing low-mass ions was constructed with the mass ions that were selected as explained above (E126), and in one embodiment, only 376 mass ions were selected by the first type discriminant from among the 10,000 mass ions, 353 mass ions were selected by the second type discriminant, or 345 mass ions were selected by the third type discriminant. Tables 221, 222, 223 provide the results of discriminating the first training sets C_{01}, C_{02}, C_{03} with the first, second and third type preliminary discriminants, according to which the discrimination performance including the sensitivity and the specificity was slightly degraded from 100%, but still the result of computing with less than 4% of the total mass ions was certainly as good as the result obtained by using the entire mass ions.

Further, FIGS. 32, 33, 34 provide the result of discriminating the set C_1 with the preliminary discriminant, in which FIG. 32 shows the result by the first type preliminary discriminant, FIG. 33 shows the result by the second type discriminant, and FIG. 34 shows the result by the third type discriminant. Compared to the sharp reduction in the number of mass ions used for the computation, the range of DS was not so influenced. This suggests that not all 10,000 mass ions are necessary to distinguish BRC patients from non-BRC patients.

【Table 221】

Set C_1	True BRC	True Non-BRC					
		CONT	CRC	GC	NHL	Sensitivity	100.0%
						Specificity	96.88%
Predicted BRC	54	1	0	1	1	PPV	94.74%
Predicted Non-BRC	0	41	31	13	8	NPV	100.0%

【Table 222】

		Sensitivit	98.15%

				y	
Set C_{02}	True BRC	True CONT		Specificit y	97.96%
Predicted BRC	53	1		PPV	98.15%
Predicted Non-BRC	1	48		NPV	97.96%

【Table 223】

Set C_{03}	True BRC	True Non-BRC				Sensitivity	96.30%
		CRC	GC	NHL		Specificity	96.72%
Predicted BRC	52	2	0	0		PPV	96.30%
Predicted Non-BRC	2	32	15	12		NPV	96.72%

The series of processes explained above may be performed at the BRC-diagnosing ion selecting means 5400 which includes the candidate ion set selecting means.

(3-7) Constructing a final discriminant

The mass ions were extracted from among the 10,000 mass ions imported in the process of constructing the preliminary discriminant, as those that contribute considerably to the numerical aspect of the DS. Considering that the selected mass ions include the mass ions that do not generate a problem in the first training set C_0, but can potentially deteriorate the discrimination performance in the discrimination with the mass spectrum that was re-measured with respect to the same BRC patient samples and non-BRC samples or in the discrimination of new BRC patient group and non-BRC patient group, additional step is necessary, which can actively remove the presence of such mass ions. The process of constructing a final discriminant includes such step before finally determining BRC-diagnosing low-mass ions.

To validate robustness of a discriminant, repeated measure experiment was conducted

with respect to the set C_1 5 times, and the repeated measure experiment was also performed 5 times with respect to the sets C_2 and D which were independent from the set C_1 and also independent from each other. It is hardly possible to confirm that the repeated measure of the mass spectrum is always conducted under the exactly same conditions in the processes like vaporization using laser beam, desorption, ionization, or the like, in addition to the process of freezing and thawing the serums and mixing the serums with methanol/chloroform to obtain extract, and it is also hard to rule out introduction of disturbances due to various causes. In other words, the DS with respect to the repeatedly-measured individual mass spectrum may have a predetermined deviation, and considering this, interpretation in one embodiment was made by computing an average DS with respect to the sample which was repeatedly measured 5 times.

Table 224 provides the result of discriminating the sets C and D with the discriminant of 10,000 terms as a result of the conventional technology, i.e., PCA-DA by MarkerView™, and Table 225 shows the result of discriminating the sets C and D with the first type preliminary discriminant with 376 terms, the second type preliminary discriminant with 353 terms, and the third type preliminary discriminant with 345 terms. Referring to the table, BRC LOME 1 (breast cancer low mass ion discriminant equation) refers to the first type discriminant, BRC LOME 2 refers to the second type discriminant, and BRC LOME 3 refers to the third type discriminant, and the following numbers indicate the number of low-mass ions included in the discriminant. Further, Table 226 shows the discrimination performance with respect to the validation set only, i.e., to the set D, in which the numbers in parenthesis refers to the discrimination performance when OVA patient group is excluded.

【Table 224】

BRC LOME 1-10000					BRC LOME 1-10000			
Set C	True	True	Non-BRC		Set D	True	True	Non-BRC

	BRC	CONT	CRC	GC	NHL
Predicted BRC	104	36	33	0	7
Predicted Non-BRC	4	59	30	31	12

	BRC	CONT	CRC	GC	NHL	OVC
Predicted BRC	46	15	32	0	0	10
Predicted Non-BRC	7	31	56	11	5	15

BRC LOME 2-10000						
Set C	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL	
Predicted BRC	100	54	35	1	5	
Predicted Non-BRC	8	41	28	30	14	

BRC LOME 2-10000						
Set D	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL	OVC
Predicted BRC	46	25	52	0	0	1
Predicted Non-BRC	7	21	36	11	5	24

BRC LOME 3-10000						
Set C	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL	
Predicted BRC	90	40	27	1	0	
Predicted Non-BRC	18	55	36	30	19	

BRC LOME 3-10000						
Set D	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL	OVC
Predicted BRC	41	17	24	0	0	7
Predicted Non-BRC	12	29	64	11	5	18

BRC LOMEs 2 & 3						
Set C	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL	
Predicted BRC	88	35	26	0	0	
Predicted Non-BRC	20	60	37	31	19	

BRC LOMEs 2 & 3						
Set D	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL	OVC
Predicted BRC	35	15	22	0	0	1
Predicted Non-BRC	18	31	66	11	5	24

【Table 225】

BRC LOME 1-376						
Set C	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL	
Predicted BRC	104	35	33	0	7	
Predicted Non-BRC	4	60	30	31	12	

BRC LOME 1-376						
Set D	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL	OVC
Predicted BRC	45	14	33	0	0	10
Predicted Non-BRC	8	32	55	11	5	15

BRC LOME 2-353						
Set C	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL	
Predicted BRC	99	54	35	3	5	
Predicted Non-BRC	9	41	28	28	14	

BRC LOME 2-353						
Set D	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL	OVC
Predicted BRC	46	25	55	0	0	2
Predicted Non-BRC	7	21	33	11	5	23

BRC LOME 3-345						
Set C	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL	
Predicted	90	40	29	1	0	

BRC LOME 3-345						
Set D	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL	OVC
Predicted	41	17	25	0	0	7

BRC						BRC						
Predicted Non-BRC	18	55	34	30	19	Predicted Non-BRC	12	29	63	11	5	18
BRC LOMEs 2 & 3						BRC LOMEs 2 & 3						
Set C	True BRC	True Non-BRC				Set D	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL			CONT	CRC	GC	NHL	OVC
Predicted BRC	87	35	28	0	0	Predicted BRC	35	15	24	0	0	2
Predicted Non-BRC	21	60	35	31	19	Predicted Non-BRC	18	31	64	11	5	23

【Table 226】

Set D	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
BRC LOME 1-10000	86.79 (86.79)	67.43 (68.67)	44.66 (49.46)	94.40 (93.64)
BRC LOME 1-376	84.91 (84.91)	67.43 (68.67)	44.12 (48.91)	93.65 (92.79)
BRC LOME 1-29	96.23 (96.23)	91.43 (94.67)	77.27 (86.44)	98.77 (98.61)
Set D	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
BRC LOME 2-10000 & BRC LOME 3-10000	66.04 (66.04)	78.29 (75.33)	47.95 (48.61)	88.39 (86.26)
BRC LOME 2-353 & BRC LOME 3-345	66.04 (66.04)	76.57 (74.00)	46.05 (47.30)	88.16 (86.05)
BRC LOME 2-42 & BRC LOME 3-75	92.45 (92.45)	96.57 (98.67)	89.09 (96.08)	97.69 (97.37)

The discriminant consisting of 10,000 mass ions exhibits perfect discrimination performance with respect to the first training set C_0, but with reference to Table 226, the positive predictability was particularly low with respect to set D. All the first, second and third preliminary discriminants exhibited very good discrimination performance (Tables 122, 123) with respect to the first training set C_0, but the discrimination result with respect to set D was far from satisfaction.

Accordingly, in one embodiment of the present invention, steps illustrated in FIG. 35 were performed to improve the preliminary discriminant to more robust discriminant.

First, the mass ions of the preliminary candidate group were divided into high sensitivity set and high specificity set (E131). As used herein, the mass ions of the high

sensitivity set have higher sensitivity per mass ions than specificity, while the mass ions of the high specificity set have higher specificity per mass ions than sensitivity.

Next, the mass ions of the high sensitivity set and the mass ions of the high specificity set were sorted in a descending order $\{Sns_1, Sns_2, Sns_3 \ldots Sns_I\}\{Spc_1, Spc_2, Spc_3 \ldots Spc_J\}$ in terms of the sum of the sensitivity and specificity per mass ions, and two top mass ions of the respective sets were taken $\{Sns_1, Sns_2, Spc_1, Spc_2\}$, and a biomarker group was selected with a combination of the best performance from among 11 combinations that are possibly made with the two or more mass ions of the four mass ions (E132).

The criteria to determine whether a combination has the best performance or not may be selected objectively and universally from among the following criteria which are listed in the order of importance:

Criterion 1) The combination with greater sum of sensitivity and specificity has better performance;

Criterion 2) The combination with less mass ions has better performance; and

Criterion 3) The combination with a greater difference between minimum DS of the true positive case and the maximum DS of true negative case has better performance.

Next, one more mass ion, i.e., the second top mass ion $\{Sns_3, Spc_3\}$ was additionally taken from each of the high sensitivity set and the high specificity, so that a set with the best performance was re-selected as a biomarker group from among the four sets {biomarker group}, {biomarker group, Sns_3}, {biomarker group, Spc_3}, {biomarker group, Sns_3, Spc_3} which are the combinations of the additionally-taken mass ions $\{Sns_3, Spc_3\}$ (E133).

The process repeated until the high sensitivity set and the high specificity set had no further mass ion to add (E134).

In other words, the process (E133) repeats as long as both the high sensitivity set and the high specificity set have mass ions to add, and when any of the high sensitivity set and the

high specificity set has no further mass ion left to add, the next top mass ion {Sns_i or Spc_j} in the set having mass ions is additionally taken, so that a biomarker group is selected with a set of the best performance among the two sets {biomarker group}, {biomarker group, Sns_i or Spc_j} which are combinations of the additionally-taken mass ion {Sns_i or Spc_j}.

The process repeats as long as the high sensitivity set or the high specificity set is out of the mass ion, and the biomarker group that is selected when there is no mass ion left in the high sensitivity set and high specificity set becomes the biomarker group 1 (BG) (E135).

The biomarker group 1 (BG) was removed from the preliminary candidate group (E136), the high sensitivity set and the high specificity set were constructed with the remaining mass ions, and the above-explained process repeats. The process repeats until any of the high sensitivity set and the high specificity has less than two mass ions therein (E137).

BK number of biomarker groups were combined with the biomarker groups 1, 2, … which were obtained by the repeated process explained above, in the order of accuracy, to form a final biomarker group. As used herein, the "accuracy" refers to a proportion of true positive and true negative cases in the entire cases. In one embodiment, BK may preferably be 1, 2, or 3 (E138)

Accordingly, the mass ions of the final biomarker group were determined to be the BRC-diagnosing low-mass ions (E139).

The preliminary candidate group of the mass ions was selected from the set C_1, and more specifically, from the subset C_0, and to avoid overfitting problem, the set C_2 which was independent from the set C_1 was added to enlarge the training set when the final biomarker group was determined from the preliminary candidate group.

As a result of performing the process explained above with respect to the samples to distinguish BRC patient group from the non-BRC patient group, 29 mass ions were selected as the first type BRC-diagnosing low-mass ions. Further, as a result of performing the

process explained above with respect to the samples to distinguish BRC patient group from the normal controls, 42 mass ions were selected as the second type BRC-diagnosing low-mass ions. Further, as a result of performing the process explained above with respect to the samples to distinguish BRC patient group from the patient groups with other types of cancers, 75 mass ions were selected as the third type BRC-diagnosing low-mass ions. The masses of the first, second and third type BRC-diagnosing low-mass ions are listed in Tables 227, 228 and 229. The low-mass ions explained above are referred to as the "first type BRC-diagnosing low-mass ions", the "second type CRC-diagnosing low-mass ions", and the "third type BRC-diagnosing low-mass ions", and the discriminant according to the present invention which is finally obtained using the same are referred to as the "first type BRC-diagnosing final discriminant", the "second type CRC-diagnosing final discriminant", and the "second type CRC-diagnosing final discriminant", respectively.

【Table 227】

74.0937	193.0665	279.0841	332.3181	476.6038	562.3074
74.1155	208.0565	280.0847	401.0588	490.3427	583.2323
76.0728	212.0949	282.2777	427.3441	498.3237	584.2415
136.1067	231.0726	313.2638	432.9954	499.3265	646.3851
173.4872	258.1364	331.2024	452.2269	512.3145	

【Table 228】

38.9779	123.0821	225.1870	313.2618	424.3216	538.3428	610.3273
46.0647	130.1539	229.0005	332.3150	426.3389	540.3250	616.3286
74.1164	185.7723	231.0675	342.2482	428.1885	570.3234	618.3352
76.0733	191.1175	244.0962	368.2624	497.3194	580.3281	646.3959
97.0686	208.0530	281.0913	398.3034	513.3193	581.2310	725.3469
122.0777	212.0960	284.3205	416.0901	532.6918	581.3377	757.1117

【Table 229】

38.9736	156.0412	228.0348	331.2036	478.8688	511.3367	583.2284
38.9892	172.3072	231.0726	332.3169	479.8724	518.8776	731.3330
44.0491	178.1330	234.0422	333.3233	480.3180	520.8826	733.3526
44.0656	182.0738	260.1013	337.1047	483.3301	534.2829	734.3563
74.0938	189.9525	279.0843	424.3272	487.3152	535.2882	735.3665
87.0991	192.1294	280.0849	426.3406	488.3287	542.8770	757.0995
104.1316	193.0660	282.2791	432.9948	488.6580	544.7878	757.3512

104.3161	196.0871	289.2960	433.9894	496.4331	544.8728	1465.5872
105.1091	212.3221	298.3425	446.0196	496.7718	546.3358	1466.5971
136.1021	217.0923	313.2630	454.3014	497.7764	559.2911	
155.1798	222.0231	316.3269	469.2924	502.8741	568.1146	

The series of the processes explained above may be performed at the BRC-diagnosing ion selecting means 5400 which includes the final ion set selecting means.

(3-8) Implementation of the final discriminant & Analysis

The interpretation is available when the first, second and third type BRC-diagnosing final discriminants using the first, second and third type BRC-diagnosing low-mass ions are implemented on the set D according to the method of FIG. 28.

The result of interpretation obtained by the final discriminant is shown in FIGS. 36, 37 and Tables 226 and 230. FIGS. 36 and 37 illustrate the result of interpretation based on the average DS of the DS of five rounds, in which FIG. 36 shows the result of interpretation on set D and FIG. 37 shows the result of interpretation on set D.

【Table 230】

BRC LOME 1-29						BRC LOME 1-29						
Set C	True BRC	True Non-BRC				Set D	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL			CONT	CRC	GC	NHL	OVC
Predicted BRC	108	2	2	1	0	Predicted BRC	51	2	6	0	0	7
Predicted Non-BRC	0	93	61	30	19	Predicted Non-BRC	2	44	82	11	5	18
BRC LOME 2-42						BRC LOME 2-42						
Set C	True BRC	True Non-BRC				Set D	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL			CONT	CRC	GC	NHL	OVC
Predicted BRC	93	0	12	9	12	Predicted BRC	49	1	28	2	1	6
Predicted Non-BRC	15	95	51	22	7	Predicted Non-BRC	4	45	60	9	4	19
BRC LOME 3-75						BRC LOME 3-75						
Set C	True BRC	True Non-BRC				Set D	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL			CONT	CRC	GC	NHL	OVC

Predicted BRC	106	31	1	1	1
Predicted Non-BRC	2	64	62	30	18

BRC LOMEs 2 & 3					
Set C	True BRC	True Non-BRC			
		CONT	CRC	GC	NHL
Predicted BRC	91	0	1	0	1
Predicted Non-BRC	17	95	62	31	18

Predicted BRC	53	22	1	0	0	8
Predicted Non-BRC	0	24	87	11	5	17

BRC LOMEs 2 & 3						
Set D	True BRC	True Non-BRC				
		CONT	CRC	GC	NHL	OVC
Predicted BRC	49	1	1	0	0	4
Predicted Non-BRC	4	45	87	11	5	21

Based on the discrimination performance of the validation set (D), compared to the result by the first type BRC-diagnosing final discriminant, the results by the second and third type BRC-diagnosing final discriminants were more accurate. When the second and third type BRC-diagnosing final discriminants were used, even with the OVC patient group included, which was excluded from the training set, all the sensitivity, specificity, positive predictability and negative predictability of set D exceeded 85%.

When the first type BRC-diagnosing final discriminant was used, the set D had 85% or above sensitivity, specificity, positive predictability and negative predictability only with respect to the set excluding OVC patient group. On the whole, the first type BRC-diagnosing final discriminant is considered to exhibit good discrimination result.

Accordingly, it is possible to discriminate the BRC patients from the non-BRC patients by analyzing the low-mass ion mass spectrum of the serum.

4. Example of an apparatus for screening gastric cancer (GC)

FIG. 38 is a detailed block diagram of the cancer diagnosing unit of FIG. 7 to diagnose GC according to an embodiment of the present invention.

Referring to FIG. 38, the cancer diagnosing unit according to one embodiment may include a first aligning means 6100 which aligns a low-mass ion mass spectrum of a candidate training set consisting of the GC patient and non-GC cases; a first DS computing

means 6200 which computes DS by conducting biostatistical analysis with respect to the aligned mass spectrum; a factor loading computing means 6300 which computes sensitivity and specificity according to DS and selects a first training set based on the computed result, and computes factor loadings per low-mass ions; a GC diagnosing ion selecting means 6400 which selects low-mass ions for the purpose of diagnosing GC in terms of the discrimination performance from among the candidate low-mass ions that meet candidate condition; a second aligning means 6500 which aligns the low-mass ion mass spectrum of a biological sample of interest to the first training set; a second DS computing means 6600 which computes DS based on peak intensities of the low-mass ions of interest and the factor loadings; and a GC determining means 6700 which determines the subject of interest to be GC positive or negative depending on the DS. The GC diagnosing ion selecting means 6400 may divide the plurality of GC patient and non-GC cases into a first type discrimination case consisting of a plurality of GC patient cases and a plurality of normal cases, a second type discrimination case consisting of the plurality of GC patient cases and a plurality of cancer patient cases with cancers other than GC, a third type discrimination case consisting of the plurality of CRC patient cases and a plurality of BRC patient cases, and a fourth type discrimination case consisting of the plurality of GC patient cases and a plurality of non-Hodgkin lymphoma (NHL) patient cases, or alternatively, may divide the plurality of GC patient and non-GC patient cases into the first type discrimination cases and a fifth type discrimination cases consisting of the plurality of GC patient cases and the normal cases, and a plurality of CRC, BRC and NHN patient cases, and executed with respect to the first, second, third, fourth and fifth type discrimination cases, respectively, to divide the GC-diagnosing low-mass ions into first type GC diagnosing low-mass ions with respect to the first type discrimination case, second type GC-diagnosing low-mass ions with respect to the second type discrimination case, third type GC diagnosing low-mass ions with respect to the

third type discrimination case, fourth type GC diagnosing low-mass ions with respect to the fourth type discrimination case, and fifth type GC diagnosing low-mass ions with respect to the fifth type discrimination case.

To the above-mentioned purpose, the low-mass ion detecting unit 1000 extracts mass spectrum of the low-mass ion by detecting peak intensity of the low-mass ions using mass spectrometer with respect to biological samples of a plurality of GC patient and non-GC cases.

The detailed components of the cancer diagnosing unit to diagnose the GC are identical to those of the apparatus for screening cancer explained above with reference to FIGS. 9 to 13. Accordingly, the like elements will not be explained in detail below for the sake of brevity.

Referring to FIG. 14, the apparatus for screening cancer according to one embodiment may be implemented in a hardware level, or alternatively, in a software level via program structure, and the example of implementation in the software level will be explained below with reference to the flowcharts accompanied hereto, to explain diagnosing GC with an apparatus for screening cancer according to an embodiment.

(4-1) Sample preparation – collecting serums

Serums were collected from 49 BRC patients (Table 301), 84 normal controls (Table 302), 77 CRC patients (Table 305), 54 BRC patients (Table 306), and 24 non-Hodgkin lymphoma (NHL) patients (Table 307) and, respectively.

【Table 305】

CRC	Sex	Age year	Stage	Location	Cell Type	CEA ng/mL
CRC-E1	M	77	I	A-colon	AC	1.8
CRC-E2	M	50	I	Rectum	AC	1.9

CRC-E3	F	47	I	S-colon	AC	0.7
CRC-E4	F	82	I	A-colon	AC	1.1
CRC-E5	M	59	I	Rectum	AC	1.9
CRC-E6	M	73	I	Rectum	AC	3.6
CRC-E7	M	71	I	S-colon	AC	3.6
CRC-E8	M	71	I	Rectum	AC	9.8
CRC-E9	F	47	I	Rectum	AC	3.9
CRC-E10	F	54	I	Rectum	AC	1.6
CRC-E11	M	73	I	S-colon	AC	7.1
CRC-E12	F	74	I	S-colon	AC	2.3
CRC-E13	M	75	II	A-colon	AC	2.1
CRC-E14	F	81	II	S-colon	AC	4.1
CRC-E15	F	76	II	Rectum	AC	25.3
CRC-E16	F	71	II	A-colon	AC	1.6
CRC-E17	M	72	II	A-colon	AC	3.8
CRC-E18	F	82	II	S-colon	AC	1.8
CRC-E19	F	68	II	D-colon	AC	1.7
CRC-E20	M	71	II	S-colon	AC	3.6
CRC-E21	F	67	II	A-colon	AC	1.9
CRC-E22	M	45	II	D-colon	MAC	3.3
CRC-E23	M	60	II	S-colon	AC	2.8
CRC-E24	M	74	II	S-colon	AC	5.3
CRC-E25	M	57	II	Rectum	AC	7.3
CRC-E26	F	51	II	Rectum	AC	6.7
CRC-E27	M	79	II	S-colon	AC	6.2
CRC-E28	F	59	II	A-colon	AC	1
CRC-E29	M	62	II	S-colon	AC	-
CRC-E30	M	84	II	S-colon	AC	11.3
CRC-E31	M	68	II	Rectum	AC	5.8
CRC-E32	M	54	II	A-colon	AC	1.1
CRC-E33	F	51	II	D-colon	AC	5.9
CRC-E34	F	56	III	S-colon	AC	1.2
CRC-E35	M	52	III	S-colon	AC	3.2
CRC-E36	F	59	III	S-colon	AC	1.7
CRC-E37	F	73	III	S-colon	AC	5.7
CRC-E38	M	70	III	S-colon	AC	3.6
CRC-E39	M	68	III	A-colon	AC	9.2
CRC-E40	F	55	III	Rectum	AC	2.1
CRC-E41	F	61	III	A-colon	AC	12.7
CRC-E42	M	59	III	S-colon	AC	2.7
CRC-E43	M	67	III	Rectum	AC	9.5
CRC-E44	M	48	III	S-colon	AC	1.3
CRC-E45	M	58	III	Rectum	AC	1.7
CRC-E46	F	50	III	S-colon	AC	4.8
CRC-E47	F	51	III	S-colon	AC	7
CRC-E48	F	74	III	T-colon	AC	2.5
CRC-E49	M	60	III	Rectum	AC	3.5
CRC-E50	M	52	III	S-colon	AC	2.5

CRC-E51	M	54	III	A-colon	AC	5.3
CRC-E52	M	82	III	S-colon	AC	2.4
CRC-E53	M	54	III	S-colon	AC	5.3
CRC-E54	F	52	III	S-colon	AC	22.1
CRC-E55	M	61	III	Rectum	AC	128.1
CRC-E56	F	47	III	S-colon	AC	1.2
CRC-E57	M	71	III	A-colon	AC	8.2
CRC-E58	M	52	III	S-colon	AC	4.1
CRC-E59	F	64	III	S-colon	AC	6.8
CRC-E60	F	51	III	S-colon	AC	1.2
CRC-E61	M	55	III	A-colon	AC	1.2
CRC-E62	M	62	III	Rectum	AC	2.5
CRC-E63	M	38	III	Rectum	AC	6.1
CRC-E64	F	65	III	D-colon	AC	3.5
CRC-E65	M	49	III	S-colon, T-colon	AC	3.8
CRC-E66	M	66	III	S-colon	AC	10.7
CRC-E67	F	54	III	S-colon	AC	8.8
CRC-E68	F	70	IV	Rectum	AC	3.9
CRC-E69	M	68	IV	Rectum	AC	6
CRC-E70	M	53	IV	Rectum	AC	54.7
CRC-E71	F	63	IV	D-colon	AC	12.3
CRC-E72	F	63	IV	A-colon	AC	1.4
CRC-E73	M	66	IV	S-colon	AC	6.4
CRC-E74	F	50	IV	Rectum	AC	62
CRC-E75	M	57	IV	Rectum	AC	6.4
CRC-E76	M	57	IV	S-colon	AC	41.7
CRC-E77	M	48	IV	A-colon	AC	59.4

AC: Adenocarcinoma

MAC: Mucinous adenocarcinoma

【Table 306】

BRC	Sex	Age year	Node	ER	ER%	PR	PR%	HER2	Tumor Size cm
BRC-E1	F	48	-	5	33-66%	6	33-66%	2	-
BRC-E2	F	35	-	6	33-66%	6	33-66%	1	-
BRC-E3	F	45	pN1a	5	33-66%	5	33-66%	0	1.5
BRC-E4	F	61	-	0	0%	0	0%	2	-
BRC-E5	F	70	pN0(sn)	0	0%	0	0%	1	<0.1
BRC-E6	F	58	ypN0	3	<10%	3	10-33%	3	0.5
BRC-E7	F	49	ypN0(i+)	0	0%	0	0%	2	1.9
BRC-E8	F	49	ypN2a	0	0%	0	0%	1	2.5

BRC-E9	F	39	pN1a	6	33-66%	7	>66%	1	2.2
BRC-E10	F	48	ypN2a	6	33-66%	4	<10%	3	5.8
BRC-E11	F	39	-	0	0%	0	0%	1	-
BRC-E12	F	56	pN1a	6	33-66%	6	33-66%	0	2.8
BRC-E13	F	59	pN0(sn)	6	33-66%	2	<10%	1	2.3
BRC-E14	F	31	pN1a	5	33-66%	4	10-33%	1	2.2
BRC-E15	F	46	pN3a	6	33-66%	6	33-66%	1	3.5
BRC-E16	F	56	-	7	>66%	4	10-33%	1	-
BRC-E17	F	55	-	0	0%	0	0%	2	-
BRC-E18	F	46	pN0	0	0%	0	0%	0	1.5
BRC-E19	F	60	ypN0	0	0%	0	0%	3	1.9
BRC-E20	F	49	pN0(sn)	5	33-66%	2	<10%	2	1.5
BRC-E21	F	55	pN1mi	0	0%	0	0%	3	1.8
BRC-E22	F	65	pN0	6	33-66%	6	33-66%	0	1.7
BRC-E23	F	35	ypN2a	6	66%	4	10-33%	2	2.6
BRC-E24	F	46	pN1a	6	33-66%	6	33-66%	3	2.5
BRC-E25	F	45	pN0(sn)	6	33-66%	6	33-66%	1	0.8
BRC-E26	F	42	pN0(sn)	3	10-33%	6	33-66%	0	1
BRC-E27	F	58	pN0(sn)	6	33-66%	6	33-66%	1	1.5
BRC-E28	F	62	pN1a	0	0%	0	0%	2	2.2
BRC-E29	F	61	-	0	0%	0	0%	1	-
BRC-E30	F	60	-	-	-	-	-	-	-
BRC-E31	F	51	-	-	-	-	-	-	-
BRC-E32	F	42	pN0	7	>66%	7	>66%	2	-
BRC-E33	F	43	pN0(sn)	3	10-33%	4	10-33%	0	2.3
BRC-E34	F	60	pN0(sn)	0	0%	0	0%	1	2.3
BRC-E35	F	61	-	6	33-66%	0	0%	2	-
BRC-E36	F	61	pN0(sn)	0	0%	2	<10%	2	1.8
BRC-E37	F	49	-	-	-	-	-	-	-
BRC-E38	F	45	ypN0	0	0%	0	0%	0	0.9
BRC-E39	F	59	pN0	0	0%	0	0%	3	1.1
BRC-E40	F	43	pN1	0	0%	0	0%	0	1.5
BRC-E41	F	46	pN1	8	100%	8	100%	0	1.3
BRC-E42	F	48	pN0	6	50-60%	5	10-20%	3	1.3
BRC-E43	F	39	pN0	0	0%	0	0%	0	2.2
BRC-E44	F	66	pN0	8	95%	8	95%	0	1.7
BRC-E45	F	39	ypN0	0	0%	0	0%	0	DCIS
BRC-E46	F	37	pN0	7	70-80%	8	80%	3	1.5
BRC-E47	F	64	pN0	8	95%	8	95%	0	0.5
BRC-E48	F	44	ypN1	7	90%	8	95%	0	2
BRC-E49	F	50	pN2	8	95%	8	100%	0	1.1
BRC-E50	F	47	pN0	7	70%	7	50-60%	1	0.5
BRC-E51	F	44	pN1	8	90%	8	95%	1	0.6
BRC-E52	F	50	pN0	0	0%	0	0%	2	2.2
BRC-E53	F	53	pN0	7	95%	8	95%	0	1.1
BRC-E54	F	65	pN0	8	95%	7	40%	0	1.5

【Table 307】

NHL	Sex	Age year	Stage	Involved Site	Subtype	IPI
NHL-E1	M	44	1	stomach	DLBL	1
NHL-E2	M	39	1	nasal cavity	NK/T cell L	1
NHL-E3	M	41	1	inguinal LN	ALCL	0
NHL-E4	F	49	1	mandibular area	DLBL	0
NHL-E5	F	48	1	neck, submandibular	DLBL	0
NHL-E6	M	63	2	stomach	DLBL	1
NHL-E7	M	64	2	stomach	DLBL	2
NHL-E8	M	52	2	spleen, pancreatic LN	DLBL	1
NHL-E9	M	42	2	multiple	DLBL	2
NHL-E10	M	54	2	stomach	DLBL	1
NHL-E11	F	41	2	stomach	DLBL	1
NHL-E12	F	66	2	gum, submandibular	DLBL	1
NHL-E13	M	65	3	multiple	DLBL	3
NHL-E14	M	65	3	multiple	DLBL	3
NHL-E15	M	65	3	multiple	Follicular L	2
NHL-E16	M	58	3	multiple	DLBL	2
NHL-E17	M	40	4	multiple	DLBL	3
NHL-E18	F	57	4	multiple	DLBL	3
NHL-E19	F	24	4	multiple	DLBL	4
NHL-E20	M	56	4	multiple	DLBL	3
NHL-E21	F	76	4	multiple	DLBL	3
NHL-E22	F	69	4	multiple	Mantle cell L	4
NHL-E23	F	64	4	multiple	DLBL	5
NHL-E24	M	44	4	multiple	DLBL	2

With respect to set E_1 consisting of 288 cases, subset E_0 was constructed into the first training set. The weightings (factor loadings) per mass ions were computed by the biostatistical analysis, and the preliminary discriminant was acquired. Further, the training set was enlarged to include the second training set E_2 consisting of the 48 GC patients of Table 308, 83 normal controls of Table 309, 175 CRC patients of Table 310, 54 BRC patients of Table 311 and 22 NHL patients of Table 312. That is, to analyze GC-diagnosing low-mass ions according to the method explained below with respect to the preliminary candidate groups of the low-mass ions constructing the preliminary discriminant, the set E, i.e., union

of set E_1 and set E_2, which are independent from each other, was used as the training set.

【Table 308】

GC	Sex	Age year	CEA ng/mL	Stage
GC-E50	M	32	-	I
GC-E51	M	71	3.54	I
GC-E52	M	56	2.83	I
GC-E53	F	40	-	I
GC-E54	M	62	-	I
GC-E55	M	79	-	I
GC-E56	M	81	-	I
GC-E57	M	52	-	I
GC-E58	M	53	-	I
GC-E59	M	72	-	II
GC-E60	F	49	-	II
GC-E61	M	69	-	II
GC-E62	M	72	-	II
GC-E63	F	49	-	II
GC-E64	M	62	-	II
GC-E65	M	67	-	II
GC-E66	F	64	-	II
GC-E67	F	40	-	II
GC-E68	M	53	1	III
GC-E69	M	42	0.69	III
GC-E70	M	81	-	III
GC-E71	M	70	1.26	III
GC-E72	F	81	-	III
GC-E73	F	36	-	III
GC-E74	M	46	-	III
GC-E75	M	62	-	III
GC-E76	M	51	-	III
GC-E77	F	42	<0.4	IV
GC-E78	M	49	104.73	IV
GC-E79	M	65	1.69	IV
GC-E80	F	57	6.98	IV
GC-E81	M	55	2.03	IV
GC-E82	F	51	0.51	IV
GC-E83	M	63	27.18	IV
GC-E84	M	51	1.93	IV
GC-E85	M	64	2.41	IV
GC-E86	M	62	2.72	IV
GC-E87	F	40	0.64	IV
GC-E88	M	66	11.68	IV
GC-E89	M	51	5.6	IV

GC-E90	M	66	1.22	IV
GC-E91	M	70	-	IV
GC-E92	F	71	-	IV
GC-E93	F	52	-	IV
GC-E94	M	68	-	IV
GC-E95	M	68	-	IV
GC-E96	F	33	-	IV
GC-E97	M	31	-	IV

【Table 309】

Control	Sex	Age year	CEA ng/mL
CONT-E85	F	67	1.5
CONT-E86	F	45	0.6
CONT-E87	M	30	1
CONT-E88	M	55	1.2
CONT-E89	M	54	2.1
CONT-E90	M	69	2.8
CONT-E91	M	53	1.8
CONT-E92	F	47	1.7
CONT-E93	M	53	3.2
CONT-E94	F	49	1.4
CONT-E95	M	62	1.7
CONT-E96	M	31	2.3
CONT-E97	M	40	0.8
CONT-E98	F	49	1.4
CONT-E99	F	33	1.7
CONT-E100	M	51	3.4
CONT-E101	M	52	2
CONT-E102	F	66	1.3
CONT-E103	F	65	1.4
CONT-E104	M	50	1.4
CONT-E105	M	54	1.3
CONT-E106	M	68	1.6
CONT-E107	M	59	2.5
CONT-E108	F	51	2.1
CONT-E109	F	39	0.8
CONT-E110	F	50	1.9
CONT-E111	F	64	2.9
CONT-E112	F	52	1.9
CONT-E113	F	37	2.1
CONT-E114	F	49	2.6
CONT-E115	F	30	<0.5
CONT-E116	F	49	2.1

CONT-E117	F	38	0.6
CONT-E118	F	59	1.6
CONT-E119	F	41	1.8
CONT-E120	F	48	1.2
CONT-E121	F	39	0.5
CONT-E122	F	51	1.1
CONT-E123	F	44	1.5
CONT-E124	F	38	1.5
CONT-E125	F	48	1.9
CONT-E126	F	70	4.8
CONT-E127	F	38	2.8
CONT-E128	F	50	1.1
CONT-E129	F	54	1.8
CONT-E130	F	58	3.1
CONT-E131	M	65	2.8
CONT-E132	M	66	0.8
CONT-E133	F	54	1.6
CONT-E134	M	50	1.9
CONT-E135	F	60	1.1
CONT-E136	F	55	8.8
CONT-E137	M	62	0.9
CONT-E138	M	65	2.3
CONT-E139	M	52	2.4
CONT-E140	F	64	1.7
CONT-E141	M	57	0.8
CONT-E142	F	54	<0.5
CONT-E143	F	59	0.8
CONT-E144	F	65	1.6
CONT-E145	F	68	1.6
CONT-E146	F	51	1.7
CONT-E147	F	62	1.3
CONT-E148	F	63	1.6
CONT-E149	F	60	1.9
CONT-E150	F	68	1.4
CONT-E151	F	62	1.9
CONT-E152	F	68	5.6
CONT-E153	M	63	4.5
CONT-E154	M	50	2.1
CONT-E155	F	53	2.3
CONT-E156	M	60	3.3
CONT-E157	M	64	1.8
CONT-E158	F	63	1.1
CONT-E159	M	53	2
CONT-E160	F	51	2
CONT-E161	F	42	-
CONT-E162	M	41	-
CONT-E163	M	40	-
CONT-E164	M	51	-

CONT-E165	F	59	-
CONT-E166	F	57	-
CONT-E167	M	47	-

【Table 310】

CRC	Sex	Age year	Stage	Location	Cell Type	CEA ng/mL
CRC-E78	M	50	I	S-colon	AC	2.5
CRC-E79	M	56	I	S-colon	AC	7.3
CRC-E80	M	61	I	Rectum	AC	7.7
CRC-E81	F	78	I	Rectum	AC	2.6
CRC-E82	M	64	I	S-colon	AC	1.8
CRC-E83	F	50	I	Rectum	AC	1.6
CRC-E84	F	59	I	Rectum	AC	1.6
CRC-E85	M	71	I	Rectum	AC	83.7
CRC-E86	M	59	I	S-colon	AC	3
CRC-E87	M	64	I	Rectum	AC	2.5
CRC-E88	M	49	I	Rectum	AC	6.6
CRC-E89	F	65	II	S-colon	AC	2.1
CRC-E90	M	77	II	A-colon	AC	1.5
CRC-E91	M	71	II	D-colon	AC	4.1
CRC-E92	F	66	II	Rectum	AC	4.3
CRC-E93	F	49	II	A-colon	AC	1.6
CRC-E94	F	79	II	A-colon	AC	2.9
CRC-E95	M	69	II	S-colon	AC	4.2
CRC-E96	M	66	II	S-colon	AC	12
CRC-E97	M	74	II	A-colon	AC	1.5
CRC-E98	M	69	II	T-colon	AC	1.2
CRC-E99	M	43	II	S-colon	AC	2.2
CRC-E100	F	67	II	A-colon	AC	1.4
CRC-E101	M	72	II	A-colon	AC	4.9
CRC-E102	F	69	II	S-colon, A-colon	AC	5.1
CRC-E103	M	39	II	S-colon	AC	2.9
CRC-E104	M	54	II	Rectum	AC	4.6
CRC-E105	M	58	II	S-colon	AC	2.9
CRC-E106	M	65	II	S-colon	AC	1.7
CRC-E107	F	52	II	S-colon	AC	<0.5
CRC-E108	F	76	II	S-colon	AC	2.2
CRC-E109	M	51	II	S-colon	ASC	8.6
CRC-E110	F	79	III	Rectum	AC	14.1
CRC-E111	F	44	III	S-colon	AC	1.4
CRC-E112	M	66	III	Rectum	AC	1.2
CRC-E113	M	53	III	A-colon	AC	4.2

CRC-E114	M	64	III	T-colon	AC	1.8
CRC-E115	F	42	III	S-colon	AC	0.8
CRC-E116	M	49	III	Rectum	AC	2.7
CRC-E117	M	68	III	Rectum	AC	3.9
CRC-E118	M	51	III	S-colon	AC	5.2
CRC-E119	M	64	III	Rectum	AC	7.7
CRC-E120	M	42	III	S-colon	AC	2.8
CRC-E121	F	43	III	A-colon	AC	4.7
CRC-E122	M	66	III	S-colon	AC	9.1
CRC-E123	M	37	III	Rectum	AC	3.7
CRC-E124	F	81	III	Rectum	AC	8.4
CRC-E125	F	73	III	S-colon	AC	1.7
CRC-E126	M	54	III	Rectum	AC	6.4
CRC-E127	F	58	III	Rectum	AC	21.3
CRC-E128	F	42	III	Rectum	AC	0.7
CRC-E129	M	62	III	S-colon	AC	10.8
CRC-E130	F	60	III	S-colon, A-colon	AC	28.5
CRC-E131	F	73	III	Rectum	AC	3.7
CRC-E132	F	54	III	D-colon	AC	1122.2
CRC-E133	F	60	III	A-colon	AC	30.4
CRC-E134	M	43	III	A-colon	MAC	77.6
CRC-E135	F	69	III	Rectum	AC	1
CRC-E136	M	72	III	A-colon	AC	2.4
CRC-E137	F	52	III	S-colon	AC	9.2
CRC-E138	M	52	III	S-colon	AC	3.2
CRC-E139	F	55	III	Rectum	AC	0.9
CRC-E140	M	77	III	S-colon	AC	2.5
CRC-E141	F	47	III	S-colon	AC	1.5
CRC-E142	M	48	III	S-colon	AC	1.7
CRC-E143	F	72	IV	A-colon	AC	73.4
CRC-E144	F	69	IV	A-colon	AC	49
CRC-E145	M	75	IV	S-colon	AC	16.7
CRC-E146	M	72	IV	Rectum	SC	8.2
CRC-E147	M	73	IV	Rectum	AC	52.2
CRC-E148	M	54	IV	A-colon	AC	2
CRC-E149	M	67	IV	Rectum	AC	16.2
CRC-E150	F	66	IV	S-colon	AC	18.5
CRC-E151	F	78	IV	A-colon	AC	12.6
CRC-E152	F	54	IV	S-colon	AC	27.9
CRC-E153	M	70	II	Rectum	AC	1.3
CRC-E154	M	55	II	Rectum	AC	22
CRC-E155	M	62	II	Rectum	AC	6.1
CRC-E156	M	64	III	Rectum	AC	4.8
CRC-E157	M	62	IV	Rectum	AC	25.3
CRC-E158	M	51	III	Rectum	AC	149.3
CRC-E159	F	45	II	Rectum	AC	2.7
CRC-E160	F	49	II	Rectum	AC	2.1

CRC-E161	F	45	0	Rectum	AC	0.9
CRC-E162	M	62	III	Rectum	AC	2.4
CRC-E163	M	54	0	Rectum	AC	6.9
CRC-E164	M	45	0	Rectum	AC	7.4
CRC-E165	F	54	0	Rectum	AC	3.6
CRC-E166	M	69	II	Rectum	AC	24
CRC-E167	M	51	I	Rectum	AC	2.7
CRC-E168	M	45	I	Rectum	AC	3.2
CRC-E169	M	67	I	Rectum	AC	2.9
CRC-E170	M	60	I	Rectum	AC	1.5
CRC-E171	M	49	0	Rectum	AC	0.8
CRC-E172	M	71	I	Rectum	AC	9.8
CRC-E173	M	62	III	Rectum	AC	2.5
CRC-E174	M	54	II	Rectum	AC	4.6
CRC-E175	M	56	II	Rectum	AC	3
CRC-E176	F	71	III	Rectum	AC	6.7
CRC-E177	M	73	0	Rectum	AC	61.5
CRC-E178	F	50	III	Rectum	AC	2.2
CRC-E179	F	49	0	Rectum	AC	1.6
CRC-E180	F	42	III	Rectum	AC	9.9
CRC-E181	M	61	III	Rectum	AC	68.1
CRC-E182	F	72	II	Rectum	AC	8
CRC-E183	F	69	III	Rectum	AC	11.3
CRC-E184	M	58	II	Rectum	AC	5.3
CRC-E185	M	56	I	Rectum	AC	24.8
CRC-E186	M	72	III	Rectum	AC	1.4
CRC-E187	M	62	III	Rectum	AC	1.6
CRC-E188	M	55	II	Rectum	AC	2.4
CRC-E189	F	71	III	Rectum	AC	1.3
CRC-E190	M	59	III	Rectum	AC	2.8
CRC-E191	M	52	II	Rectum	AC	4
CRC-E192	M	47	III	Rectum	AC	2.3
CRC-E193	M	58	II	Rectum	AC	1.1
CRC-E194	M	60	0	Rectum	AC	2
CRC-E195	M	64	I	Rectum	AC	2
CRC-E196	M	41	III	Rectum	AC	1.6
CRC-E197	M	48	I	Rectum	AC	0.8
CRC-E198	M	58	II	Rectum	AC	1.1
CRC-E199	M	61	I	Rectum	AC	2.6
CRC-E200	M	63	I	Rectum	AC	1.3
CRC-E201	F	52	II	Rectum	AC	1.6
CRC-E202	M	53	II	Rectum	AC	2
CRC-E203	M	64	I	Rectum	AC	2
CRC-E204	M	73	II	Rectum	AC	5.6
CRC-E205	M	41	III	Rectum	AC	1.6
CRC-E206	M	57	III	Rectum	AC	2
CRC-E207	M	48	I	Rectum	AC	0.8
CRC-E208	M	72	III	Rectum	AC	6.1

CRC-E209	F	67	0	Rectum	AC	4.4
CRC-E210	F	66	II	Rectum	AC	4.8
CRC-E211	M	47	III	S-colon	AC	3.7
CRC-E212	M	40	III	A-colon	AC	1.2
CRC-E213	M	55	II	D-colon	AC	6
CRC-E214	F	73	I	D-colon, T-colon	AC	2
CRC-E215	F	69	I	A-colon	AC	5
CRC-E216	F	69	I	A-colon	AC	5.7
CRC-E217	F	74	II	D-colon	AC	12.5
CRC-E218	M	61	II	S-colon	MAC	1.9
CRC-E219	M	37	III	Rectum	AC	6
CRC-E220	M	60	III	S-colon	AC	5.4
CRC-E221	M	70	II	S-colon	AC	2.6
CRC-E222	M	68	III	Rectum	AC	13.2
CRC-E223	M	73	I	Rectum	AC	1.7
CRC-E224	M	82	III	T-colon	AC	2.1
CRC-E225	F	75	II	Rectum	AC	0.9
CRC-E226	F	57	I	A-colon	AC	1.5
CRC-E227	F	62	III	S-colon	AC	4.4
CRC-E228	M	73	II	Rectum	AC	15.5
CRC-E229	M	59	I	S-colon	AC	1.1
CRC-E230	F	74	III	Rectum	AC	31
CRC-E231	F	70	I	A-colon	AC	2.5
CRC-E232	M	74	II	S-colon	AC	15.4
CRC-E233	M	69	II	Rectum	AC	2.1
CRC-E234	M	61	II	A-colon, T-colon	AC	2.3
CRC-E235	M	73	I	Rectum	AC	1.9
CRC-E236	M	64	I	Rectum	AC	2.8
CRC-E237	M	69	II	D-colon	AC	5
CRC-E238	M	58	III	Rectum	AC	1.6
CRC-E239	M	73	II	T-colon	AC	2.6
CRC-E240	M	70	II	A-colon	AC	20.8
CRC-E241	M	56	IV	Rectum	AC	29.9
CRC-E242	F	70	II	A-colon	AC	5.9
CRC-E243	M	71	III	S-colon	AC	110.1
CRC-E244	M	47	III	Rectum	AC	13.7
CRC-E245	M	61	III	Rectum	AC	2.8
CRC-E246	F	77	II	S-colon	AC	1.5
CRC-E247	F	62	III	Rectum	AC	13.7
CRC-E248	M	61	II	S-colon	AC	2.3
CRC-E249	M	66	II	S-colon	AC	1.7
CRC-E250	M	64	III	A-colon	AC	1
CRC-E251	M	69	II	S-colon	AC	23
CRC-E252	M	66	0	Rectum	AC	58.4

ASC: Adenosquamous carcinoma

【Table 311】

BRC	Sex	Age year	Node	ER	ER%	PR	PR%	HER2	Tumor Size cm
BRC-E55	F	44	pN0	6	33-66%	7	>66%	1	1.2
BRC-E56	F	72	pN0(sn)	0	0%	0	0%	0	1.8
BRC-E57	F	48	pN0(sn)	5	33-66%	4	10-33%	1	0.8
BRC-E58	F	44	pN0	5	33-66%	7	>66%	1	2
BRC-E59	F	41	pN2a	5	33-66%	6	33-66%	1	4
BRC-E60	F	58	pN0	6	33-66%	0	0%	2	<0.1
BRC-E61	F	42	-	5	33-66%	6	33-66%	2	-
BRC-E62	F	44	pN1a	4	10-33%	2	<10%	2	5.5
BRC-E63	F	62	pN0(sn)	7	>66%	0	0%	0	2
BRC-E64	F	47	pN0	6	33-66%	6	33-66%	2	2.4
BRC-E65	F	52	pN1a	6	33-66%	0	0%	3	1.8
BRC-E66	F	44	pN0(sn)	6	33-66%	0	0%	0	2
BRC-E67	F	49	pN0(sn)	2	<10%	2	<10%	3	0.4
BRC-E68	F	46	pN0(sn)	6	33-66%	5	33-66%	1	0.7
BRC-E69	F	58	pN0(sn)	7	>66%	5	33-66%	1	2.3
BRC-E70	F	64	pN1a	6	33-66%	7	>66%	1	2
BRC-E71	F	47	-	6	33-66%	6	33-66%	2	-
BRC-E72	F	74	pN1a	6	33-66%	6	33-66%	1	1.8
BRC-E73	F	64	pN0(sn)	0	0%	0	0%	1	2.2
BRC-E74	F	40	ypN1a	6	33-66%	6	33-66%	1	3.5
BRC-E75	F	43	pN0	6	33-66%	6	33-66%	2	2.5
BRC-E76	F	43	ypN0	0	0%	0	0%	2	-
BRC-E77	F	42	pN0	0	0%	0	0%	0	2.3
BRC-E78	F	37	pN0(i+)	6	33-66%	6	33-66%	1	1
BRC-E79	F	50	pN1a	6	33-66%	6	33-66%	1	1
BRC-E80	F	57	pN0(sn)	6	33-66%	96	33-66%	1	1.4
BRC-E81	F	38	ypN0	0	0%	0	0%	1	2
BRC-E82	F	67	-	6	33-66%	2	<10%	1	-
BRC-E83	F	42	pN0(sn)	6	33-66%	6	33-66%	2	0.5
BRC-E84	F	46	pN0(sn)	6	33-66%	6	33-66%	1	1
BRC-E85	F	48	pN2a	4	10-33%	4	10-33%	3	2.5
BRC-E86	F	58	pN0	2	<10%	0	0	1	0.5
BRC-E87	F	53	pN0(sn)	0	0%	0	0%	3	<0.1
BRC-E88	F	56	-	0	0%	0	0%	0	-
BRC-E89	F	45	pN0(sn)	6	33-66%	6	33-66%	2	<0.1
BRC-E90	F	59	pN0(sn)	5	33-66%	0	0%	2	1.4
BRC-E91	F	40	ypN1a	2	<10%	0	0%	0	0.3
BRC-E92	F	39	pN1	7	>95%	3	<10%	0	2.2
BRC-E93	F	54	pN0(i+)	7	95%	5	10-30%	1	1.7
BRC-E94	F	48	pN3a	7	90%	8	90%	0	3.2

BRC-E95	F	54	pN0	0	0%	0	0%	0	3
BRC-E96	F	43	pN0	7	50-60%	7	50-60%	3	2.3
BRC-E97	F	61	pN0	8	95%	8	95%	0	1.6
BRC-E98	F	54	-	0	0%	0	0%	3	-
BRC-E99	F	46	pN0	7	80%	8	95%	0	2.2
BRC-E100	F	61	pN0(i+0)	7	>95%	0	0%	0	4
BRC-E101	F	53	pN0	7	80%	5	25%	0	0.6
BRC-E102	F	49	pN0	3	20%	7	60%	0	0.3
BRC-E103	F	57	pN0	0	0%	0	0%	0	0.8
BRC-E104	F	68	pN0	0	0%	3	1%	3	1.2
BRC-E105	F	58	pN0	8	95%	4	40%	0	0.8
BRC-E106	F	40	-	8	95%	8	95%	0	-
BRC-E107	F	29	pN0	8	95%	8	95%	1	1.2
BRC-E108	F	40	-	-	-	-	-	-	-

【Table 312】

NHL	Sex	Age year	Stage	Involved Site	Subtype	IPI
NHL-E25	F	56	1	breast	DLBL	0
NHL-E26	F	38	1	stomach	DLBL	0
NHL-E27	F	73	1	nasal cavity	DLBL	2
NHL-E28	F	48	1	breast	DLBL	1
NHL-E29	F	72	1	stomach	DLBL	2
NHL-E30	M	44	2	cervical LN, tonsil	DLBL	0
NHL-E31	F	38	2	tonsil, neck LN	DLBL	0
NHL-E32	M	70	2	neck area LN	DLBL	1
NHL-E33	M	80	2	stomach	PTCL	1
NHL-E34	F	61	2	stomach	DLBL	3
NHL-E35	F	76	2	stomach	DLBL	1
NHL-E36	M	67	3	multiple	Burkitt's L	3
NHL-E37	F	73	3	multiple	DLBL	2
NHL-E38	M	49	3	multiple	DLBL	3
NHL-E39	F	69	3	multiple	ATCL	3
NHL-E40	M	71	4	multiple	Mantle cell L	3
NHL-E41	F	38	4	multiple	DLBL	3
NHL-E42	F	70	4	multiple	DLBL	3
NHL-E43	M	25	4	multiple	NK/T cell L	3
NHL-E44	M	48	4	multiple	DLBL	3
NHL-E45	M	67	4	multiple	MZBCL	2
NHL-E46	M	24	4	multiple	DLBL	3

Further, validation set was constructed with set E and set F consisting of 44 GC

patients of Table 313, 81 normal controls of Table 314, 168 CRC patients of Table 315, 53 BRC patients of Table 316, 20 NHL patents of Table 317, and 25 ovarian cancer (OVC) patients of Table 318. The OVC patients were not reflected at all when obtaining weighting per mass ions or investigating GC-diagnosing low-mass ions, and included to see how these particular patient group IS discriminated with the discriminant constructed according to the present invention.

【Table 313】

GC	Sex	Age year	CEA ng/mL	Stage	GC	Sex	Age year	CEA ng/mL	Stage
GC-F1	F	62	-	I	GC-F23	M	81	-	III
GC-F2	M	52	1.86	I	GC-F24	F	81	-	III
GC-F3	F	64	4.16	I	GC-F25	M	70	-	III
GC-F4	M	67	-	I	GC-F26	M	51	-	III
GC-F5	M	61	-	I	GC-F27	M	71	8.46	IV
GC-F6	F	77	-	I	GC-F28	M	46	2.67	IV
GC-F7	F	74	-	I	GC-F29	M	68	24.93	IV
GC-F8	F	81	-	I	GC-F30	M	68	3.23	IV
GC-F9	F	55	-	I	GC-F31	M	57	41.32	IV
GC-F10	M	69	21.71	II	GC-F32	M	71	2.8	IV
GC-F11	M	59	-	II	GC-F33	F	43	1.62	IV
GC-F12	M	64	-	II	GC-F34	M	58	6.6	IV
GC-F13	M	68	-	II	GC-F35	M	73	-	IV
GC-F14	M	54	-	II	GC-F36	M	61	10.41	IV
GC-F15	F	52	-	II	GC-F37	M	66	-	IV
GC-F16	M	59	-	II	GC-F38	F	57	2.46	IV
GC-F17	F	81	-	II	GC-F39	M	52	-	IV
GC-F18	F	68	5.56	III	GC-F40	M	59	-	IV
GC-F19	M	48	1.44	III	GC-F41	M	56	-	IV
GC-F20	F	80	-	III	GC-F42	M	82	-	IV
GC-F21	M	46	1.68	III	GC-F43	F	52	-	IV
GC-F22	M	42	-	III	GC-F44	M	82	-	IV

【Table 314】

Control	Sex	Age year	CEA ng/mL	Control	Sex	Age year	CEA ng/mL

CONT-F1	M	49	1.2	CONT-F42	M	51	-
CONT-F2	F	38	0.9	CONT-F43	F	52	-
CONT-F3	F	44	-	CONT-F44	F	52	-
CONT-F4	M	52	-	CONT-F45	M	57	3.3
CONT-F5	F	45	-	CONT-F46	M	61	2.8
CONT-F6	F	54	-	CONT-F47	F	68	1.4
CONT-F7	F	51	3.1	CONT-F48	F	52	1.5
CONT-F8	M	54	6.4	CONT-F49	M	60	4.6
CONT-F9	M	46	1.1	CONT-F50	M	55	2.2
CONT-F10	M	47	1.8	CONT-F51	M	55	1.8
CONT-F11	M	49	1.7	CONT-F52	M	56	2.2
CONT-F12	F	55	<0.5	CONT-F53	F	63	1.8
CONT-F13	M	46	3.7	CONT-F54	F	65	1.1
CONT-F14	F	46	<0.5	CONT-F55	F	55	4.8
CONT-F15	M	34	1.7	CONT-F56	M	63	2.6
CONT-F16	M	53	2.9	CONT-F57	F	52	4.1
CONT-F17	M	45	3.7	CONT-F58	M	51	4
CONT-F18	M	47	4.5	CONT-F59	M	59	2
CONT-F19	F	34	0.6	CONT-F60	M	68	4.6
CONT-F20	F	58	1.5	CONT-F61	M	50	5
CONT-F21	F	54	-	CONT-F62	F	64	<0.5
CONT-F22	M	35	1.8	CONT-F63	F	63	2.2
CONT-F23	M	49	1.4	CONT-F64	M	64	1.7
CONT-F24	M	48	3.2	CONT-F65	M	51	2.3
CONT-F25	F	34	<0.5	CONT-F66	F	62	1.1
CONT-F26	M	45	4.4	CONT-F67	M	54	2.5
CONT-F27	M	52	-	CONT-F68	F	53	0.7
CONT-F28	F	44	-	CONT-F69	F	65	3.8
CONT-F29	M	58	-	CONT-F70	F	64	1.5
CONT-F30	M	45	4.3	CONT-F71	F	53	1
CONT-F31	M	61	1.4	CONT-F72	M	50	1.1
CONT-F32	M	42	2.7	CONT-F73	F	66	1.7
CONT-F33	M	48	3	CONT-F74	F	50	1.9
CONT-F34	M	53	1.9	CONT-F75	M	61	1.5
CONT-F35	F	54	2.3	CONT-F76	M	81	-
CONT-F36	F	39	1.3	CONT-F77	F	53	-
CONT-F37	F	55	1.3	CONT-F78	M	75	-
CONT-F38	M	53	-	CONT-F79	F	44	-
CONT-F39	F	45	-	CONT-F80	M	42	-
CONT-F40	F	63	-	CONT-F81	M	62	-
CONT-F41	F	51	-				

【Table 315】

CRC	Sex	Age	Stage	Location	Cell	CEA

		year			Type	ng/mL
CRC-F1	M	73	I	Rectum	AC	1.9
CRC-F2	M	65	I	S-colon	AC	14
CRC-F3	M	72	I	S-colon	AC	4.6
CRC-F4	M	82	I	Rectum	AC	3.2
CRC-F5	M	77	I	D-colon	AC	6.4
CRC-F6	M	78	I	Rectum	AC	2.7
CRC-F7	F	46	I	S-colon	AC	1.4
CRC-F8	M	61	I	Rectum	AC	1.4
CRC-F9	M	43	I	Rectum	AC	0.5
CRC-F10	M	53	I	Rectum	AC	3.5
CRC-F11	F	67	II	A-colon	AC	7.3
CRC-F12	F	75	II	Rectum	AC	12.6
CRC-F13	M	68	II	D-colon	AC	4.7
CRC-F14	F	60	II	S-colon	AC	3.3
CRC-F15	M	74	II	S-colon	AC	9
CRC-F16	M	63	II	D-colon	AC	4.9
CRC-F17	F	66	II	S-colon	AC	4.2
CRC-F18	M	48	II	Rectum	AC	28.4
CRC-F19	M	68	II	S-colon	AC	2.3
CRC-F20	M	48	II	S-colon	AC	4.8
CRC-F21	F	81	II	S-colon	AC	2.4
CRC-F22	M	56	II	A-colon	AC	34.6
CRC-F23	M	56	II	Rectum	AC	3
CRC-F24	F	77	II	Rectum	AC	6.2
CRC-F25	M	44	II	T-colon	AC	1.8
CRC-F26	F	82	II	A-colon	AC	2.8
CRC-F27	M	67	II	A-colon	AC	20.1
CRC-F28	M	72	II	A-colon	AC	3.4
CRC-F29	M	59	II	S-colon	AC	2.1
CRC-F30	F	50	III	D-colon	AC	6.4
CRC-F31	M	56	III	S-colon	AC	7.3
CRC-F32	F	58	III	S-colon	AC	2.1
CRC-F33	M	71	III	Rectum	AC	16.5
CRC-F34	M	66	III	S-colon	AC	689.8
CRC-F35	M	65	III	D-colon	AC	3.4
CRC-F36	F	65	III	S-colon	MAC	2.7
CRC-F37	F	51	III	Rectum	AC	1.4
CRC-F38	M	58	III	S-colon	AC	2.8
CRC-F39	F	48	III	A-colon	AC	0.9
CRC-F40	M	71	III	S-colon	AC	6
CRC-F41	M	68	III	A-colon	AC	2.7
CRC-F42	F	54	III	A-colon	AC	1.7
CRC-F43	F	49	III	S-colon	AC	1
CRC-F44	F	63	III	A-colon	AC	58.2
CRC-F45	M	74	III	A-colon	AC	2.8
CRC-F46	F	54	III	T-colon	AC	2.2
CRC-F47	M	68	III	Rectum	AC	22.5

CRC-F48	M	66	III	Rectum	MAC	1.2
CRC-F49	F	70	III	S-colon	MAC	36
CRC-F50	M	64	III	A-colon	AC	2.2
CRC-F51	F	54	III	Rectum	AC	5.5
CRC-F52	M	53	III	Rectum	AC	1.4
CRC-F53	M	81	III	A-colon	MAC	10.9
CRC-F54	F	52	III	A-colon	AC	1.2
CRC-F55	F	71	III	A-colon	AC	2.8
CRC-F56	M	84	III	Rectum	AC	15
CRC-F57	F	33	III	D-colon	AC	4.7
CRC-F58	F	68	III	Rectum	AC	3.3
CRC-F59	M	69	III	Rectum	AC	3.5
CRC-F60	F	61	III	A-colon	AC	2.8
CRC-F61	M	73	III	Rectum	AC	11.1
CRC-F62	M	64	III	D-colon	AC	8.2
CRC-F63	F	54	IV	S-colon	AC	29.8
CRC-F64	M	43	IV	Rectum	AC	36.4
CRC-F65	F	52	IV	A-colon	MAC	9
CRC-F66	M	48	IV	S-colon	AC	15.9
CRC-F67	M	62	IV	Rectum	AC	6.3
CRC-F68	M	69	IV	A-colon	AC	33.5
CRC-F69	M	78	IV	Rectum	AC	4.1
CRC-F70	M	38	IV	Rectum	AC	2.1
CRC-F71	M	74	II	Rectum	AC	7.9
CRC-F72	F	59	III	Rectum	AC	1.4
CRC-F73	M	56	I	Rectum	AC	2.6
CRC-F74	M	69	II	Rectum	AC	14
CRC-F75	M	58	II	Rectum	AC	10.2
CRC-F76	F	75	II	Rectum	AC	2.4
CRC-F77	M	47	II	Rectum	AC	3.2
CRC-F78	F	68	II	Rectum	AC	0.7
CRC-F79	M	52	III	Rectum	AC	2.9
CRC-F80	M	68	I	Rectum	AC	7
CRC-F81	M	51	II	Rectum	AC	1.4
CRC-F82	M	66	0	Rectum	AC	1.2
CRC-F83	M	74	0	Rectum	AC	4.5
CRC-F84	M	43	II	Rectum	AC	12.3
CRC-F85	M	68	III	Rectum	AC	2.5
CRC-F86	M	68	III	Rectum	AC	19.4
CRC-F87	F	56	I	Rectum	AC	2.3
CRC-F88	M	63	0	Rectum	AC	1.3
CRC-F89	M	65	II	Rectum	AC	2.1
CRC-F90	M	60	II	Rectum	AC	4.6
CRC-F91	M	51	II	Rectum	AC	1.3
CRC-F92	M	44	0	Rectum	AC	2.2
CRC-F93	M	61	II	Rectum	AC	2
CRC-F94	M	57	III	Rectum	AC	2.2
CRC-F95	M	41	II	Rectum	AC	3.1

CRC-F96	M	50	I	Rectum	AC	4.9
CRC-F97	F	56	III	Rectum	AC	1
CRC-F98	M	54	III	Rectum	AC	1.7
CRC-F99	F	69	I	Rectum	AC	1.5
CRC-F100	M	54	I	Rectum	AC	2.6
CRC-F101	M	61	II	Rectum	AC	3.7
CRC-F102	M	72	III	Rectum	AC	3
CRC-F103	F	71	III	Rectum	AC	1.8
CRC-F104	M	54	II	Rectum	AC	3
CRC-F105	M	77	II	Rectum	AC	1.6
CRC-F106	M	67	III	Rectum	AC	1.1
CRC-F107	M	59	II	Rectum	AC	7.2
CRC-F108	M	56	III	Rectum	AC	9
CRC-F109	F	51	I	Rectum	AC	1.5
CRC-F110	F	67	III	Rectum	AC	3.4
CRC-F111	F	76	III	Rectum	AC	1
CRC-F112	F	38	III	Rectum	AC	0.7
CRC-F113	M	53	II	Rectum	AC	3.3
CRC-F114	M	58	III	Rectum	AC	1.6
CRC-F115	M	69	III	Rectum	AC	6.4
CRC-F116	F	60	I	Rectum	AC	1.2
CRC-F117	M	52	II	Rectum	AC	4
CRC-F118	M	59	III	Rectum	AC	2.8
CRC-F119	F	56	III	Rectum	AC	2.3
CRC-F120	F	68	I	Rectum	AC	2
CRC-F121	M	65	I	Rectum	AC	1.6
CRC-F122	M	33	II	Rectum	AC	1.9
CRC-F123	M	61	III	Rectum	AC	3.2
CRC-F124	F	41	III	Rectum	AC	1.5
CRC-F125	M	61	I	Rectum	AC	1.6
CRC-F126	F	34	III	Rectum	AC	5.2
CRC-F127	M	47	III	Rectum	AC	2.3
CRC-F128	F	61	III	A-colon	AC	30.4
CRC-F129	M	71	IV	A-colon	AC	33.5
CRC-F130	M	44	III	A-colon	MAC	77.6
CRC-F131	F	71	III	Rectum	AC	1
CRC-F132	M	59	II	S-colon	AC	2.9
CRC-F133	M	79	IV	Rectum	AC	4.1
CRC-F134	M	66	II	S-colon	AC	1.7
CRC-F135	M	78	III	S-colon	AC	2.5
CRC-F136	F	53	II	S-colon	AC	1.3
CRC-F137	M	50	III	S-colon	AC	1.7
CRC-F138	F	77	II	S-colon	AC	2.2
CRC-F139	M	53	II	S-colon	ASC	8.6
CRC-F140	M	63	I	Rectum	AC	1.4
CRC-F141	F	71	III	S-colon	MAC	36
CRC-F142	F	79	II	Rectum	AC	6.2
CRC-F143	M	83	III	A-colon	MAC	10.9

CRC-F144	F	53	III	A-colon	AC	1.2
CRC-F145	F	72	III	A-colon	AC	2.8
CRC-F146	F	34	III	D-colon	AC	4.7
CRC-F147	M	70	III	Rectum	AC	3.5
CRC-F148	F	62	III	A-colon	AC	2.8
CRC-F149	M	45	II	T-colon	AC	1.8
CRC-F150	F	84	II	A-colon	AC	2.8
CRC-F151	M	74	III	Rectum	AC	11.1
CRC-F152	M	65	III	D-colon	AC	8.2
CRC-F153	M	69	II	A-colon	AC	20.1
CRC-F154	M	73	II	A-colon	AC	2.3
CRC-F155	M	61	II	S-colon	AC	2.1
CRC-F156	F	71	II	S-colon	AC	15.3
CRC-F157	F	56	I	S-colon	AC	0.7
CRC-F158	F	70	II	S-colon	AC	1.4
CRC-F159	F	62	III	Rectum	AC	235.4
CRC-F160	M	61	III	S-colon	AC	11.2
CRC-F161	F	52	III	S-colon	AC	6.4
CRC-F162	M	62	II	S-colon	AC	4.9
CRC-F163	F	61	III	T-colon	AC	13.9
CRC-F164	F	88	II	A-colon	AC	3
CRC-F165	M	73	II	S-colon	AC	16.5
CRC-F166	M	69	III	A-colon	AC	1.7
CRC-F167	M	71	III	A-colon	MAC	2.4
CRC-F168	F	45	0	Rectum	AC	-

【Table 316】

BRC	Sex	Age year	Node	ER	ER%	PR	PR%	HER2	Tumor Size cm
BRC-F1	F	34	pN0(sn)	2	<10%	0	0%	2	2
BRC-F2	F	69	-	6	33-66%	6	33-66%	1	-
BRC-F3	F	52	-	-	-	-	-	-	-
BRC-F4	F	67	-	-	-	-	-	-	-
BRC-F5	F	61	-	6	33-66%	2	<10%	0	-
BRC-F6	F	38	pN1a	6	33-66%	5	33-66%	1	-
BRC-F7	F	60	pN0	6	33-66%	3	10-33%	1	1
BRC-F8	F	55	pN2a	5	33-66%	0	0%	2	2.2
BRC-F9	F	46	ypN0	5	33-66%	2	<10%	1	1.5
BRC-F10	F	67	pN0	6	33-66%	6	33-66%	1	2.8
BRC-F11	F	46	pN1a	6	33-66%	6	33-66%	2	0.7
BRC-F12	F	39	pN1mi	6	33-66%	6	33-66%	2	2.5
BRC-F13	F	50	pN0(sn)	4	10-33%	5	33-66%	0	1
BRC-F14	F	31	pN1mi(sn)	6	33-66%	6	33-66%	1	1
BRC-F15	F	46	pN0	6	33-66%	7	>66%	1	1.2

BRC-F16	F	44	pN0(sn)	6	33-66%	7	>66%	1	2.5
BRC-F17	F	40	pN0	0	0%	0	0%	0	-
BRC-F18	F	40	-	6	33-66%	6	33-66%	1	-
BRC-F19	F	56	-	7	>66%	0	0	0	0.6
BRC-F20	F	48	pN1a	0	0%	0	0%	0	3
BRC-F21	F	39	pN0(sn)	6	33-66%	6	33-66%	1	3.5
BRC-F22	F	40	ypN1a	6	33-66%	4	10-33%	2	3
BRC-F23	F	48	pN0(sn)	6	33-66%	6	33-66%	0	2.5
BRC-F24	F	59	-	7	>66%	2	<10%	1	-
BRC-F25	F	46	-	0	0%	0	0%	2	-
BRC-F26	F	37	pN3a	6	33-66%	6	33-66%	2	0.6
BRC-F27	F	38	pN0(sn)	6	33-66%	6	33-66%	2	0.3
BRC-F28	F	66	pN1a	6	33-66%	6	33-66%	0	1.5
BRC-F29	F	58	pN0(sn)	0	0%	0	0%	2	1.7
BRC-F30	F	42	pN3a	5	33-66%	6	33-66%	0	1.8
BRC-F31	F	52	pN0	6	33-66%	6	33-66%	0	0.7
BRC-F32	F	46	pN0(sn)	0	0%	2	<10%	1	1.5
BRC-F33	F	42	pN0(sn)	4	10-33%	6	33-66%	1	0.6
BRC-F34	F	48	-	-	-	-	-	-	-
BRC-F35	F	47	pN0	6	33-66%	2	<10%	2	3
BRC-F36	F	59	pN1a	6	33-66%	4	10-33%	1	1.8
BRC-F37	F	56	-	0	0%	0	0%	3	-
BRC-F38	F	61	pN0(i+0)	7	>95%	0	0%	0	4
BRC-F39	F	40	-	8	95%	8	95%	0	-
BRC-F40	F	43	pN0	0	0%	0	0%	3	0.7
BRC-F41	F	59	pN0	8	95%	8	95%	0	1.2
BRC-F42	F	45	PN2	7	95%	8	95%	1	2.1
BRC-F43	F	55	pN0	0	0%	0	0%	3	1.8
BRC-F44	F	52	pN0	7	80-90%	8	80-90%	0	0.3
BRC-F45	F	59	pN0	8	95%	5	2~3%	1	1.3
BRC-F46	F	39	-	7	>95%	7	70-80%	0	-
BRC-F47	F	39	pN0	0	0%	0	0%	3	1.1
BRC-F48	F	40	pN0	5	50-60%	5	20-30%	0	0.8
BRC-F49	F	46	pN0	7	95%	8	95%	0	4.9
BRC-F50	F	51	pN0	0	<1%	0	0%	0	0.9
BRC-F51	F	61	pN0	7	90%	8	90%	0	1.3
BRC-F52	F	48	pN0	0	0%	0	0%	0	0.6
BRC-F53	F	47	pN0	8	>95%	8	95%	0	0.7

【Table 317】

NHL	Sex	Age year	Stage	Involved Site	Subtype	IPI
NHL-F1	F	41	1	0	DLBL	0
NHL-F2	M	73	1	nasal cavity	DLBL	1

NHL-F3	M	79	1	nasal cavity	malignant L	2
NHL-F4	M	37	1	cervical LN	DLBL	0
NHL-F5	F	39	2	tonsil, neck LN	DLBL	0
NHL-F6	M	31	2	neck	DLBL	0
NHL-F7	M	46	2	nasopharynx, tonsil	DLBL	0
NHL-F8	M	72	2	stomach	DLBL	1
NHL-F9	M	34	2	neck, SCN	DLBL	1
NHL-F10	M	70	2	stomach	DLBL	1
NHL-F11	M	52	3	multiple	DLBL	2
NHL-F12	M	52	3	multiple	DLBL	2
NHL-F13	M	67	4	multiple	DLBL	2
NHL-F14	M	73	4	tibia, leg(skin)	DLBL	3
NHL-F15	F	48	4	multiple	DLBL	3
NHL-F16	M	38	4	multiple	Hodgkin L	-
NHL-F17	M	70	4	multiple	DLBL	3
NHL-F18	M	64	4	multiple	DLBL	4
NHL-F19	M	25	4	multiple	PTCL	2
NHL-F20	M	71	-	stomach	r/o Lymphoma	-

【Table 318】

OVC	Age year	Histology	Stage
OVC-F1	56	IIIc	Clear cell carcinoma
OVC-F2	52	IIa	Endometrioid adenocarcinoma
OVC-F3	63	IV	Papillary serous adenocarcinoma
OVC-F4	55	Ia	Malignant Brenner tumor
OVC-F5	47	IIIc	Papillary serous adenocarcinoma
OVC-F6	50	Ic	Clear cell carcinoma
OVC-F7	68	Ib	Serous adenocarcinoma
OVC-F8	74	IIIc	Papillary serous adenocarcinoma
OVC-F9	43	Ic	Mucinous adenocarcinoma
OVC-F10	44	IIIc	Papillary serous adenocarcinoma
OVC-F11	54	IIIc	Papillary serous adenocarcinoma
OVC-F12	55	IV	Serous adenocarcinoma
OVC-F13	72	IIIc	Serous adenocarcinoma
OVC-F14	58	IIIc	Mucinous adenocarcinoma
OVC-F15	44	IIIc	Papillary serous adenocarcinoma
OVC-F16	57	IV	Serous adenocarcinoma
OVC-F17	54	IIIc	Papillary serous adenocarcinoma
OVC-F18	73	IIIc	Serous adenocarcinoma
OVC-F19	47	IIIc	Papillary serous adenocarcinoma
OVC-F20	40	Ic	Papillary serous adenocarcinoma
OVC-F21	74	IIb	Transitional cell carcinoma
OVC-F22	65	IIIc	Papillary serous adenocarcinoma

OVC-F23	47	IV	Serous adenocarcinoma
OVC-F24	58	IIc	Serous adenocarcinoma
OVC-F25	57	Ib	Mixed cell adenocarcinoma

(4-2) Sample preparation – preparing serum and measuring mass spectrum

4X volume of methanol/chloroform (2:1, v/v) was mixed with 25㎕ serum violently and incubated at room temperature for 10 min. The mixture was centrifuged at 4℃, 10 min, 6000 × g. The supernatant was completely dried for 1 h in the concentrator, and dissolved in the vortexer in 30㎕ of 50% acetonitrile/0.1% trifluoroacetic acid (TFA).

Methanol/chloroform extract was mixed with a-cyano-4-hydroxycinnamic acid solution in 50% acetonitrile/0.1% TFA (1:12, v/v), and 1㎕ mixture was placed on MALDI-target plate. The mass spectra of the serum extracts from the BRC patients and normal subjects were measured using the Proteomics Analyzer (Applied Biosystems, Foster City, CA, USA).

The mass spectrum data for one sample is extracted based on the average of spectrum which was repeatedly measured 20 times. The mass region of the entire individual samples was adjusted so that the maximum mass was set at approximately 2500 m/z. To minimize experimental error, various factors including focus mass, laser intensity, target plate, data acquisition time were taken into consideration.

The focus mass and the laser intensity were fixed at preferable levels, i.e., 500 m/z and 5000, respectively. In addition to the fixed focus mass and the laser intensity, the entire samples were repeatedly measured at least five times under viewpoint of other extraction and other data collection. The set C_1, from which weightings per mass ions were computed, was measured one more time.

Accordingly, the low-mass ion detecting means 6000 extracted the low-mass ion mass spectrum from the serum sample via the processes explained above, using the MALDI-

TOF.

(4-3) Discrimination strategy

In order for the constructed discriminant to be GC specific, the discriminant is required to discriminate the GC patient group from not only the normal control, but also the patient groups with other cancer types. In one embodiment, the patient groups with other cancer types include CRC patients, BRC patients and NHL patients. Table 319 provides the result of implementing the conventional PCA-DA to investigate whether one discriminant can discriminate the GC patient group from the non-GC group (normal controls, CRC patient group, BRC patient group and NHL patient group). The specificity of the NHL patient group was as low as 25.00%, and this reveals the fact that one discriminant cannot discriminate the GC patient group from the non-GC groups.

【Table 319】

						Sensitivity		97.96%
Set E_1	True GC	True Non-GC				Specificity	CONT	95.24%
		CONT	CRC	BRC	NHL		CRC	83.12%
Predicted GC	48	4	13	8	18		BRC	85.19%
Predicted Non-GC	1	80	64	46	6		NHL	25.00%

Referring to FIG. 6 and Table 304, considering the excellent discrimination result of the GC patient group from the normal controls, it was also investigated if the GC patient group was discriminated from the patient groups with other cancer types, and the result is provided by Tables 320 to 322.

【Table 320】

				Sensitivity	93.88%
Set E_1	True GC	True CRC		Specificity	98.70%
Predicted GC	46	1		PPV	97.87%
Predicted CRC	3	76		NPV	96.20%

【Table 321】

				Sensitivity	93.88%
Set E_1	True GC	True BRC		Specificity	98.15%
Predicted GC	46	1		PPV	97.87%
Predicted BRC	3	53		NPV	94.64%

【Table 322】

				Sensitivity	100.0%
Set E_1	True GC	True NHL		Specificity	100.0%
Predicted GC	49	0		PPV	100.0%
Predicted NHL	0	24		NPV	100.0%

Accordingly, discriminating the GC patient group from the non-GC patient groups may implement four discriminants consisting of a first type discriminant to discriminate GC patient group from normal controls, a second type discriminant to discriminate the GC patient

group from the CRC patient group, a third type discriminant to discriminate the GC patient group from BRC patient group, and a fourth type discriminant to discriminate the GC patient group from the NHL patient group, in which the GC patient is determined if all of the four discriminant indicate GC, while the non-GC patient is determined if any of the four discriminants indicates non-GC patient.

Considering the requirement that GC be determined based on all the discriminants will inevitably compromise the sensitivity as the number of discriminants increases, the number of discriminants may be reduced. Table 323 shows GC patient group and the normal controls distinguished from the patient groups with other types of cancers, which generally exhibits good discrimination result. Accordingly, to distinguish the GC patient group from the non-GC patient group, it is possible to combine this discriminant with the first type discriminant to distinguish the GC patient group and the normal controls from the patient groups with other types of cancers, and then distinguish the GC patient group from the normal controls. The discriminant to distinguish the GC patient group and the normal control from the patient groups with the other types of cancers will be referred to as a fifth type discriminant. It is possible to implement four discriminants or alternatively, to implement two discriminants, and these examples will be explained below.

【Table 323】

Set E_1	True GC/CONT		True CRC/BRC/NHL				Sensitivity	GC	89.80%
								CONT	95.24%
	GC	CONT	CRC	BRC	NHL		Specificity	CRC	87.01%
Predicted GC/CONT	44	80	10	0	0			BRC	100.0%
Predicted CRC/BRC/NHL	5	4	67	54	24			NHL	100.0%

(4-4) Selecting first training set E_0 and computing weightings per mass ions

Although the result of discrimination of Tables 304, 320, 321, 323 are good, the sensitivity and the specificity are not always 100%. In one embodiment of the present invention, the first training set E_0 with predetermined sensitivity and specificity is selected, and weightings per mass ions of the first training set E_0 were computed, in which the predetermined sensitivity and specificity were both 100%.

A method for selecting the first training set E_0 with the predetermined sensitivity and specificity will be explained below with reference to FIG. 39.

The first DS computing means 6200 aligned and imported the low-mass ion mass spectra of the GC patient group and the normal control group of set E_1 (F111), normalized the imported peak intensities (E112), Pareto-scaled the normalized peak intensities (F113), and computed DS by performing biostatistical analysis with respect to the Pareto-scaled peak intensities (F114).

Among a variety of biostatistical analyzing methods that can be implemented to compute DS, in one embodiment, the PCA-DA was performed. Sensitivity and specificity were computed based on the DS (F115) and the result is shown in Table 304.

Next, sensitivity threshold GN_1 and specificity threshold GN_2 were set (F116), and false positive or false negative cases were excluded when the sensitivity or the specificity was less than the corresponding threshold (F117).

In one embodiment, both the sensitivity threshold GN_1 and the specificity threshold GN_2 were set to 1, to thus find the first training set E_{01} with both the sensitivity and the specificity being 100%. That is, steps F111 to F115 were performed again with respect to the set from which one false negative case in Table 304 were excluded. It was thus confirmed

that the first type discriminant directly achieved 100% of sensitivity and specificity, but considering that the sensitivity and the specificity did not directly reach 100% when the steps F111 to F115 were repeated with respect to the set excluding the false negative case, the first training set E_{01} with both the sensitivity and the specificity being 100% was found after the steps F111 to F117 were repeated predetermined number of times (F118).

The first type discriminant to discriminate GC patient group from the normal controls reached the first training set E_{01} when 1 false negative case was excluded, the second type discriminant to discriminate GC patient group from the CRC patient group reached the first training set E_{01} when 4 false negative cases and 2 false positive cases were excluded, the third type discriminant to discriminate GC patient group from the BRC patient groups reached the first training set E_{03} when 4 false negative cases and 1 false positive case were excluded, and the fifth type discriminant to discriminate the GC patient group and the normal control from the patient groups with the other types of cancers reached the first training set E_{05} when 11 false negative cases (5 GC and 6 CONT) and 21 false positive cases (20 CRC, 1 BRC) were excluded, with both the sensitivity and specificity of each first training set reaching 100%.

Since the fourth type discriminant to discriminate the GC patient group from the NHL patient group already has 100% sensitivity and specificity as indicated in Table 322, the corresponding cases were used as they area for the first training set E_{04}. Through this process, it is possible to derive factor loadings per mass ions which provide discrimination result with both 100% sensitivity and specificity (F119).

The series of the processes explained above may be performed at the factor loading computing means 6300.

(4-5) Implementing a discriminant

The process of implementing the constructed discriminant on the sample of interest

will be explained below.

First, MarkerView™ supports the function that can be used for the similar purpose. That is, it is possible to apply the PCA-DA on only the part of the imported sample data, and discriminate the rest samples using the discriminant constructed as a result. According to this function, it is possible to select only the first training set after the import of the first training set and the other samples for analysis so that only the first training set undergoes the PCA-DA to show how the samples for analysis are interpreted.

Meanwhile, the peak alignment function to align the peaks is performed in the import process of MarkerView™. Because there is no function to align the peaks of the samples of interest based on the first training set, the peak table (matrix of m/z rows and rows of peak intensities per samples) obtained when only the first training set is imported, does not match the first training set of the peak table which is generated when the first training set is imported together with the samples of interest. The peak intensity matrices are difference, and the m/z values corresponding to the same peak intensity column also do not always appear the same. Accordingly, in order to compute DS by implementing the discriminant constructed from the first training set on the samples of interest, a realignment operation to realign the peak table, generated when the first training set is imported together with the samples of interest, to the peak table generated when only the first training set is imported.

The misalignment becomes more serious, if several samples of interests are imported together with the first training set. Accordingly, in one embodiment, with respect to the entire samples of interest, one sample of interest is added to the first training set to be imported, realigned, normalized and Pareto-scaled.

The embodiment will be explained in greater detail below with reference to FIG. 40.

First, the low-mass ion mass spectra of the samples of interest were aligned with the first training set and imported (F211).

Meanwhile, since MarkerView™ in one embodiment does not support the function of aligning and importing the sample of interest to the first training set, as explained above, a program may be designed to realign the peak table generated after importing the low-mass ion mass spectrum of the sample of interest together with the first training set to the peak table which is generated after importing the first training set only, so that the low-mass ion mess spectrum of the sample of interest aligned with the first training set is extracted. However, it is more preferable that the sample of interest is directly aligned and imported to the first training set without having realigning process and this is implementable by designing a program.

Next, the imported peak intensities were normalized (F212), and the normalized peak intensities were Pareto-scaled (F213).

Next, discriminant score was computed using the Pareto-scaled peak intensities of the low-mass ions and the factor loadings per mass ions acquired by the PCA-DA (F214).

It is determined whether or not the computed DS exceeds a reference GS (F215), and if so, it is interpreted positive (F216), while it is interpreted negative if the computed DS is less than the reference GS (F217). In one embodiment, the reference GS may preferably be 0.

The series of processes explained above may be performed at the second aligning means 6500, the second DS computing means 6600 and a GC determining means 6700.

The DS was computed by applying factor loadings per mass ions computed at Clause (4-4) with respect to the 1 GC patient sample which was excluded when constructing the first training set E_{01} from the set E_1 to construct the first type discriminant, 4 GC patient samples and 2 CRC patient samples which were excluded when constructing the first training set E_{02} from the set E_1 to construct the second type discriminant, 4 GC patient samples and 1 BRC patient sample which were excluded when constructing the first training set E_{03} from the set

E_1 to construct the third type discriminant, and 5 GC patient samples, 6 normal control samples, 20 CRC patient samples, and 1 BRC patient sample which were excluded when constructing the first training set E_{05} from the set E_1 to construct the fifth type discriminant. Considering that the cases were excluded when constructing the first training sets E_{01}, E_{02}, E_{03} and E_{05}, it was expected that the cases would be discriminated to be false positive or false negative, they were determined to be the false positive or false negative cases as expected when the computation was done, except for two cases from the GC patient group and one case from the normal control group related to the fifth type discriminant which were determined to be true positive. The result of discrimination of the set E_1 by applying the factor loadings per mass ions computed at Clause (4-4) is presented in FIGS. 41 to 45, in which FIG. 41 shows the result of the first type discriminant, FIG. 42 shows the result of the second discriminant, FIG. 43 shows the result of the third discriminant, FIG. 44 shows the result of the fourth discriminant, and FIG. 45 shows the result of the fifth discriminant.

(4-6) Constructing preliminary discriminant

Conventionally, DS is computed using the entire mass ions that are taken into consideration in the PCA-DA and the GC patient was determined according to the computed DS. In one embodiment of the present invention, a preliminary discriminant is constructed, which uses only the mass ions that contribute considerably to the DS, in order to derive a discriminant with robust discrimination performance. As used herein, the term "preliminary discriminant" refers to an intermediate form of a discriminant which is obtained before the final discriminant is obtained, and the low-mass ions constructing the discriminant are the "preliminary candidate group" of the GC-diagnosing low-mass ions to construct the final discriminant.

Through the process of FIG. 46, predetermined mass ions were selected, which give

considerable influence on the DS, from among 10,000 mass ions. In one embodiment, 299 mass ions were selected by the first type discriminant, 351 mass ions were selected by the second discriminant, 384 mass ions were selected by the third discriminant, 348 mass ions were selected by the fourth discriminant, and 383 mass ions were selected by the fifth type discriminant.

As explained above with reference to Table 303, because the maximum number of the peaks under the import condition is set to 10,000 and sufficient samples are imported, the discriminant constructed by the PCA-DA of MarkerView^{TM} consists of 10,000 terms. However, not all the 10,000 terms have the equal importance particularly in distinguishing GC patients and non-GC patients. Accordingly, the mass ions that give considerable influence on the DS were selected from among the 10,000 mass ions by two steps according to the process of FIG. 46. This particular step is employed to remove unnecessary mass ions in distinguishing GC patients from non-GC patients from the 10,000 mass ions.

The mass ions were preliminarily selected under corresponding case categories, if the absolute product obtained by multiplying the peak intensities by the factor loadings per mass ions exceeds the threshold GT_1 (F121). In one embodiment, the threshold GT_1 may preferably be 0.1.

Next, the mass ions were secondarily selected from among the preliminarily-selected mass ions under each case category, if the mass ions appear commonly in the cases exceeding the threshold percentage GT_2 (F122). In one embodiment, the threshold percentage GT_2 may preferably be 50. That is, take the fourth type discriminant for example, only the mass ions that appear commonly in at least 37 cases from among the 73 cases of the first training set were used to construct the preliminary discriminant.

The DS was again computed exclusively with the mass ions that were selected as explained above, and the sensitivity and the specificity were computed accordingly (F123).

Again, the sensitivity threshold GN_3 and the specificity threshold GN_4 were set (F124), so that if the sensitivity or the specificity is less than the corresponding threshold, the threshold GT_1 used at step F121 and/or the threshold GT_2 used at step F122 was changed (F125) and the steps from F121 to F124 were repeated. In one embodiment, the sensitivity threshold GN_3 and the specificity threshold GN_4 may preferably be 0.9, respectively.

The preliminary candidate group of the GC-diagnosing low-mass ions was constructed with the mass ions that were selected as explained above (F126), and in one embodiment, only 299 mass ions were selected by the first type discriminant from among the 10,000 mass ions, 351 mass ions were selected by the second type discriminant, 384 mass ions were selected by the third type discriminant, 348 mass ions were selected by the fourth type discriminant, and 383 mass ions were selected by the fifth type discriminant,. Tables 324 to 328 provide the results of discriminating the first training sets E_{01} to E_{05} with the first, second, third, fourth and fifth type preliminary discriminants, according to which the discrimination performance including the sensitivity and the specificity was slightly degraded from 100%, but still the result of computing with less than 4% of the total mass ions was certainly as good as the result obtained by using the entire mass ions.

Further, FIGS. 47 to 51 provide the result of discriminating the set E_1 with the preliminary discriminant, in which FIG. 47 shows the result by the first type preliminary discriminant, FIG. 48 shows the result by the second type discriminant, FIG. 49 shows the result by the third type discriminant, FIG. 50 shows the result by the fourth type discriminant, and FIG. 51 shows the result by the fifth type discriminant. Compared to the sharp reduction in the number of mass ions used for the computation, the range of DS was not so influenced. This suggests that not all 10,000 mass ions are necessary to distinguish GC patients from non-GC patients.

【Table 324】

				Sensitivity	95.83%
Set E_{01}	True GC	True CONT		Specificity	98.81%
Predicted GC	46	1		PPV	97.87%
Predicted CONT	2	83		NPV	97.65%

【Table 325】

				Sensitivity	91.11%
Set E_{02}	True GC	True CRC		Specificity	97.33%
Predicted GC	41	2		PPV	95.35%
Predicted CRC	4	73		NPV	94.81%

【Table 326】

				Sensitivity	100.0%
Set E_{03}	True GC	True BRC		Specificity	100.0%
Predicted GC	45	0		PPV	100.0%
Predicted BRC	0	53		NPV	100.0%

【Table 327】

				Sensitivity	93.88%
Set E_{04}	True GC	True		Specificit	100.0%

		NHL		y	
Predicted GC	46	0		PPV	100.0%
Predicted NHL	3	24		NPV	88.89%

【Table 328】

Set E_{05}	True GC/CONT		True CRC/BRC/NHL				Sensitivity	96.72%
	GC	CONT	CRC	BRC	NHL		Specificity	97.76%
Predicted GC/CONT	41	77	3	0	0		PPV	97.52%
Predicted CRC/BRC/NHL	3	1	54	53	24		NPV	97.04%

The series of processes explained above may be performed at the GC-diagnosing ion selecting means 6400 which includes the candidate ion set selecting means.

(4-7) Constructing a final discriminant

The mass ions were extracted from among the 10,000 mass ions imported in the process of constructing the preliminary discriminant, as those that contribute considerably to the numerical aspect of the DS. Considering that the selected mass ions include the mass ions that do not generate a problem in the first training set E_0, but can potentially deteriorate the discrimination performance in the discrimination with the mass spectrum that was re-measured with respect to the same GC patient samples and non-GC samples or in the discrimination of new GC patient group and non-GC patient group, additional step is necessary, which can actively remove the presence of such mass ions. The process of constructing a final discriminant includes such step before finally determining GC-diagnosing

low-mass ions.

To validate robustness of a discriminant, repeated measure experiment was conducted with respect to the set E_1 5 times, and the repeated measure experiment was also performed 5 times with respect to the sets E_2 and F which were independent from the set E_1 and also independent from each other. It is hardly possible to confirm that the repeated measure of the mass spectrum is always conducted under the exactly same conditions in the processes like vaporization using laser beam, desorption, ionization, or the like, in addition to the process of freezing and thawing the serums and mixing the serums with methanol/chloroform to obtain extract, and it is also hard to rule out introduction of disturbances due to various causes. In other words, the DS with respect to the repeatedly-measured individual mass spectrum may have a predetermined deviation, and considering this, interpretation in one embodiment was made by computing an average DS with respect to the sample which was repeatedly measured 5 times.

Table 329 provides the result of discriminating the sets E and F with the discriminant of 10,000 terms as a result of the conventional technology, i.e., PCA-DA by MarkerView™, and Table 330 shows the result of discriminating the sets E and F with the first type preliminary discriminant with 299 terms, the second type preliminary discriminant with 351 terms, the third type preliminary discriminant with 384 terms, the fourth type preliminary discriminant with 348 terms, and the fifth type preliminary discriminant with 383 terms.

Referring to the table, GC LOME 1 to 5 (gastric cancer low mass ion discriminant equation) refers to the first to fifth type discriminants, and the following numbers indicate the number of low-mass ions included in the discriminant. Further, Table 331 shows the discrimination performance with respect to the validation set only, i.e., to the set F.

【Table 329】

GC LOME 1-10000						GC LOME 1-10000						
Set E	True GC	True Non-GC				Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL			CONT	CRC	BRC	NHL	OVC
Predicted GC	88	9	86	38	46	Predicted GC	36	5	68	21	20	20
Predicted Non-GC	9	158	166	70	0	Predicted Non-GC	8	76	100	32	0	5
GC LOME 2-10000						GC LOME 2-10000						
Set E	True GC	True Non-GC				Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL			CONT	CRC	BRC	NHL	OVC
Predicted GC	81	13	76	29	43	Predicted GC	35	10	66	15	18	21
Predicted Non-GC	16	154	176	79	3	Predicted Non-GC	9	71	102	38	2	4
GC LOME 3-10000						GC LOME 3-10000						
Set E	True GC	True Non-GC				Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL			CONT	CRC	BRC	NHL	OVC
Predicted GC	88	32	77	19	31	Predicted GC	37	16	45	15	15	18
Predicted Non-GC	9	135	175	89	15	Predicted Non-GC	7	65	123	38	5	7
GC LOME 4-10000						GC LOME 4-10000						
Set E	True GC	True Non-GC				Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL			CONT	CRC	BRC	NHL	OVC
Predicted GC	67	146	151	38	0	Predicted GC	32	69	86	11	0	11
Predicted Non-GC	30	21	101	70	46	Predicted Non-GC	12	12	82	42	20	14
GC LOME 5-10000						GC LOME 5-10000						
Set E	True GC	True Non-GC				Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL			CONT	CRC	BRC	NHL	OVC
Predicted GC	60	137	87	0	2	Predicted GC	30	36	58	2	1	8
Predicted Non-GC	37	30	165	108	44	Predicted Non-GC	14	45	110	51	19	17
GC LOMEs 1, 2, 3 & 4						GC LOMEs 1, 2, 3 & 4						
Set E	True GC	True Non-GC				Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL			CONT	CRC	BRC	NHL	OVC
Pred	54	0	4	0	0	Predicted	23	0	4	0	0	6

icted GC						GC						
Predicted Non-GC	43	167	248	108	46	Predicted Non-GC	21	81	164	53	20	19
GC LOMEs 1 & 5						GC LOMEs 1 & 5						
Set E	True GC	True Non-GC				Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL			CONT	CRC	BRC	NHL	OVC
Predicted GC	54	5	17	0	2	Predicted GC	24	3	20	0	1	4
Predicted Non-GC	43	162	235	108	44	Predicted Non-GC	20	78	148	53	19	21

【Table 330】

GC LOME 1-299						GC LOME 1-299						
Set E	True GC	True Non-GC				Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL			CONT	CRC	BRC	NHL	OVC
Predicted GC	87	9	84	38	46	Predicted GC	36	8	65	21	20	20
Predicted Non-GC	10	158	168	70	0	Predicted Non-GC	8	73	103	32	0	5
GC LOME 2-351						GC LOME 2-351						
Set E	True GC	True Non-GC				Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL			CONT	CRC	BRC	NHL	OVC
Predicted GC	78	12	73	29	42	Predicted GC	35	10	63	15	18	21
Predicted Non-GC	19	155	179	79	4	Predicted Non-GC	9	71	105	38	2	4
GC LOME 3-384						GC LOME 3-384						
Set E	True GC	True Non-GC				Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL			CONT	CRC	BRC	NHL	OVC
Predicted GC	87	29	75	18	34	Predicted GC	37	16	43	14	15	19
Predicted Non-GC	10	138	177	90	12	Predicted Non-GC	7	65	125	39	5	6
GC LOME 4-348						GC LOME 4-348						

Set E	True GC	True Non-GC			
		CONT	CRC	BRC	NHL
Predicted GC	68	146	152	40	0
Predicted Non-GC	29	21	100	68	46

Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL	OVC
Predicted GC	32	67	84	10	0	12
Predicted Non-GC	12	14	84	43	20	13

GC LOME 5-383

Set E	True GC	True Non-GC			
		CONT	CRC	BRC	NHL
Predicted GC	56	134	84	2	1
Predicted Non-GC	41	33	168	106	45

GC LOME 5-383

Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL	OVC
Predicted GC	29	35	59	1	1	6
Predicted Non-GC	15	46	109	52	19	19

GC LOMEs 1, 2, 3 & 4

Set E	True GC	True Non-GC			
		CONT	CRC	BRC	NHL
Predicted GC	54	0	4	0	0
Predicted Non-GC	43	167	248	108	46

GC LOMEs 1, 2, 3 & 4

Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL	OVC
Predicted GC	23	0	5	0	0	7
Predicted Non-GC	21	81	163	53	20	18

GC LOMEs 1 & 5

Set E	True GC	True Non-GC			
		CONT	CRC	BRC	NHL
Predicted GC	52	4	13	0	1
Predicted Non-GC	45	163	239	108	45

GC LOMEs 1 & 5

Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL	OVC
Predicted GC	23	5	18	0	1	4
Predicted Non-GC	21	76	150	53	19	21

【Table 331】

Set F	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
GC LOME 1-10000, GC LOME 2-10000, GC LOME 3-10000 & GC LOME 4-10000	52.27	97.12	69.70	94.13
GC LOME 1-299, GC LOME 2-351,	52.27	96.54	65.71	94.10

GC LOME 3-384 & GC LOME 4-348				
GC LOME 1-14, GC LOME 2-36, GC LOME 3-50 & GC LOME 4-46	93.18	98.85	91.11	99.13
Set F	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
GC LOME 1-10000 & GC LOME 5-10000	54.55	91.93	46.15	94.10
GC LOME 1-299 & GC LOME 5-383	52.27	91.93	45.10	93.82
GC LOME 1-14 & GC LOME 5-55	79.55	98.56	87.50	97.44

The discriminant consisting of 10,000 mass ions exhibits perfect discrimination performance with respect to the first training set E_0, but with reference to Table 331, the positive predictability was particularly low with respect to set F. All the first, second, third, fourth and fifth preliminary discriminants exhibited generally good discrimination performance (Tables 324 to 328) with respect to the first training set E_0, but the discrimination result with respect to set F was far from satisfaction.

Accordingly, in one embodiment of the present invention, steps illustrated in FIG. 52 were performed to improve the preliminary discriminant to more robust discriminant.

First, the mass ions of the preliminary candidate group were divided into high sensitivity set and high specificity set (F131). As used herein, the mass ions of the high sensitivity set have higher sensitivity per mass ions than specificity, while the mass ions of the high specificity set have higher specificity per mass ions than sensitivity.

Next, the mass ions of the high sensitivity set and the mass ions of the high specificity set were sorted in a descending order $\{Sns_1, Sns_2, Sns_3 \ldots Sns_I\}\{Spc_1, Spc_2, Spc_3 \ldots Spc_J\}$ in terms of the sum of the sensitivity and specificity per mass ions, and two top mass ions of the respective sets were taken $\{Sns_1, Sns_2, Spc_1, Spc_2\}$, and a biomarker group was selected with

a combination of the best performance from among 11 combinations that are possibly made with the two or more mass ions of the four mass ions (F132).

The criteria to determine whether a combination has the best performance or not may be selected objectively and universally from among the following criteria which are listed in the order of importance:

Criterion 1) The combination with greater sum of sensitivity and specificity has better performance;

Criterion 2) The combination with less mass ions has better performance; and

Criterion 3) The combination with a greater difference between minimum DS of the true positive case and the maximum DS of true negative case has better performance.

Next, one more mass ion, i.e., the second top mass ion {Sns_3, Spc_3} was additionally taken from each of the high sensitivity set and the high specificity, so that a set with the best performance was re-selected as a biomarker group from among the four sets {biomarker group}, {biomarker group, Sns_3}, {biomarker group, Spc_3}, {biomarker group, Sns_3, Spc_3} which are the combinations of the additionally-taken mass ions {Sns_3, Spc_3} (F133).

The process repeated until the high sensitivity set and the high specificity set had no further mass ion to add (F134).

In other words, the process (F133) repeats as long as both the high sensitivity set and the high specificity set have mass ions to add, and when any of the high sensitivity set and the high specificity set has no further mass ion left to add, the next top mass ion {Sns_i or Spc_j} in the set having mass ions is additionally taken, so that a biomarker group is selected with a set of the best performance among the two sets {biomarker group}, {biomarker group, Sns_i or Spc_j} which are combinations of the additionally-taken mass ion {Sns_i or Spc_j}.

The process repeats as long as the high sensitivity set or the high specificity set is out of the mass ion, and the biomarker group that is selected when there is no mass ion left in the

high sensitivity set and high specificity set becomes the biomarker group 1 (GG) (F135).

The biomarker group 1 (GG) was removed from the preliminary candidate group (F136), the high sensitivity set and the high specificity set were constructed with the remaining mass ions, and the above-explained process repeats. The process repeats until any of the high sensitivity set and the high specificity has less than two mass ions therein (F137).

GK number of biomarker groups were combined with the biomarker groups 1, 2, ... which were obtained by the repeated process explained above, in the order of accuracy, to form a final biomarker group. As used herein, the "accuracy" refers to a proportion of true positive and true negative cases in the entire cases. In one embodiment, GK may preferably be 1, 2, or 3 (F138)

Accordingly, the mass ions of the final biomarker group were determined to be the BRC-diagnosing low-mass ions (F139).

The preliminary candidate group of the mass ions was selected from the set E_1, and more specifically, from the subset E_0, and to avoid overfitting problem, the set E_2 which was independent from the set E_1 was added to enlarge the training set when the final biomarker group was determined from the preliminary candidate group.

As a result of performing the process explained above with respect to the samples to distinguish GC patient group from the normal control group, 14 mass ions were selected as the first type GC-diagnosing low-mass ions. Further, as a result of performing the process explained above with respect to the samples to distinguish GC patient group from the CRC patient group, 36 mass ions were selected as the second type GC-diagnosing low-mass ions. Further, as a result of performing the process explained above with respect to the samples to distinguish GC patient group from the BRC patient group, 50 mass ions were selected as the third type GC-diagnosing low-mass ions. Further, as a result of performing the process explained above with respect to the samples to distinguish GC patient group from the NHL

patient group, 46 mass ions were selected as the fourth type GC-diagnosing low-mass ions. Further, as a result of performing the process explained above with respect to the samples to distinguish GC patient group from the cancer patient group with other types of cancers, 55 mass ions were selected as the fifth type GC-diagnosing low-mass ions.

The masses of the first to fifth type GC-diagnosing low-mass ions are listed in Tables 332 to 336. The low-mass ions explained above are referred to as the "first type GC-diagnosing low-mass ions", "second type GC-diagnosing low-mass ions", "third type GC-diagnosing low-mass ions", "fourth type GC-diagnosing low-mass ions", and "fifth type GC-diagnosing low-mass ions", and the discriminants according to the present invention which is finally obtained using the same are referred to as the "first type GC-diagnosing final discriminant", "second type GC-diagnosing final discriminant", "third type GC-diagnosing final discriminant", "fourth type GC-diagnosing final discriminant", and "fifth type GC-diagnosing final discriminant", respectively.

【Table 332】

22.9851	123.0842	324.1365	488.6538	526.3426	576.2893	616.1397
87.0959	314.2151	366.2424	490.3374	532.3719	606.2658	1466.5612

【Table 333】

18.0260	137.0721	207.0729	401.0680	489.3564	528.3633	585.2726
22.9830	144.1092	265.2034	431.9882	489.5293	535.2970	587.2805
38.9752	156.0171	356.1278	442.3197	490.2775	553.3205	710.3687
72.0788	172.3740	380.1643	445.0278	490.3586	557.4392	946.4028
86.1216	172.6583	381.0949	458.3228	525.3611	584.2675	1466.6433
122.0584						

【Table 334】

22.9852	184.1123	299.3423	430.3313	487.3295	534.2973	580.3417
74.0764	212.1032	314.2316	432.9929	488.3316	535.3013	583.2274
104.1387	217.9461	338.1143	456.2963	490.3400	537.3199	584.2345
105.1157	226.0798	377.0710	459.2425	496.8846	550.3255	584.3355
106.0555	228.0046	387.9830	480.3312	506.9148	560.3121	585.2423
148.0788	284.3291	426.3417	481.3399	509.3577	562.3203	600.3366
173.4924	299.1308	427.3321	482.3368	532.3532	574.3090	616.1446
176.1198						

【Table 335】

18.0264	112.0850	176.1298	213.0575	274.0827	430.3169	491.3348
22.9798	123.0738	178.1388	229.0033	284.3265	434.2556	532.2725
23.0539	129.0710	179.1466	232.0822	314.2277	456.3015	534.2841
38.9638	155.1762	192.1245	234.0749	326.3916	459.2257	569.3303
38.9937	164.0701	201.2036	235.0331	383.0532	460.9913	
46.0666	165.0955	204.1077	240.0907	417.0381	489.3314	
86.1328	175.1219	212.3577	251.9799	429.3172	490.3361	

【Table 336】

38.9674	190.1141	267.9562	368.2644	443.2100	548.3441	684.3511
76.0758	193.0672	289.2849	369.2702	445.0283	552.3114	708.3570
123.0414	215.0444	295.1666	370.2806	498.3276	553.3178	711.3711
156.0432	228.0389	301.1386	371.2848	510.2755	571.3341	723.3455
163.1135	230.0004	315.2230	396.0400	511.3414	573.2402	725.3580
164.0712	256.3291	330.2485	412.1977	513.3220	584.2661	726.3760
184.1062	257.2950	342.2497	428.1904	530.3908	666.3899	741.3357
184.1375	265.9579	346.2809	442.3155	532.2863	683.3451	

The series of processes explained above may be performed at the GC-diagnosing ion selecting means 6400 which includes the candidate ion set selecting means.

(4-8) Implementation of the final discriminant & Analysis

The interpretation is available when the first to fourth type, or first and fifth type GC-diagnosing final discriminants using the first to fifth type, or first and fifth type GC-

diagnosing low-mass ions are implemented on the set F according to the method of FIG. 40.

The result of interpretation obtained by the final discriminant is shown in FIGS. 53 and 54 and Tables 331 and 337. FIGS. 53 and 54 illustrate the result of interpretation based on the average DS of the DS of five rounds, in which FIG. 53 shows the result of interpretation on set F and FIG. 54 shows the result of interpretation on set F. Since the three-dimensional representation is necessary when the first to fourth GC-diagnosing final discriminants are used, illustration thereof is omitted, while the example of using the first and fifth GC-diagnosing final discriminants is illustrated in the accompanying drawing.

【Table 337】

GC LOME 1-14						GC LOME 1-14						
Set E	True GC	True Non-GC				Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL			CONT	CRC	BRC	NHL	OVC
Predicted GC	95	0	107	13	43	Predicted GC	42	0	92	5	19	14
Predicted Non-GC	2	167	145	95	3	Predicted Non-GC	2	81	76	48	1	11
GC LOME 2-36						GC LOME 2-36						
Set E	True GC	True Non-GC				Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL			CONT	CRC	BRC	NHL	OVC
Predicted GC	93	9	7	5	22	Predicted GC	42	12	9	3	8	14
Predicted Non-GC	4	158	245	103	24	Predicted Non-GC	2	69	159	50	12	11
GC LOME 3-50						GC LOME 3-50						
Set E	True GC	True Non-GC				Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL			CONT	CRC	BRC	NHL	OVC
Predicted GC	96	79	133	1	24	Predicted GC	44	35	111	0	13	15
Predicted Non-GC	1	88	119	107	22	Predicted Non-GC	0	46	57	53	7	10
GC LOME 4-46						GC LOME 4-46						
Set E	True GC	True Non-GC				Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL			CONT	CRC	BRC	NHL	OVC
Predicted	95	145	164	30	0	Predicted	44	70	100	6	0	3

GC					
Predicted Non-GC	2	22	88	78	46

GC LOME 5-55					
Set E	True GC	True Non-GC			
		CONT	CRC	BRC	NHL
Predicted GC	70	153	28	7	1
Predicted Non-GC	27	14	224	101	45

GC LOMEs 1, 2, 3 & 4					
Set E	True GC	True Non-GC			
		CONT	CRC	BRC	NHL
Predicted GC	89	0	5	0	0
Predicted Non-GC	8	167	247	108	46

GC LOMEs 1 & 5					
Set E	True GC	True Non-GC			
		CONT	CRC	BRC	NHL
Predicted GC	69	0	12	0	1
Predicted Non-GC	28	167	240	108	45

GC						
Predicted Non-GC	0	11	68	47	20	22

GC LOME 5-55						
Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL	OVC
Predicted GC	37	60	12	3	1	0
Predicted Non-GC	7	21	156	50	19	25

GC LOMEs 1, 2, 3 & 4						
Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL	OVC
Predicted GC	41	0	4	0	0	0
Predicted Non-GC	3	81	164	53	20	25

GC LOMEs 1 & 5						
Set F	True GC	True Non-GC				
		CONT	CRC	BRC	NHL	OVC
Predicted GC	35	0	4	0	1	0
Predicted Non-GC	9	81	164	53	19	25

Based on the discrimination performance of the validation set (F), compared to the result by the first and fifth type GC-diagnosing final discriminants, the results by the first to fifth type GC-diagnosing final discriminants were more accurate. While the increased number of discriminants is generally accompanied with the reduction in the sensitivity, considering that the third and fourth discriminants show 100% sensitivity as explained in the example, from a viewpoint of the degradation of sensitivity, it is almost like when there are indeed two discriminants. In other words, the sensitivity is not severely influenced according to the number of discriminants.

When the second and third type BRC-diagnosing final discriminants were used, even

with the OVC patient group included, which was excluded from the training set, all the sensitivity, specificity, positive predictability and negative predictability of set D exceeded 85%.

When the first to fifth type GC-diagnosing final discriminant were used, the set F had 90% or above sensitivity, specificity, positive predictability and negative predictability. When the first and fifth type GC-diagnosing final discriminant were used, the set F had approximately 80% or above sensitivity, specificity, positive predictability and negative predictability. On the whole, the first and fifth type GC-diagnosing final discriminants are also considered to exhibit good discrimination result.

Accordingly, it is possible to discriminate the GC patients from the non-GC patients by analyzing the low-mass ion mass spectrum of the serum.

The embodiment of the present invention is easily expanded to construct a discriminant to distinguish a specific cancer patient group other than CRC, BRC or GC patient groups from the normal control groups by the similar processes explained above. Further, those skilled in the art would be easily able to appreciate that it is possible to expand the embodiment of the present invention to screening of not only cancers, but also other disease types.

[Industrial Applicability]

An apparatus for cancer diagnosis of an embodiment of the present invention has a very low analysis cost in case of CRS diagnosis, short analysis cost, possible of large-scale analysis, and sensitivity, specificity, positive predictive value or PPV, negative predictive value or NPV are all over 85% not only in terms of not only in terms of a training group of CRC but also in determining the subject for cancer screening. Additionally, an apparatus for cancer diagnosis of an embodiment of the present invention may be applied on various

diseases through altering the CRC patient and normal subject to patients of other diseases and normal subject.

The apparatus for cancer diagnosis of an embodiment of the present invention has a very low analysis cost in case of BRC diagnosis, short analysis cost, possible of large-scale analysis, and sensitivity, specificity, positive predictive value or PPV, negative predictive value or NPV are all over 85% not only in terms of not only in terms of a training group of BRC but also in determining the subject for cancer screening. Additionally, an apparatus for cancer diagnosis of an embodiment of the present invention may be applied on various diseases through altering the BRC patient and normal subject to patients of other diseases and normal subject.

An apparatus for cancer diagnosis of an embodiment of the present invention has a very low analysis cost in case of GC diagnosis, short analysis cost, possible of large-scale analysis, and sensitivity, specificity, positive predictive value or PPV, negative predictive value or NPV are all over 85% not only in terms of not only in terms of a training group of GC but also in determining the subject for cancer screening. Additionally, an apparatus for cancer diagnosis of an embodiment of the present invention may be applied on various diseases through altering the GC patient and normal subject to patients of other diseases and normal subject.

CLAIMS

What is claimed is:

1. An apparatus for cancer diagnosis, comprising:

a low-mass ion detecting unit which detects mass spectra of low-mass ions of biological materials;

a cancer diagnosing unit which compares and analyzes patterns of mass spectra and diagnoses cancer; and

a display unit which displays cancer diagnosis information from the cancer diagnosing unit.

2. The apparatus of claim 1, wherein the low-mass ion detecting unit extracts the mass spectra of the low-mass ions by detecting peak intensities, peak area and mass-to-charge ratio of the low-mass ions of the biological materials.

3. The apparatus of claim 2, wherein the low-mass ion detecting unit comprises a mass measurement device including mass spectrometer.

4. The apparatus of claim 1, wherein the cancer diagnosing unit comprises:

a first aligning means which aligns the low-mass ion mass spectra of the patients with cancer and the non-cancer subjects of a candidate training set;

a first discriminant score computing means which computes a discriminant score by performing biostatistical analysis with respect to the mass spectra as aligned;

factor loadings computing means which computes sensitivity and specificity according to the discriminant score and selects a first training set by the sensitivity and specificity, and computes factor loadings based on the first training set;

a cancer diagnosing ion selecting means which selects low-mass ions for cancer diagnosis from the candidate low-mass ions meeting a condition for candidate, based on a discriminating performance thereof;

a second aligning means which aligns the low-mass ion mass spectrum of a biological sample for cancer screening with the first training set;

a second discriminant score computing means which computes a discriminant score based on peak intensities of the biological materials for cancer screening and the factor loadings; and

a cancer determining means which determines the subject for cancer screening

to be cancer positive or negative depending on the discriminant score.

5. The apparatus of claim 4, wherein the first discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the low-mass ion mass spectra of the candidate training set;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score by performing the biostatistical analysis with respect to the scaled peak intensities.

6. The apparatus of claim 5, wherein the scaling module performs Pareto scaling.

7. The apparatus of claim 5, wherein the discriminant score computing module performs the biostatistical analysis using a principal component analysis-based linear discriminant analysis (PCA-DA).

8. The apparatus of claim 7, wherein the discriminant score computing module computes the discriminant score using both the factor loadings acquired by the PCA-DA and the scaled peak intensities.

9. The apparatus of claim 4, wherein the factor loading computing means comprises a first training set selecting means which performs biostatistical analysis with respect to the aligned mass spectra and selects training cases that meet a condition for training from among the patients with cancer and the non-cancer subjects based on the result of the biostatistical analysis, and computes the factor loadings based on the first training set.

10. The apparatus of claim 9, wherein the first training set selecting means sets the first training set with the patients with cancer and the non-cancer subjects, if the result of the biostatistical analysis indicates that the sensitivity equals to or is greater than a threshold (N_1), and the specificity equals to or is greater than a threshold (N_2).

11. The apparatus of claim 10, wherein the thresholds (N_1, N_2) are 1, respectively.

12. The apparatus of claim 4, wherein the second discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the biological materials for cancer screening;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score based

on the scaled peak intensities and the factor loadings.

13. The apparatus of claim 12, wherein the scaling module performs Pareto scaling.

14. The apparatus of claim 12, wherein the discriminant score computing module computes the discriminant score based on the scaled peak intensities of the low-mass ions for cancer diagnosis and the associated factor loadings.

15. The apparatus of claim 4, wherein the cancer determining means determines the subject for cancer screening to be cancer positive or negative depending on the discriminant score, in which the cancer determining means determines cancer positive if the discriminant score of the subject for cancer screening is greater than the threshold (S), or determines cancer negative if the discriminant score of the subject for cancer screening is less than the threshold (S).

16. The apparatus of claim 15, wherein the threshold(S) is 0.

17. The apparatus of claim 15, wherein the cancer determining means determines the cancer information of the subject for cancer screening based on an average of a plurality of the discriminant scores which are computed with respect to a plurality of low-

mass ion mass spectra obtained as a result of repeatedly measuring the biological sample for cancer screening.

18. The apparatus of claim 4, wherein the cancer diagnosing ion selecting means comprises:

a candidate ion set selecting means which selects a candidate ion set with candidate low-mass ions that meet a condition for candidate from the first training set; and

a final ion set selecting means which selects a final ion set with low-mass ions for cancer diagnosis based on individual or combinational discriminating performance of the candidate low-mass ions of the candidate ion set.

19. The apparatus of claim 18, wherein the candidate ion set selecting means comprises a first low-mass ion selecting module which selects first low-mass ions for each training case, if a product of multiplying the peak intensity of each low-mass ion by the associated factor loading is greater than a threshold (T_1).

20. The apparatus of claim 19, wherein the threshold (T_1) is 0.1.

21. The apparatus of claim 19, wherein the candidate ion set selecting means comprises a candidate ion set pre-selecting module which selects the candidate ion set with second low-mass ions present commonly in cases above a threshold percent (T_2) from among

the first low-mass ions.

22. The apparatus of claim 21, wherein the threshold (T_2) is 50.

23. The apparatus of claim 21, wherein the candidate ion set selecting means further comprises:

a sensitivity and specificity computing module which computes a discriminant score, indicative of whether each of the training cases is cancer positive or negative using the second low-mass ions, and computes sensitivity and specificity according to the discriminant score; and

a final candidate ion set selecting module which changes at least one from among the thresholds (T_1, T_2) if the sensitivity is less than a threshold (N_3) or the specificity is less than a threshold (N_4), and selects the candidate ion set by repeating the processes.

24. The apparatus of claim 23, wherein the thresholds (N_3 ,N_4) are 0.9, respectively.

25. The apparatus of claim 18, wherein a criterion to evaluate the discriminating performance in the final ion set selecting means comprises a first criterion according to which a low-mass ion is selected if a sum of the sensitivity and the specificity thereof equals to or is greater than a threshold, or a combination of the candidate low-mass ions is selected if a sum

of the sensitivity and the specificity thereof is greater than any other combinations in a comparison group.

26. The apparatus of claim 18, wherein a criterion to evaluate the discriminating performance in the final ion set selecting means comprises a second criterion according to which a combination of a least number of low-mass ions is selected from among the combinations of the candidate low-mass ions in a comparison group.

27. The apparatus of claim 18, wherein a criterion to evaluate the discriminating performance in the final ion set selecting means comprises a third criterion according to which a combination of the candidate low-mass ions is selected, if a difference between the lowest discriminant score of true positive cases and the highest discriminant score of true negative cases thereof is greater than any other combinations in a comparison group, wherein the discriminant score is computed based on the scaled peak intensities of the candidate low-mass ions and the associated factor loadings, and indicative of cancer positive or negative.

28. The apparatus of claim 18, wherein the final ion set selecting means comprises:

an ion classifying module which classifies the candidate low-mass ions into a high sensitivity set $\{Sns_1, Sns_2, Sns_3 \ldots Sns_I\}$ which includes a high sensitivity low-mass ions with sensitivity exceeding the specificity and arranges the high sensitivity low-mass ions in a descending order of the sum of the sensitivity and the specificity, and a high specificity set

$\{Spc_1, Spc_2, Spc_3 \ldots Spc_J\}$ which includes a high specificity low-mass ions and arranges the high specificity low-mass ions in a descending order of the sum of the sensitivity and the specificity;

a pre-selecting module which selects a biomarker group with a combination selected from candidate combinations of two or more low-mass ions from

L upper high sensitivity low-mass ions $\{Sns_1, Sns_2, Sns_3 \ldots Sns_L\}$ and L upper high

specificity low-mass ions $\{Spc_1, Spc_2, Spc_3 \ldots Spc_L\}$, if the combination meets one or more of the first, second and third criteria for evaluating the discriminating performance;

a re-selecting module which re-selects the group of low-mass ions with a combination selected from among the group of low-mass ions and candidate combinations in which one or more low-mass ions from M next upper high sensitivity low-mass ions and

M next upper high specificity low-mass ions are added to the group of low-mass ions, if the combination meets one or more of the first, second and third criteria; and

a final group of low-mass ions selecting module which finalizes the selection of the group of low-mass ions after repeating the re-selecting until there are no next upper low-mass ions left in the high sensitivity set or the high specificity set.

29. The apparatus of claim 28, wherein the final ion set selecting means further comprises:

an additional group of low-mass ions selecting module which selects additional groups of low-mass ions by repeating the three processes to select the group of low-mass ions

with respect to the candidate ion set excluding the group of low-mass ions finalized by the final group of low-mass ions selecting module, until there are less than L low-mass ions left in the high sensitivity set or the high specificity set; and

a final cancer diagnosing low-mass ion selecting module which selects a combination of low-mass ions of top K groups of low-mass ions in terms of accuracy from among the group of low-mass ions and the additional groups of low-mass ions.

30. The apparatus of claim 29, wherein L is 2, M is 1, K is 1, 2 or 3.

31. The apparatus of claim 18, wherein the final ion set selecting means performs a low-mass ion selecting process with respect to a training set enlarged by adding a second training set, independent of the first training set, to the first training set.

32. The apparatus of claim 4, wherein the patients with cancer comprise

CRC patients with colorectal cancer, BCR patients with breast cancer, GC patients with gastric cancer, or patients with other types of cancer

33. The apparatus of claim 1, wherein the low-mass ion detector extracts mass spectra of the low-mass ions by detecting peak intensities of the low-mass ions using mass spectrometer, from biological samples of a plurality of CRC patients and normal subjects,

the cancer diagnosing unit comprises,

a first aligning means which aligns the low-mass ion mass spectra of the CRC patients and the normal subjects of a candidate training set,

a first discriminant score computing means which computes a discriminant score by performing biostatistical analysis with respect to the mass spectra as aligned,

factor loadings computing means which computes sensitivity and specificity according to the discriminant score and computes factor loadings by selecting a first training set based on the result,

a CRC-diagnosing ion selecting means which selects low-mass ions for CRC screening from the candidate low-mass ions meeting a condition for candidate, based on a discriminating performance thereof,

a second aligning means which aligns the low-mass ion mass spectra of the biological samples for interpretation with the first training set,

a second discriminant score computing means which computes a discriminant score based on a peak intensity of the low-mass ions for interpretation and the factor loading value, and

a CRC determining means which determines the subject for interpretation to be CRC positive or negative depending on the discriminant score, in which

the CRC-diagnosing ion selecting means classifies the plurality of CRC patients and the normal subjects into first cases comprising a plurality of CRC patients and a plurality of normal subjects, and second cases comprising CRC patients and non-CRC patients, and

as the first and second cases are executed, respectively,

the low-mass ions for CRC screening are classified into low-mass ions for first CRC screening with respect to the first cases and second low-mass ions for second CRC screening with respect to the second cases.

34. The apparatus of claim 33, wherein mass of each of the low-mass ions for first CRC screening is one or more selected from a group consisting of: 8.0260, 22.9797, 74.0948, 76.0763, 102.0916, 105.1078, 106.0899, 107.0477, 118.0822, 23.0395, 137.0423, 137.0729, 147.0573, 147.1058, 169.0653, 181.0656, 190.0849, 191.0848, 91.3324, 195.0785, 212.3195, 231.0667, 235.0053, 256.0939, 266.9557, 267.9501, 288.2033, 91.0997, 295.0663, 300.1297, 301.1269, 316.2288, 317.2311, 335.1862, 340.2241, 343.2451, 45.2583, 357.0666, 357.2784, 366.2310, 368.2551, 369.3302, 377.0570, 379.1438, 379.4765, 83.0529, 384.1745, 388.2688, 401.0531, 423.0313, 428.1878, 454.2090, 465.3014, 466.1923, 68.1851, 469.2831, 477.1721, 478.1678, 480.1715, 482.3220, 483.3258, 496.8683, 497.7636, 03.8719, 508.3407, 510.3265, 512.3119, 513.3177, 518.2931, 518.8555, 519.2967, 519.8598, 25.3449, 534.2739, 537.2800, 538.3306, 540.2629, 540.8144, 542.8457, 544.8692, 548.2856, 66.8375, 581.1957, 582.1888, 583.2242, 656.0270, 667.3291, 709.3519, 710.3581, 711.3617, 12.3683, 713.3798, 991.6196, 992.6209, 1016.6113, 1020.4817, 1206.5305, 1207.5571, 1465.6184, 1466.6096, 1467.5969, 2450.9701, 2451.9662 and 2452.9546 m/z (margin of error: ±0.1 m/z).

35. The apparatus of claim 33, wherein the non-CRC patients of the second cases comprise one or more of a BCR patient group, a NHL patient group with non-Hodgkin lymphoma (NHL) and a GC patient group, and

the mass of the low-mass ions for second CRC screening is one or more selected

from a group consisting of: 60.0476, 138.0540, 172.6653, 173.1158, 179.1451, 191.1277, 279.0855, 280.0895, 280.2642, 281.1440, 296.2574, 312.3248, 332.3224, 333.3324, 369.3406, 465.3161, 486.6356, 488.6882, 544.8908, 551.3287, 566.8737, 707.3475 and 733.3569 m/z (margin of error: ±0.1 m/z).

36. The apparatus of claim 33, wherein the discriminant score comprises a first class discriminant score based on the first class of the low-mass ions and a second discriminant score based on the second class of the low-mass ions, in which

the subject for interpretation is determined to be CRC positive, if the first class discriminant score is greater than CS_{11}, and the second class discriminant score is greater than CS_{21}, or

the subject for interpretation is determined to be CRC negative, if the first class discriminant score is less than CS_{12}, or the second class discrminant score is less than CS_{22}.

37. The apparatus of claim 36, wherein CS_{11}, CS_{12}, CS_{21} and CS_{22} are 0, respectively.

38. The apparatus of claim 33, wherein the low-mass ion group for discriminating CRC patients from the normal subjects using the CRC-diagnosing ion selecting means comprises fibrinogen or fibrinogen alpha chain.

39. The apparatus of claim 33, wherein the low-mass ion group for discriminating the CRC patients from the normal subjects comprises transthyretin.

40. The apparatus of claim 33, wherein the first discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the low-mass ion mass spectra of the candidate training set;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score by performing the biostatistical analysis with respect to the scaled peak intensities.

41. The apparatus of claim 40, wherein the scaling module performs Pareto scaling.

42. The apparatus of claim 40, wherein the discriminant score computing module performs the biostatistical analysis using a principal component analysis-based linear discriminant analysis (PCA-DA).

43. The apparatus of claim 42, wherein the discriminant score computing module computes the discriminant score using both the factor loadings acquired by the PCA-DA and the scaled peak intensities.

44. The apparatus of claim 33, wherein the factor loading computing means comprises a first training set selecting means which performs biostatistical analysis with respect to the aligned mass spectra and selects training cases that meet a condition for training from among the patients with CRC and the non-CRC subjects based on the result of the biostatistical analysis, and computes the factor loadings based on the first training set.

45. The apparatus of claim 44, wherein the first training set selecting means sets the first training set with the patients with CRC and the non-CRC subjects, if the result of the biostatistical analysis indicates that the sensitivity equals to or is greater than a threshold (N_1), and the specificity equals to or is greater than a threshold (N_2).

46. The apparatus of claim 45, wherein the thresholds (N_1, N_2) are 1, respectively.

47. The apparatus of claim 33, wherein the second discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the biological materials for cancer screening;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score based

on the scaled peak intensities and the factor loadings.

48. The apparatus of claim 47, wherein the scaling module performs Pareto scaling.

49. The apparatus of claim 47, wherein the discriminant score computing module computes the discriminant score based on the scaled peak intensities of the low-mass ions for CRC diagnosis and the associated factor loadings.

50. The apparatus of claim 33, wherein the cancer determining means determines the subject for cancer screening to be CRC positive or negative depending on the discriminant score, in which the cancer determining means determines CRC positive if the discriminant score of the subject for cancer screening is greater than the threshold (S), or determines CRC negative if the discriminant score of the subject for cancer screening is less than the threshold (S).

51. The apparatus of claim 50, wherein the threshold(S) is 0.

52. The apparatus of claim 33, wherein the cancer determining means determines the CRC information of the subject for cancer screening based on an average of a plurality of the discriminant scores which are computed with respect to a plurality of low-

mass ion mass spectra obtained as a result of repeatedly measuring the biological sample for cancer screening.

53. The apparatus of claim 33, wherein the CRC-diagnosing ion selecting means comprises:

a candidate ion set selecting means which selects a candidate ion set with candidate low-mass ions that meet a condition for candidate from the first training set; and

a final ion set selecting means which selects a final ion set with low-mass ions for cancer screening based on individual or combinational discriminating performance of the candidate low-mass ions of the candidate ion set.

54. The apparatus of claim 53, wherein the candidate ion set selecting means comprises a first low-mass ion selecting module which selects first low-mass ions for each training case, if a product of multiplying the peak intensity of each low-mass ion by the associated factor loading is greater than a threshold (T_1).

55. The apparatus of claim 54, wherein the threshold (T_1) is 0.1.

56. The apparatus of claim 54, wherein the candidate ion set selecting means comprises a candidate ion set pre-selecting module which selects the candidate ion set with second low-mass ions present commonly in cases above a threshold percent (T_2) from among

the first low-mass ions.

57. The apparatus of claim 56, wherein the threshold (T_2) is 50.

58. The apparatus of claim 56, wherein the candidate ion set selecting means further comprises:

a sensitivity and specificity computing module which computes a discriminant score, indicative of whether each of the training cases is CRC positive or negative using the second low-mass ions, and computes sensitivity and specificity according to the discriminant score; and

a final candidate ion set selecting module which changes at least one from among the thresholds (T_1, T_2) if the sensitivity is less than a threshold (N_3) or the specificity is less than a threshold (N_4), and selects the candidate ion set by repeating the processes.

59. The apparatus of claim 58, wherein the thresholds (N_3 ,N_4) are 0.9, respectively.

60. The apparatus of claim 53, wherein a criterion to evaluate the discriminating performance in the final ion set selecting means comprises a first criterion according to which a low-mass ion is selected if a sum of the sensitivity and the specificity thereof equals to or is greater than a threshold, or a combination of the candidate low-mass ions is selected if a sum

of the sensitivity and the specificity thereof is greater than any other combinations in a comparison group.

61. The apparatus of claim 53, wherein a criterion to evaluate the discriminating performance in the final ion set selecting means comprises a second criterion according to which a combination of a least number of low-mass ions is selected from among the combinations of the candidate low-mass ions in a comparison group.

62. The apparatus of claim 53, wherein a criterion to evaluate the discriminating performance in the final ion set selecting means comprises a third criterion according to which a combination of the candidate low-mass ions is selected, if a difference between the lowest discriminant score of true positive cases and the highest discriminant score of true negative cases thereof is greater than any other combinations in a comparison group, wherein the discriminant score is computed based on the scaled peak intensities of the candidate low-mass ions and the associated factor loadings, and indicative of CRC positive or negative.

63. The apparatus of claim 53, wherein the final ion set selecting means comprises:

an ion classifying module which classifies the candidate low-mass ions into a high sensitivity set $\{Sns_1, Sns_2, Sns_3 \ldots Sns_I\}$ which includes a high sensitivity low-mass ions with sensitivity exceeding the specificity and arranges the high sensitivity low-mass ions in a descending order of the sum of the sensitivity and the specificity, and a high specificity set

{Spc_1, Spc_2, Spc_3 ... Spc_J} which includes a high specificity low-mass ions and arranges the high specificity low-mass ions in a descending order of the sum of the sensitivity and the specificity;

a pre-selecting module which selects a biomarker group with a combination selected from candidate combinations of two or more low-mass ions from

L upper high sensitivity low-mass ions {Sns_1, Sns_2, Sns_3 ... Sns_L} and L upper high

specificity low-mass ions {Spc_1, Spc_2, Spc_3 ... Spc_L}, if the combination meets one or more of the first, second and third criteria for evaluating the discriminating performance;

a re-selecting module which re-selects the group of low-mass ions with a combination selected from among the group of low-mass ions and candidate combinations in which one or more low-mass ions from M next upper high sensitivity low-mass ions and

M next upper high specificity low-mass ions are added to the group of low-mass ions, if the combination meets one or more of the first, second and third criteria; and

a final group of low-mass ions selecting module which finalizes the selection of the group of low-mass ions after repeating the re-selecting until there are no next upper low-mass ions left in the high sensitivity set or the high specificity set.

64. The apparatus of claim 63, wherein the final ion set selecting means further comprises:

an additional group of low-mass ions selecting module which selects additional groups of low-mass ions by repeating the three processes to select the group of low-mass ions

with respect to the candidate ion set excluding the group of low-mass ions finalized by the final group of low-mass ions selecting module, until there are less than L low-mass ions left in the high sensitivity set or the high specificity set; and

a final CRC-diagnosing low-mass ion selecting module which selects a combination of low-mass ions of top K groups of low-mass ions in terms of accuracy from among the group of low-mass ions and the additional groups of low-mass ions.

65. The apparatus of claim 64, wherein L is 2, M is 1, K is 1, 2 or 3.

66. The apparatus of claim 53, wherein the final ion set selecting means performs a low-mass ion selecting process with respect to a training set enlarged by adding a second training set, independent of the first training set, to the first training set.

67. The apparatus of claim 1, wherein the low-mass ion detector extracts mass spectra of the low-mass ions by detecting peak intensities of the low-mass ions using mass spectrometer, from biological samples of a plurality of BCR patients and normal subjects,

the cancer diagnosing unit comprises,

a first aligning means which aligns the low-mass ion mass spectra of the BCR patients and the normal subjects of a candidate training set,

a first discriminant score computing means which computes a discriminant score by performing biostatistical analysis with respect to the mass spectra as aligned,

factor loadings computing means which computes sensitivity and specificity according to the discriminant score and computes factor loadings by selecting a first training set based on the result,

a BCR diagnosing ion selecting means which selects low-mass ions for BCR diagnosis from the candidate low-mass ions meeting a condition for candidate, based on a discriminating performance thereof,

a second aligning means which aligns the low-mass ion mass spectra of the biological samples for interpretation with the first training set,

a second discriminant score computing means which computes a discriminant score based on a peak intensity of the low-mass ions for interpretation and the factor loading value, and

a BCR determining means which determines the subject for interpretation to be positive or negative of BCR depending on the discriminant score, in which

the BCR diagnosing ion selecting means classifies the plurality of BCR patients and the normal subjects into first cases, or

classifies the plurality of BCR patients and the normal subjects into second cases comprising a plurality of BCR patients and a plurality of non-BCR subjects, and third cases comprising BCR patients and non-BCR patients, and

as the first, second and third cases are executed, respectively,

the low-mass ions for screening BCR are classified into low-mass ions for first BCR screening with respect to the first cases, second low-mass ions for second BCR screening with respect to the second cases, and third low-mass ions for third

BCR screening with respect to the third cases.

68. The apparatus of claim 67, wherein the non-BCR patients of the first cases comprise one or more of a patient group of normal subjects, a CRC patient group, a NHL patient group with non-Hodgkin lymphoma (NHL) and a GC patient group, and the mass of the low-mass ions for first BCR screening is one or more selected from a group consisting of: 74.0937, 74.1155, 76.0728, 136.1067, 173.4872, 193.0665, 208.0565, 212.0949, 231.0726, 258.1364, 279.0841, 280.0847, 282.2777, 313.2638, 331.2024, 332.3181, 401.0588, 427.3441, 432.9954, 452.2269, 476.6038, 490.3427, 498.3237, 499.3265, 512.3145, 562.3074, 583.2323, 584.2415, 646.3851 m/z (margin of error: ±0.1 m/z).

69. The apparatus of claim 67, wherein the mass of the low-mass ions for second BCR screening is one or more selected from a group consisting of: 38.9779, 46.0647, 74.1164, 76.0733, 97.0686, 122.0777, 123.0821, 130.1539, 185.7723, 191.1175, 208.0530, 212.0960, 225.1870, 229.0005, 231.0675, 244.0962, 281.0913, 284.3205, 313.2618, 332.3150, 342.2482, 368.2624, 398.3034, 416.0901, 424.3216, 426.3389, 428.1885, 497.3194, 513.3193, 532.6918, 538.3428, 540.3250, 570.3234, 580.3281, 581.2310, 581.3377, 610.3273, 616.3286, 618.3352, 646.3959, 725.3469, 757.1117 m/z (margin of error: ±0.1 m/z).

70. The apparatus of claim 67, wherein the non-BCR patients of the third cases comprise one or more of a CRC patient group, a patient group with non-Hodgkin lymphoma

(NHL) and a GC patient group, and the mass of the low-mass ions for third BCR screening is one or more selected from a group consisting of: 38.9736, 38.9892, 44.0491, 44.0656, 74.0938, 87.0991, 104.1316, 104.3161, 105.1091, 136.1021, 155.1798, 156.0412, 172.3072, 178.1330, 182.0738, 189.9525, 192.1294, 193.0660, 196.0871, 212.3221, 217.0923, 222.0231, 228.0348, 231.0726, 234.0422, 260.1013, 279.0843, 280.0849, 282.2791, 289.2960, 298.3425, 313.2630, 316.3269, 331.2036, 332.3169, 333.3233, 337.1047, 424.3272, 426.3406, 432.9948, 433.9894, 446.0196, 454.3014, 469.2924, 478.8688, 479.8724, 480.3180, 483.3301, 487.3152, 488.3287, 488.6580, 496.4331, 496.7718, 497.7764, 502.8741, 511.3367, 518.8776, 520.8826, 534.2829, 535.2882, 542.8770, 544.7878, 544.8728, 546.3358, 559.2911, 568.1146, 583.2284, 731.3330, 733.3526, 734.3563, 735.3665, 757.0995, 757.3512, 1465.5872, 1466.5971 m/z (margin of error: ±0.1 m/z).

71. The apparatus of claim 67, wherein the discriminant score is a first class discriminant score based on the first class low-mass ions, in which the subject for interpretation is determined to be positive of BCR if the discriminant score is greater than BS_{11}, or determined to be negative of BCR if the discriminant score is less than BS_{12}.

72. The apparatus of claim 71, wherein BS_{11} and BS_{12} are 0, respectively.

73. The apparatus of claim 67, wherein the discriminant score comprises a second class discriminant score based on the second class low-mass ions and a third class

discriminant score based on the third class low-mass ions, in which

the subject for interpretation is determined to be positive of BCR, if the second class discriminant score is greater than BS_{21} and the third class discriminant score is greater than BS_{31}, or

determined to be negative of BCR, if the second class discriminant score is less than BS_{22} or the third class discriminant score is less than BS_{32}.

74. The apparatus of claim 73, wherein BS_{21}, BS_{22}, BS_{31} and BS_{32} are 0, respectively.

75. The apparatus of claim 67, wherein the first discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the low-mass ion mass spectra of the candidate training set;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score by performing the biostatistical analysis with respect to the scaled peak intensities.

76. The apparatus of claim 75, wherein the scaling module performs Pareto scaling.

77. The apparatus of claim 75, wherein the discriminant score computing module performs the biostatistical analysis using a principal component analysis-based linear discriminant analysis (PCA-DA).

78. The apparatus of claim 77, wherein the discriminant score computing module computes the discriminant score using both the factor loadings acquired by the PCA-DA and the scaled peak intensities.

79. The apparatus of claim 67, wherein the factor loading computing means comprises a first training set selecting means which performs biostatistical analysis with respect to the aligned mass spectra and selects training cases that meet a condition for training from among the BRC patients and the non-BRC subjects based on the result of the biostatistical analysis, and computes the factor loadings based on the first training set.

80. The apparatus of claim 79, wherein the first training set selecting means sets the first training set with the patients with BRC and the non-BRC subjects, if the result of the biostatistical analysis indicates that the sensitivity equals to or is greater than a threshold (N_1), and the specificity equals to or is greater than a threshold (N_2).

81. The apparatus of claim 80, wherein the thresholds (N_1, N_2) are 1,

respectively.

82. The apparatus of claim 67, wherein the second discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the biological materials for cancer screening;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score based on the scaled peak intensities and the factor loadings.

83. The apparatus of claim 82, wherein the scaling module performs Pareto scaling.

84. The apparatus of claim 82, wherein the discriminant score computing module computes the discriminant score based on the scaled peak intensities of the low-mass ions for BRC screening and the associated factor loadings.

85. The apparatus of claim 67, wherein the cancer determining means determines the subject for cancer screening to be BRC positive or negative depending on the discriminant score, in which the cancer determining means determines BRC positive if the discriminant score of the subject for cancer screening is greater than the threshold (S), or

determines BRC negative if the discriminant score of the subject for cancer screening is less than the threshold (S).

86. The apparatus of claim 85, wherein the threshold(S) is 0.

87. The apparatus of claim 67, wherein the cancer determining means determines the BRC information of the subject for cancer screening based on an average of a plurality of the discriminant scores which are computed with respect to a plurality of low-mass ion mass spectra obtained as a result of repeatedly measuring the biological sample for cancer screening.

88. The apparatus of claim 67, wherein the BRC-diagnosing ion selecting means comprises:

a candidate ion set selecting means which selects a candidate ion set with candidate low-mass ions that meet a condition for candidate from the first training set; and

a final ion set selecting means which selects a final ion set with low-mass ions for cancer screening based on individual or combinational discriminating performance of the candidate low-mass ions of the candidate ion set.

89. The apparatus of claim 88, wherein the candidate ion set selecting means comprises a first low-mass ion selecting module which selects first low-mass ions for each

training case, if a product of multiplying the peak intensity of each low-mass ion by the associated factor loading is greater than a threshold (T_1).

90. The apparatus of claim 89, wherein the threshold (T_1) is 0.1.

91. The apparatus of claim 89, wherein the candidate ion set selecting means comprises a candidate ion set pre-selecting module which selects the candidate ion set with second low-mass ions present commonly in cases above a threshold percent (T_2) from among the first low-mass ions.

92. The apparatus of claim 91, wherein the threshold (T_2) is 50.

93. The apparatus of claim 91, wherein the candidate ion set selecting means further comprises:

a sensitivity and specificity computing module which computes a discriminant score, indicative of whether each of the training cases is BRC positive or negative using the second low-mass ions, and computes sensitivity and specificity according to the discriminant score; and

a final candidate ion set selecting module which changes at least one from among the thresholds (T_1, T_2) if the sensitivity is less than a threshold (N_3) or the specificity is less than a threshold (N_4), and selects the candidate ion set by repeating the processes.

94. The apparatus of claim 93, wherein the thresholds (N_3 ,N_4) are 0.9, respectively.

95. The apparatus of claim 88, wherein a criterion to evaluate the discriminating performance in the final ion set selecting means comprises a first criterion according to which a low-mass ion is selected if a sum of the sensitivity and the specificity thereof equals to or is greater than a threshold, or a combination of the candidate low-mass ions is selected if a sum of the sensitivity and the specificity thereof is greater than any other combinations in a comparison group.

96. The apparatus of claim 88, wherein a criterion to evaluate the discriminating performance in the final ion set selecting means comprises a second criterion according to which a combination of a least number of low-mass ions is selected from among the combinations of the candidate low-mass ions in a comparison group.

97. The apparatus of claim 88, wherein a criterion to evaluate the discriminating performance in the final ion set selecting means comprises a third criterion according to which a combination of the candidate low-mass ions is selected, if a difference between the lowest discriminant score of true positive cases and the highest discriminant score of true negative cases thereof is greater than any other combinations in a comparison group, wherein the discriminant score is computed based on the scaled peak intensities of the candidate low-

mass ions and the associated factor loadings, and indicative of BRC positive or negative.

98. The apparatus of claim 88, wherein the final ion set selecting means comprises:

an ion classifying module which classifies the candidate low-mass ions into a high sensitivity set $\{Sns_1, Sns_2, Sns_3 \ldots Sns_I\}$ which includes a high sensitivity low-mass ions with sensitivity exceeding the specificity and arranges the high sensitivity low-mass ions in a descending order of the sum of the sensitivity and the specificity, and a high specificity set $\{Spc_1, Spc_2, Spc_3 \ldots Spc_J\}$ which includes a high specificity low-mass ions and arranges the high specificity low-mass ions in a descending order of the sum of the sensitivity and the specificity;

a pre-selecting module which selects a biomarker group with a combination selected from candidate combinations of two or more low-mass ions from

L upper high sensitivity low-mass ions $\{Sns_1, Sns_2, Sns_3 \ldots Sns_L\}$ and L upper high

specificity low-mass ions $\{Spc_1, Spc_2, Spc_3 \ldots Spc_L\}$, if the combination meets one or more of the first, second and third criteria for evaluating the discriminating performance;

a re-selecting module which re-selects the group of low-mass ions with a combination selected from among the group of low-mass ions and candidate combinations in which one or more low-mass ions from M next upper high sensitivity low-mass ions and

M next upper high specificity low-mass ions are added to the group of low-mass ions, if the combination meets one or more of the first, second and third criteria; and

a final group of low-mass ions selecting module which finalizes the selection of the group of low-mass ions after repeating the re-selecting until there are no next upper low-mass ions left in the high sensitivity set or the high specificity set.

99. The apparatus of claim 98, wherein the final ion set selecting means further comprises:

an additional group of low-mass ions selecting module which selects additional groups of low-mass ions by repeating the three processes to select the group of low-mass ions with respect to the candidate ion set excluding the group of low-mass ions finalized by the final group of low-mass ions selecting module, until there are less than L low-mass ions left in the high sensitivity set or the high specificity set; and

a final BRC-diagnosing low-mass ion selecting module which selects a combination of low-mass ions of top K groups of low-mass ions in terms of accuracy from among the group of low-mass ions and the additional groups of low-mass ions.

100. The apparatus of claim 99, wherein L is 2, M is 1, K is 1, 2 or 3.

101. The apparatus of claim 88, wherein the final ion set selecting means performs a low-mass ion selecting process with respect to a training set enlarged by adding a second training set, independent of the first training set, to the first training set.

102. The apparatus of claim 1, wherein the low-mass ion detector extracts mass spectra of the low-mass ions by detecting peak intensities of the low-mass ions using mass spectrometer, from biological samples of a plurality of GC patients and normal subjects,

the cancer diagnosing unit comprises,

a first aligning means which aligns the low-mass ion mass spectra of the GC patients and the normal subjects of a candidate training set,

a first discriminant score computing means which computes a discriminant score by performing biostatistical analysis with respect to the mass spectra as aligned,

factor loadings computing means which computes sensitivity and specificity according to the discriminant score and computes factor loadings by selecting a first training set based on the result,

a GC-diagnosing ion selecting means which selects low-mass ions for GC screening from the candidate low-mass ions meeting a condition for candidate, based on a discriminating performance thereof,

a second aligning means which aligns the low-mass ion mass spectra of the biological samples for interpretation with the first training set,

a second discriminant score computing means which computes a discriminant score based on a peak intensity of the low-mass ions for interpretation and the factor loading value, and

a GC-determining means which determines the subject for interpretation to be positive or negative of GC depending on the discriminant score, in which

the GC-diagnosing ion selecting means classifies the plurality of GC patients and the normal subjects into a first class comprising a plurality of GC patients and a plurality of normal subjects, a second class comprising the plurality of GC patients and a plurality of CRC patients, a third class comprising the plurality of GC patients and a plurality of BCR patients, and a fourth class comprising the plurality of GC patients and a plurality of NHL patients, or

classifies the plurality of GC patients and the non-GC subjects into the first class and a fifth class comprising the plurality of GC patients and the normal subjects, and a plurality of CRC patients, BCR and NHL subjects, and

as the first, second, third, fourth and fifth cases are executed, respectively,

the low-mass ions for GC screening are classified into low-mass ions for first GC screening with respect to the first cases, second low-mass ions for second GC screening with respect to the second cases, third low-mass ions for third GC screening with respect to the third cases, fourth low-mass ions for third GC screening with respect to the third cases, and fifth low-mass ions for third GC screening with respect to the third cases.

103. The apparatus of claim 102, wherein the mass of the low-mass ions for first GC screening is one or more selected from a group consisting of: 22.9851, 87.0959, 123.0842, 314.2151, 324.1365, 366.2424, 488.6538, 490.3374, 526.3426, 532.3719, 576.2893, 606.2658, 616.1397, 1466.5612 m/z (margin of error: ±0.1 m/z).

104. The apparatus of claim 102, wherein the mass of the low-mass ions for second GC screening is one or more selected from a group consisting of: 18.0260, 22.9830, 38.9752, 72.0788, 86.1216, 122.0584, 137.0721, 144.1092, 156.0171, 172.3740, 172.6583, 207.0729, 265.2034, 356.1278, 380.1643, 381.0949, 401.0680, 431.9882, 442.3197, 445.0278, 458.3228, 489.3564, 489.5293, 490.2775, 490.3586, 525.3611, 528.3633, 535.2970, 553.3205, 557.4392, 584.2675, 585.2726, 587.2805, 710.3687, 946.4028, 1466.6433 m/z (margin of error: ±0.1 m/z).

105. The apparatus of claim 102, wherein the mass of the low-mass ions for third GC screening is one or more selected from a group consisting of: 22.9852, 74.0764, 104.1387, 105.1157, 106.0555, 148.0788, 173.4924, 176.1198, 184.1123, 212.1032, 217.9461, 226.0798, 228.0046, 284.3291, 299.1308, 299.3423, 314.2316, 338.1143, 377.0710, 387.9830, 426.3417, 427.3321, 430.3313, 432.9929, 456.2963, 459.2425, 480.3312, 481.3399, 482.3368, 487.3295, 488.3316, 490.3400, 496.8846, 506.9148, 509.3577, 532.3532, 534.2973, 535.3013, 537.3199, 550.3255, 560.3121, 562.3203, 574.3090, 580.3417, 583.2274, 584.2345, 584.3355, 585.2423, 600.3366, 616.1446 m/z (margin of error: ±0.1 m/z).

106. The apparatus of claim 102, wherein the mass of the low-mass ions for fourth GC screening is one or more selected from a group consisting of: 18.0264, 22.9798, 23.0539, 38.9638, 38.9937, 46.0666, 86.1328, 112.0850, 123.0738, 129.0710, 155.1762, 164.0701, 165.0955, 175.1219, 176.1298, 178.1388, 179.1466, 192.1245, 201.2036, 204.1077, 212.3577, 213.0575, 229.0033, 232.0822, 234.0749, 235.0331, 240.0907,

251.9799, 274.0827, 284.3265, 314.2277, 326.3916, 383.0532, 417.0381, 429.3172, 430.3169, 434.2556, 456.3015, 459.2257, 460.9913, 489.3314, 490.3361, 491.3348, 532.2725, 534.2841, 569.3303 m/z (margin of error: ±0.1 m/z).

107. The apparatus of claim 102, wherein the mass of the low-mass ions for fifth GC screening is one or more selected from a group consisting of: 38.9674, 76.0758, 123.0414, 156.0432, 163.1135, 164.0712, 184.1062, 184.1375, 190.1141, 193.0672, 215.0444, 228.0389, 230.0004, 256.3291, 257.2950, 265.9579, 267.9562, 289.2849, 295.1666, 301.1386, 315.2230, 330.2485, 342.2497, 346.2809, 368.2644, 369.2702, 370.2806, 371.2848, 396.0400, 412.1977, 428.1904, 442.3155, 443.2100, 445.0283, 498.3276, 510.2755, 511.3414, 513.3220, 530.3908, 532.2863, 548.3441, 552.3114, 553.3178, 571.3341, 573.2402, 584.2661, 666.3899, 683.3451, 684.3511, 708.3570, 711.3711, 723.3455, 725.3580, 726.3760, 741.3357 m/z (margin of error: ±0.1 m/z).

108. The apparatus of claim 102, wherein the discriminant score comprises a first class discriminant score based on the first class low-mass ions, a second class discriminant score based on the second class low-mass ions, a third class discriminant score based on the third class low-mass ions, and a fourth class discriminant score based on the fourth class low-mass ions, in which

the subject for interpretation is determined to be positive of GC if the first class discriminant score is greater than GS_{11}, and the second class discriminant score is greater than GS_{21}, the third class discriminant score is greater than GS_{31}, and the fourth class discriminant score is greater than GS_{41},

or the subject for interpretation is determined to be negative of GC if the first class discriminant score is less than GS_{12}, or the second class discriminant score is less than GS_{22}, or the third class discriminant score is less than GS_{32}, or the fourth class discriminant score is less than GS_{42}.

109. The apparatus of claim 108, wherein GS_{11}, GS_{12}, GS_{21}, GS_{22}, GS_{31}, GS_{32} GS_{41} and GS_{42} are 0, respectively.

110. The apparatus of claim 102, wherein the discriminant score comprises the first class discriminant score based on the first class low-mass ions and the fifth class discriminant score based on the fifth class low-mass ions, in which

the subject for interpretation is determined to be positive of GC if the first class discriminant score is greater than GS_{11}, and the fifth class discriminant score is greater than GS_{51},

or the subject for interpretation is determined to be negative of GC if the first class discriminant score is less than GS_{12}, or the fifth class discriminant score is less than GS_{52}.

111. The apparatus of claim 110, wherein GS_{11}, GS_{12}, GS_{51} and GS_{52} are 0, respectively.

112. The apparatus of claim 102, wherein the first discriminant score computing

means comprises:

a normalizing module which normalizes the peak intensities of the low-mass ion mass spectra of the candidate training set;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score by performing the biostatistical analysis with respect to the scaled peak intensities.

113. The apparatus of claim 112, wherein the scaling module performs Pareto scaling.

114. The apparatus of claim 112, wherein the discriminant score computing module performs the biostatistical analysis using a principal component analysis-based linear discriminant analysis (PCA-DA).

115. The apparatus of claim 114, wherein the discriminant score computing module computes the discriminant score using both the factor loadings acquired by the PCA-DA and the scaled peak intensities.

116. The apparatus of claim 102, wherein the factor loading computing means comprises a first training set selecting means which performs biostatistical analysis with respect to the aligned mass spectra and selects training cases that meet a condition for

training from among the GC patients and the non-GC subjects based on the result of the biostatistical analysis, and computes the factor loadings based on the first training set.

117. The apparatus of claim 116, wherein the first training set selecting means sets the first training set with the GC patients and the non-GC subjects, if the result of the biostatistical analysis indicates that the sensitivity equals to or is greater than a threshold (N_1), and the specificity equals to or is greater than a threshold (N_2).

118. The apparatus of claim 117, wherein the thresholds (N_1, N_2) are 1, respectively.

119. The apparatus of claim 102, wherein the second discriminant score computing means comprises:

a normalizing module which normalizes the peak intensities of the biological materials for cancer screening;

a scaling module which scales the normalized peak intensities; and

a discriminant score computing module which computes the discriminant score based on the scaled peak intensities and the factor loadings.

120. The apparatus of claim 119, wherein the scaling module performs Pareto scaling.

121. The apparatus of claim 119, wherein the discriminant score computing module computes the discriminant score based on the scaled peak intensities of the low-mass ions for GC screening and the associated factor loadings.

122. The apparatus of claim 102, wherein the cancer determining means determines the subject for cancer screening to be GC positive or negative depending on the discriminant score, in which the cancer determining means determines GC positive if the discriminant score of the subject for cancer screening is greater than the threshold (S), or determines GC negative if the discriminant score of the subject for cancer screening is less than the threshold (S).

123. The apparatus of claim 122, wherein the threshold(S) is 0.

124. The apparatus of claim 102, wherein the cancer determining means determines the GC information of the subject for cancer screening based on an average of a plurality of the discriminant scores which are computed with respect to a plurality of low-mass ion mass spectra obtained as a result of repeatedly measuring the biological sample for cancer screening.

125. The apparatus of claim 102, wherein the GC-diagnosing ion selecting means

comprises:

a candidate ion set selecting means which selects a candidate ion set with candidate low-mass ions that meet a condition for candidate from the first training set; and

a final ion set selecting means which selects a final ion set with low-mass ions for cancer screening based on individual or combinational discriminating performance of the candidate low-mass ions of the candidate ion set.

126. The apparatus of claim 125, wherein the candidate ion set selecting means comprises a first low-mass ion selecting module which selects first low-mass ions for each training case, if a product of multiplying the peak intensity of each low-mass ion by the associated factor loading is greater than a threshold (T_1).

127. The apparatus of claim 126, wherein the threshold (T_1) is 0.1.

128. The apparatus of claim 126, wherein the candidate ion set selecting means comprises a candidate ion set pre-selecting module which selects the candidate ion set with second low-mass ions present commonly in cases above a threshold percent (T_2) from among the first low-mass ions.

129. The apparatus of claim 128, wherein the threshold (T_2) is 50.

130. The apparatus of claim 128, wherein the candidate ion set selecting means further comprises:

a sensitivity and specificity computing module which computes a discriminant score, indicative of whether each of the training cases is GC positive or negative using the second low-mass ions, and computes sensitivity and specificity according to the discriminant score; and

a final candidate ion set selecting module which changes at least one from among the thresholds (T_1, T_2) if the sensitivity is less than a threshold (N_3) or the specificity is less than a threshold (N_4), and selects the candidate ion set by repeating the processes.

131. The apparatus of claim 130, wherein the thresholds (N_3 ,N_4) are 0.9, respectively.

132. The apparatus of claim 125, wherein a criterion to evaluate the discriminating performance in the final ion set selecting means comprises a first criterion according to which a low-mass ion is selected if a sum of the sensitivity and the specificity thereof equals to or is greater than a threshold, or a combination of the candidate low-mass ions is selected if a sum of the sensitivity and the specificity thereof is greater than any other combinations in a comparison group.

133. The apparatus of claim 125, wherein a criterion to evaluate the discriminating performance in the final ion set selecting means comprises a second criterion

according to which a combination of a least number of low-mass ions is selected from among the combinations of the candidate low-mass ions in a comparison group.

134. The apparatus of claim 125, wherein a criterion to evaluate the discriminating performance in the final ion set selecting means comprises a third criterion according to which a combination of the candidate low-mass ions is selected, if a difference between the lowest discriminant score of true positive cases and the highest discriminant score of true negative cases thereof is greater than any other combinations in a comparison group, wherein the discriminant score is computed based on the scaled peak intensities of the candidate low-mass ions and the associated factor loadings, and indicative of GC positive or negative.

135. The apparatus of claim 125, wherein the final ion set selecting means comprises:

an ion classifying module which classifies the candidate low-mass ions into a high sensitivity set $\{Sns_1, Sns_2, Sns_3 \ldots Sns_I\}$ which includes a high sensitivity low-mass ions with sensitivity exceeding the specificity and arranges the high sensitivity low-mass ions in a descending order of the sum of the sensitivity and the specificity, and a high specificity set $\{Spc_1, Spc_2, Spc_3 \ldots Spc_J\}$ which includes a high specificity low-mass ions and arranges the high specificity low-mass ions in a descending order of the sum of the sensitivity and the specificity;

a pre-selecting module which selects a biomarker group with a combination selected

from candidate combinations of two or more low-mass ions from

L upper high sensitivity low-mass ions {Sns_1, Sns_2, Sns_3 ... Sns_L} and L upper high

specificity low-mass ions {Spc_1, Spc_2, Spc_3 ... Spc_L}, if the combination meets one or more of the first, second and third criteria for evaluating the discriminating performance;

a re-selecting module which re-selects the group of low-mass ions with a combination selected from among the group of low-mass ions and candidate combinations in which one or more low-mass ions from M next upper high sensitivity low-mass ions and

M next upper high specificity low-mass ions are added to the group of low-mass ions, if the combination meets one or more of the first, second and third criteria; and

a final group of low-mass ions selecting module which finalizes the selection of the group of low-mass ions after repeating the re-selecting until there are no next upper low-mass ions left in the high sensitivity set or the high specificity set.

136. The apparatus of claim 135, wherein the final ion set selecting means further comprises:

an additional group of low-mass ions selecting module which selects additional groups of low-mass ions by repeating the three processes to select the group of low-mass ions with respect to the candidate ion set excluding the group of low-mass ions finalized by the final group of low-mass ions selecting module, until there are less than L low-mass ions left in the high sensitivity set or the high specificity set; and

a final GC-diagnosing low-mass ion selecting module which selects a combination of

low-mass ions of top K groups of low-mass ions in terms of accuracy from among the group of low-mass ions and the additional groups of low-mass ions.

137. The apparatus of claim 136, wherein L is 2, M is 1, K is 1, 2 or 3.

138. The apparatus of claim 125, wherein the final ion set selecting means performs a low-mass ion selecting process with respect to a training set enlarged by adding a second training set, independent of the first training set, to the first training set.