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

~~{$Spc_1$, $Spc_2$, $Spc_3$ ... $Spc_J$} 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.

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.~~

CLAIMS

What is claimed is:

1. An apparatus for cancer diagnosis comprises:

a low-mass ion detecting unit which detects mass spectra of low-mass ions of biological materials from a plurarity of subjects with cancer and normal subjects; and

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

wherein the cancer diagnosing unit comprises;

a first aligning means which aligns the 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, in which

wherein mass of each of the low-mass ions equals to or is greater than 18.0260, equals to or less than 2452.9546 m/z, equals to or greater than 38.9736, equals to or less than 1466.5971 m/z, or equals to or greater than 18.0260, equals to or less than 1466.6433 m/z (margin of error: ±0.1 m/z).

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

5. The apparatus of claim 1, 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 5, 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 1, 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 1, 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 9, 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 (T1, T2) if the sensitivity is less than a threshold (N3), or the specificity is less than a threshold (N4), and re-selects the first low-mass ions and the second low-mass ions, and computes sensitivity and specificity using the first and the second low-mass ions and selects the candidate ion set by repeating comparing process with the threshold.

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 25, 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 26, wherein a criterion to evaluate the discriminating

performance in the final ion set selecting means comprises; Korean Patent Application 10-1461615

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 27, wherein 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 biomarker group 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 biomarker group selecting module which finalizes the selection of the biomarker group 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. a biomarker group additional selection module which selects additional biomarker group by repeating pre-selecting, reselecting, and final selecting process of the biomarker group with respect to the candidate ion set excluding the group of low-mass ions finalized by a biomarker group additional selection 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 biomarker groups based on analyzing accuracy of the true positive and the true negative from among the biomarker group and the additional biomarker groups.

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 1, 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. a low-mass ion detecting unit which detects the peak intensity having mass of biological materials from a plurality of CRC patients and normal subjects with cancer and normal subjects equals to or greater than 18.0260, equals to or less than 2452.9546 m/z; and

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

wherein 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 in the normalizing module; and

a discriminant score computing module which computes the discriminant score in the scaling module 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 40, 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 in the normalizing module; and

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

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 44, 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 first and

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 (CT1, CT2) if the sensitivity is less than a threshold (CN3) or the specificity is less than a threshold (CN4), reselects the candidate ion set, and computes sensitivity and specifity using the reselected the first and the second low-mass ions by repeating comparing to the threshold 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 60, wherein a criterion to evaluate the discriminating performance in the final ion set selecting means further 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 61, 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 62, wherein 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.

64. The apparatus of claim 63, wherein the final ion set selecting means further comprises:

a biomarker group additional selection module which selects additional biomarker group by repeating pre-selecting, reselecting, and final selecting process of the biomarker group with respect to the candidate ion set excluding the group of low-mass ions finalized by the biomarker group additional selection 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 biomarker groups in terms of accuracy from among the biomarker group and the additional biomarker groups.

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 cancer diagnosing appararus comprises; low-mass ion detecting unit extracts the mass spectra of the low-mass ions by detecting peak intensities having mass of biological materials from a plurality of BCR patients and normal subjects with cancer and normal subjects equals to or greater than 38.9736, equals to or less than 1466.5971 m/z (margin of error: ±0.1 m/z); and;

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

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 75, 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 in the normalizing module; and

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

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 79, 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 (BT1, BT2) if the sensitivity is less than a threshold (BN3) or the specificity is less than a threshold (BN4), and reselects the first low-mass ion and the second low-mass ion and computes the sensitivity and specificity using the reselected first and the second low-mass ions by repeating comparing process with the threshold.

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 95, 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 96, 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 97, wherein 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.

99. The apparatus of claim 98, wherein the final ion set selecting means further comprises:

a biomarker group additional selection module which selects additional biomarker group by repeating pre-selecting, reselecting, and final selecting process of the biomarker group with respect to the candidate ion set excluding the group of low-mass ions finalized by the biomarker group additional selection 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 biomarker groups based on analyzing accuracy of the true positive and the true negative from among the biomarker group and the additional biomarker groups.

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. a low-mass ion detecting unit which detects the peak intensity having mass of biological materials from a plurality of GC patients and normal subjects with cancer and normal subjects equals to or greater than 18.0260, equals to or less than 2452.9546 m/z; and

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

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 for GC screening, a second class discriminant score based on the second class low-mass ions for GC screening, a third class discriminant score based on the third class low-mass ions for GC screening, and a fourth class

discriminant score based on the fourth class low-mass ions for GC screening, 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.

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 for GC screening and the fifth class discriminant score based on the fifth class low-mass ions for GC screening, 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.

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 in the normalizing module; and

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

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 112, 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 in the normalizing

module; and

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

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 116, 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 (GT1, GT2) if the sensitivity is less than a threshold (GN3), or the specificity is less than a threshold (GN4), and re-selects the first low-mass ions and the second low-mass ions, and computes sensitivity and specificity using the first and the second low-mass ions and selects the candidate ion set by repeating comparing process with the threshold.

131. The apparatus of claim 130, wherein the thresholds ($N_3$, N4) 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 132, wherein a criterion to evaluate the discriminating performance in the final ion set selecting means further 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 133, 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 134, wherein 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.

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 biomarker group pre-selecting, reselecting, and final selecting process 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 based on analyzing accuracy of the true positive and the true negative 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.