

SPECIFICATION

SPECTROSCOPIC MEASURING APPARATUS WITH MONITORING CAPABILITY

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TECHNICAL FIELD

The present invention relates to a spectroscopic measuring system, and particularly, to a downsized spectroscopic measuring apparatus capable of monitoring the
10 vicinities of a measuring field to be scanned.

BACKGROUND ART

There is known a system of scanning and spectroscopically measuring a measuring object, to early
15 diagnose a skin disease such as a melanoma. A spectroscopic measuring apparatus has a spectroscope (first optical device) and an autofocus controller (second optical device) and arranges a slit mirror in the vicinity of a focus of an objective optical system. Reflected light from
20 the slit mirror is detected with a position sensor, to autofocus-control the objective optical system. Transmitted light straight from the slit is made incident to the spectroscope and is spectroscopically measured with a diffraction grating. Scanning the measuring object
25 provides two-dimensional spectroscopic information about the measuring object. With the use of part of the reflected light from the slit mirror, it is possible to monitor, with a two-dimensional camera, the measuring object other than the spectroscopically measured field.
30 Related arts are, for example, Japanese Unexamined Patent

Application Publications No. 2001-289619, No. 2001-208979,
No. 2004-145372, and No. 2007-086470.

SUMMARY OF INVENTION

5 Problem to be Solved by Invention

The above-mentioned related art, however, is configured to connect the separate spectroscope to a main body including the slit mirror. Transmitted light from the slit is again collected with an optical system, and in this
10 state, a measuring position must be identified. For this, the light must be passed through an incident slit to the spectroscope such as the grating. This raises problems of elongating the total length of the apparatus and needing a large-scale scanning device.

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Means to Solve Problem

In considering the above-mentioned problems, the present invention downsizes a spectroscope, reduces the weight of a scanning device, and increases the scanning
20 speed and operability of a measuring object. The present invention allows a spectroscopic object region to be monitored in real time with two-dimensional monitor images.

According to a technical aspect of the present invention, there is provided a spectroscopic measuring
25 apparatus with monitoring capability. The apparatus includes a first optical path that guides a first beam from a measuring object to a spectroscope main body, a second optical path that guides a second beam from the measuring object to a two-dimensional photographing unit, an optical
30 system that passes the first and second optical paths, and

a reflection block that transmits the first beam passed through the optical system and reflects the second beam passed through the optical system, the reflection block having a reflection area to reflect beams other than the first beam and a slit area formed in the reflection area and positioned in the first optical path and in a focal plane of the optical system, the spectroscope main body being arranged adjacent to the reflection block.

10 BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a schematic view of a spectroscopic measuring system according to the present invention.

Figure 2 is a schematic view of a partial transmission block according to the present invention.

15 Figure 3 is a schematic view of a monitor display of the spectroscopic measuring system according to the present invention.

Figure 4 is an example of the spectroscopic measuring system according to the present invention installed in an orbiting satellite.

MODE OF IMPLEMENTING INVENTION

An embodiment of the present invention will be explained with reference to Figs. 1 to 4. According to the embodiment, a spectroscopic measuring system 1 is an apparatus for scanning and spectroscopically measuring a predetermined region on a skin surface. In the drawings, directions are expressed on an XYZ orthogonal coordinate system. The spectroscopic measuring system 1 according to the embodiment of the present invention includes an optical

system 30, a reflection block 21 having a slit 23 that is at a focal line FL and serves as a light transmission area, a spectroscope main body 25 that spectroscopically measures a spectroscopic measuring field Sf that corresponds to the slit 23 and is linearly distributed, and a two-dimensional photographing unit 28 that provides a spectroscopic result.

The spectroscopic measuring apparatus 1 is installed in a scanning unit (not illustrated), to repeatedly scan and measure a measuring target T on a skin surface in a direction A that is parallel to an X-axis. The spectroscopic measuring field Sf is a linear area corresponding to an instantaneous field of view of a spectroscopic unit 20 and reflected light (including light emission and fluorescence) therefrom advances along an optical path L1 that is an optical axis of the optical system 30, converges on and transmits through the slit 23, and reaches the spectroscope main body 25. Reflected light from a peripheral region Vo of the spectroscopic measuring field Sf is reflected by a reflection plane part 22 of the reflection block 21, advances along an optical path L2, and forms an image on a photographing plane of a two-dimensional photographing unit 40.

In Fig. 1, a measuring field Sm of the two-dimensional image obtained by the two-dimensional photographing unit 40 and the spectroscopic measuring field Sf of the spectroscopic unit 20 move in the direction A according to time due to scanning.

The optical system 30 includes an objective optical system and is controlled and moved in the direction of the optical axis with an autofocus mechanism (not illustrated),

so that the focal level FL is maintained at the position of the slit 23. The autofocus mechanism may be based on a related art. If the mechanism of the above-mentioned patent literature Japanese Unexamined Patent Application
5 Publication No. 2007-086470 is employed, a laser beam scattered on the measuring target *T* and branched from the optical path L2 is detectable with a position sensor (not illustrated).

<Slit-Mirror Block>

10 The reflection block (hereinafter referred to as the slit-mirror block) 21 having the slit 23, i.e., the light transmission area serves as a slit of the spectroscopic unit 25 to be explained later and as a mirror to reflect observation light toward the two-dimensional photographing
15 unit 40. Figure 2 is a model view illustrating the slit-mirror block. The slit-mirror block 21 forms, in a prism having a predetermined refractive index, a reflection plane part obliquely crossing the optical axis L1. The reflection plane part 22 has a mirror face having an
20 elongated opening. The block is typically a rectangular parallelepiped and may be constituted by bonding two triangle prisms together with the mirror face interposed between them.

The elongated opening is the slit 23 and is made of a
25 material having the same refractive index as the prism, and therefore, transmitted light straightly advances through the slit 23. A main axis of the slit 23 is arranged in a Y-axis direction. One face of the triangle prism serving as a bonding face may be coated with a metal thin film to
30 form a thin mirror-face film, thereby constituting the

reflection part 22 and slit 23.

The focal level FL of the optical system 30 is always positioned at the slit 23, and therefore, reflected light only from the spectroscopic measuring field Sf, which is a specific elongated area in the measuring field Sm, passes the slit 23. Reflected light from the remaining region Vo is reflected by the reflection area 22, travels along the optical path L2, and forms an image in the two-dimensional photographing unit 40. Another idea may be suggested to form a transmission area in a plate mirror and obliquely arrange the plate mirror to serve a partial transmission member. In this case, the transmission area is oblique, and therefore, ghost will occur due to multiple reflection in the plate mirror depending on the thickness of the plate mirror. This makes it difficult to correctly carry out spectroscopic measurement. The slit-mirror block 21 of the embodiment is integrated with the spectroscope main body to be explained later, to realize compactness and correct spectroscopic measurement. The sandwiching configuration of the mirror face according to the embodiment ensures mechanical stability and reliability.

According to the present embodiment, the mirror face 22 changes the optical path by 90 degrees. The angle of the mirror face 22 with respect to the optical axis L1 is not limited to 45 degrees but is optional.

<Spectroscopic Unit>

The spectroscopic unit 20 according to the present invention includes the slit-mirror block 21 that serves the slit and the spectroscope main body 25 that includes a

grating 35 arranged adjacent to the slit-mirror block 21. The grating 35 may be of a transmission type or of a reflection type.

Depending on the position of the slit 23 of the slit-mirror block 21, the specific linear area (spectroscopic measuring field) S_f is selected on the measuring target T . Namely, the spectroscopic measuring field S_f is an instantaneous field of view and a real image thereof is formed by the optical system 30 at the focal level FL. An effective width δ of the slit 23 corresponds to an X-direction width of the spectroscopic measuring field S_f .

Reflected light from the spectroscopic measuring field S_f is transmitted through the slit 23 and is changed by a collimator lens 33 into a parallel pencil, which is spectrally separated by the grating 35 according to the position of the spectroscopic measuring field S_f in the Y-axis direction. The spectroscopic result is passed through a condensing optical system 37 and is obtained by the two-dimensional photographing unit 28 as a two-dimensional image containing positional information and spectral information.

Output data from the two-dimensional photographing unit 28 may be monitored as it is, or is stored in connection with a monitor image of the measuring field S_m to be explained later.

<Real-Time Monitoring>

The two-dimensional photographing unit 40 includes an area CCD camera having a two-dimensional image sensor, to obtain a two-dimensional image (hereinafter referred to as

a monitor image) of the measuring field S_m that is a peripheral region of the spectroscopic measuring field S_f . When a skin surface is scanned and spectroscopically measured in the direction A (X-axis direction), it is possible to always obtain two-dimensional images of the region V_o of the measuring field S_m except the spectroscopic measuring field S_f . In Figs. 1 and 2, a reflected beam from the region V_o out of the spectroscopic measuring field S_f is indicated with dotted lines.

10 The spectroscopic measuring field S_f moves according to time due to scanning. With the measuring field S_m being displayed, it is easy to confirm in real time the spectroscopic measuring field S_f that is presently measured. No reflected light from the spectroscopic measuring field S_f reaches the two-dimensional photographing unit 40, and therefore, a real image of the slit 23 in the monitor image is displayed in black. Accordingly, the position of the spectroscopic measuring field S_f is easily and correctly confirmable.

20 Figure 3 schematically illustrates an improved display of the monitor image by the two-dimensional photographing unit. As mentioned above, the image of the spectroscopic measuring field S_f is not contained in the monitor image and is displayed as a black void Bf_2 (Bf_1). If a preceding ($t = t_1$) monitor image contains a partial image Df_2 corresponding to the spectroscopic measuring field S_f , image processing may be carried out to paste the same onto the void Bf_2 .

 The monitor image is temporarily stored in a storage device (memory) of an image processing unit (not

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illustrated). A pixel range corresponding to the slit 23 is identifiable in the monitor image, and therefore, the black image element Bf2 ($t = t_2$, $t_1 < t_2$) can be replaced with the image element Df2 ($t = t_1$) corresponding to the
5 slit, to constitute a monitor image Dm2' having no void.

As a result, it is possible to display, as illustrated in Fig. 3(c), the image Dm2' supplemented with the element Df2 corresponding to the spectroscopic measuring field Sf and having no void. In addition, a
10 frame If2 is displayed to clarify the position of the spectroscopic measuring field Sf. This makes it possible, as illustrated in Fig. 3, to confirm a specific region E such as an affected part in real time in the two-dimensional monitor image and visually observe a positional
15 relationship with respect to the spectroscopic measuring field.

The preceding monitor image is an image that has been taken just before the present monitor image and contains the partial image Df2. The preceding monitor image may be
20 formed by combining a plurality of preceding images that contain the partial image Df2.

<Modification>

The spectroscopic measuring system capable of
25 monitoring a measuring object is installable in a flying object, to conduct remote sensing. Figure 4 illustrates an example that installs the spectroscopic measuring system 1 in an orbiting satellite 50 that orbits a celestial body such as a planet. The spectroscopic measuring field Sf
30 corresponds to an instantaneous field of view (IFOV) on the

surface of a measuring object viewed through the slit 23. The peripheral measuring field S_m corresponds to an instantaneous field of view of the two-dimensional image sensor (such as CCD) installed in the two-dimensional
5 photographing unit 40 for obtaining monitor images.

In this case, the autofocus control and scanning mechanism of the optical system (telescope) 30 are not needed. The main axis direction (Y-axis direction) of the slit is set to be orthogonal to a flying direction
10 (scanning direction) A of the orbiting satellite 50. The spectroscopic measuring system 1 according to the present invention is compact because the partial transmission mechanism 21 having the slit mirror is integrated with the spectroscope main body 25. In addition, it adopts the
15 slit-mirror block 21 to correctly and stably carry out spectroscopic measurement. Accordingly, it is installable in the flying object that must be lightweight and highly reliable.

The two-dimensional photographing unit 40 is able to
20 conduct real-time monitoring. It may be provided with an image storage unit having a predetermined capacity, to temporarily store spectroscopic measurement images and monitor images that are related to each other. It is possible to store a series of image data during
25 spectroscopic measurement, and after the measurement, transmit predetermined image data to a ground station. In a series of measurement data received on the ground, the black void image element BF2 is replaced with the image element Df2 corresponding to the slit 23, to provide the
30 monitor image $Dm2'$ having no void.

EFFECTS OF INVENTION

As mentioned above, the present invention integrates the slit-mirror block and spectroscope main body into the spectroscopic unit, to reduce the size and weight of the apparatus. The reflection area and slit are integrated into the block, to eliminate an influence of multiple reflection at the slit and improve the strength and reliability of the apparatus.

Through the slit-mirror block, a monitor image is obtained, and therefore, the position of a spectroscopic measuring field is confirmable in real time. A preceding monitor image is used to supplement a present image of the spectroscopic measuring field, and therefore, it is easy to visually observe the position and image of the spectroscopic measuring field in real time.

(United States Designation)

In connection with United States designation, this international patent application claims the benefit of priority under 35 U.S.C. 119(a) to Japanese Patent Application No. 2010-243381 filed on October 29, 2010 whose disclosed contents are cited herein.

CLAIMS

1. A spectroscopic measuring apparatus with monitoring capability, having a first optical path that guides a first
5 beam from a measuring object to a spectroscope main body and a second optical path that guides a second beam from the measuring object to a two-dimensional photographing unit, the spectroscopic measuring apparatus comprising:
 - an optical system, the first and second optical paths
10 passing through the optical system; and
 - a reflection block transmitting the first beam passed through the optical system and reflecting the second beam passed through the optical system, wherein
 - the reflection block including:
15 a reflection area reflecting beams other than the first beam; and
 - a slit formed in the reflection area and positioned in the first optical path and in a focal plane of the optical system,
 - 20 the spectroscope main body being arranged adjacent to the reflection block.
2. The spectroscopic measuring apparatus with monitoring capability according to claim 1, wherein
25 the reflection block other than the reflection area has an uniform refractive index.
3. The spectroscopic measuring apparatus with monitoring capability according to claim 1 or 2, further comprising
30 a storage unit configured to relate spectroscopic

measurement data of the spectroscope main body and two-dimensional monitor image data with each other and temporarily stores the same.

5 4. The spectroscopic measuring apparatus with monitoring capability according to claim 3, further comprising
an image processing unit configured to supplement the two-dimensional monitor image data corresponding to the slit area according to preceding image data of the
10 measuring object.

5. The spectroscopic measuring apparatus with monitoring capability according to any one of claims 1 to 4, wherein
the optical system includes an objective optical
15 system that is movable in an optical-axis direction and is autofocus-controlled with respect to the measuring object.

6. The spectroscopic measuring apparatus with monitoring capability according to any one of claims 1 to 4, installed
20 in a flying object that flies and travels with respect to the measuring object, the apparatus scanning the measuring object in a flying direction and spectroscopically measuring the measuring object.