

CLAIMS

1. An inspection and measurement system comprising:

an inspection and measurement lighting device configured to irradiate an inspection object with inspection light, the inspection and measurement lighting device being capable of setting rendering shapes, and inclines of optical axes, of irradiation solid angles of the inspection light applied to respective points on the inspection object ~~such that, in each irradiation solid angle, a plurality of solid-angle regions having different optical attributes are radially arranged around an optical axis thereof, and being capable of rendering shapes of the irradiation solid-angles and inclines of the optical axes thereof~~ substantially uniform at all the respective points on the inspection object at the same time irrespective of distances from the inspection and measurement lighting device to the respective points on the inspection object; and

an imaging device configured to image object light including regularly reflected light or regularly transmitted light or scattered light reflected or transmitted by the respective points on the inspection object, ~~the imaging device—being capable of selectively imaging different optical attributes of the object light, ————wherein, the inspection and measurement system being configured to identify incline angles of surfaces in the vicinity of respective points on the inspection object by sensing a variation in optical axes of solid angles of the regularly reflected light or the regularly transmitted light at the respective points on the inspection object as brightness thereof, based on inclusive relations with observation solid angles formed at the respective points on the inspection object by the imaging device, or by sensing a variation in ~~solid angles of regularly reflected-light or regularly transmitted light of the object~~ illuminance of the inspection light at the respective points on the inspection object ~~can be sensed~~ as a ~~first~~-variation in ~~the object light that has a plurality of optical attributes resulting from the plurality of solid angle regions of the inspection object, based on inclusive relations between the solid angles of the regularly reflected light or the regularly—~~~~

~~transmitted light of the object light and the observation solid angles~~brightness of the scattered light,

~~wherein, in a region in which~~ incline angles cannot be continuously identified, a variation in the solid angles of the regularly reflected light or the

5 ~~regularly transmitted light of the object light is not sensed, a range and a shape of that region and a variation in solid angles of regularly reflected light or regularly-transmitted light of the object light~~ in the vicinity of that region ~~can be~~is sensed as a ~~second variation in the object light,~~

10 ~~— for scattered light of the object light, a variation in brightness for each of thereof based on the inclusive relations with the plurality of optical attributes— resulting from the plurality of observation solid angle regions of the inspection light can be sensed as a third variation in the object light,~~

15 ~~— with use of at least one of the first, second, and third variations in the object light, based on an amount of variation in the object light for each of the plurality of optical attributes, incline directions or incline angles, or both, of inclines in a plurality of directions at the respective points on the inspection object— are specified, and, in a region in which incline directions and incline angles of inclines in a plurality of directions at respective points on the inspection object— cannot be continuously identified, , and~~ at least a difference in height between

20 regions adjacent to that region is ~~specified, and~~calculated using information regarding the sensed brightness, information regarding a geometric shape of that region, and an effective half plane angle in which both the irradiation solid angle and the observation solid angle function effectively, and thereby three-dimensional characteristics of a surface of the inspection object can be specified.

25 ~~— thereby three-dimensional characteristics of a surface of the inspection object can be specified.~~

2. The inspection and measurement system according to claim 1, the
30 inspection and measurement system being configured such that:

the irradiation solid angles of the inspection light applied to the respective points on the inspection object are set such that, in each irradiation solid angle, a plurality of solid angle regions having different optical attributes are radially arranged around an optical axis thereof, and

the imaging device is capable of selectively imaging different optical attributes of the object light, and incline angles, or both the incline angles and incline directions, of surfaces in the vicinity of the respective points on the inspection object are identified by the imaging device sensing a variation in the optical axes of the solid angles of the regularly reflected light or the regularly transmitted light at the respective points on the inspection object, based on the inclusive relations with the observation solid angles formed at the respective points on the inspection object by the imaging device, as a variation in brightness for each of the optical attributes resulting from the plurality of solid angle regions of the inspection light, or by the imaging device sensing a variation in illuminance at the respective points on the inspection object for each of the optical attributes resulting from the plurality of solid angle regions of the inspection light as a variation in brightness of the scattered light for each optical attribute,

wherein, in a region in which incline angles cannot be continuously identified, a variation in the solid angles of the regularly reflected light or the regularly transmitted light in the vicinity of that region is sensed as a variation in brightness for each of the optical attributes resulting from the plurality of solid angle regions of the inspection light, and at least a difference in height between regions adjacent to that region is calculated, and thereby three-dimensional characteristics of a surface of the inspection object can be specified.

3. The inspection and measurement system according to claim 2,

wherein the observation solid angles at the respective points on the inspection object are each set to be smaller than a corresponding irradiation solid angle, and, in the plurality of solid angle regions that are formed in the irradiation solid angle and that have different optical attributes, the optical attributes are

each continuously and smoothly varied.

~~3. An inspection and measurement system comprising:~~

~~—— an inspection and measurement lighting device configured to irradiate an inspection object with inspection light, the inspection and measurement lighting device being capable of rendering shapes, and inclines of optical axes, of irradiation solid angles of the inspection light applied to respective points on the inspection object substantially uniform at all the respective points on the inspection object at the same time irrespective of distances from the inspection and measurement lighting device to the respective points on the inspection object; and~~

~~—— an imaging device configured to image object light reflected or transmitted by the respective points on the inspection object,~~

~~—— wherein, with observation solid angles formed at respective points on the inspection object by the imaging device, a variation in solid angles of regularly reflected light or regularly transmitted light of the object light at the respective points on the inspection object can be sensed as a first variation in the object light, based on inclusive relations between the solid angles of the regularly reflected light or the regularly transmitted light of the object light and the observation solid angles,~~

~~—— in a region in which regularly reflected light or regularly transmitted light of the object light is not sensed, a range and a shape of that region and a variation in solid angles of regularly reflected light or regularly transmitted light of the object light in the vicinity of that region can be sensed as a second variation in the object light,~~

~~—— for scattered light of the object light, a variation in brightness thereof can be sensed as a third variation in the object light,~~

~~—— with use of at least one of the first, second, and third variations in the object light, incline angles at the respective points on the inspection object are identified based on a form of variation in the object light,~~

~~—— in a region in which incline angles at respective points on the inspection~~

~~object cannot be continuously identified, at least a difference in height between regions adjacent to that region is identified, and
 ————— thereby three-dimensional characteristics of a surface of the inspection object can be identified.~~

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4. The inspection and measurement system according to any one of claims 1 to 3,

wherein, in the inspection and measurement lighting device configured to irradiate an inspection object with inspection light, the inspection light applied to
 10 respective points on the inspection object ~~can be~~ is polarized,

the imaging device configured to image object light reflected or transmitted by the respective points on the inspection object is capable of selectively imaging a variation in the object light based on a polarization state of the object light, and the object light returned from the respective points on the inspection object is
 15 classified into regularly reflected light or regularly transmitted light, or scattered light, ~~and~~

if the object light is regularly reflected light or regularly transmitted light, brightness thereof is sensed based on the inclusive relations with the observation solid angles formed at the respective points on the inspection object, ~~which of the first, second, and third types of variations in the object light is to be used to identify the three-dimensional characteristics of~~ by the surface of imaging device,
 20 ~~identify the three-dimensional characteristics of~~

if the inspection object ~~can be set~~ light is scattered light, a variation in brightness with respect to the scattered light is sensed, and

thereby three-dimensional characteristics of a surface of the inspection object can be specified.

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5. The inspection and measurement system according to any one of claims 1 to 3,

wherein the imaging device configured to image object light reflected or

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transmitted by respective points on the inspection object is capable of imaging and recording brightness of the object light as a luminance value in a floating-point format, ~~and~~

~~_____~~ whether the object light returned from the respective points on the

5 inspection object is regularly reflected light or regularly transmitted light, or scattered light can be determined as ~~a~~ being a region ~~of a certain size or larger~~ that is divided according to a band of brightness thereof, ~~and~~

if the object light is regularly reflected light or regularly transmitted light, brightness thereof is sensed based on the inclusive relations with the observation
10 solid angles formed at the respective points on the inspection object, ~~which of the first, second, and third types of variations by the imaging device,~~

~~_____~~ if the object light is scattered light, a variation in ~~the object light is~~ brightness with respect to ~~be used to identify the~~ the scattered light is sensed, and

~~_____~~ thereby three-dimensional characteristics of ~~the~~ a surface of the inspection
15 object can be ~~set~~ specified.

6. The inspection and measurement system according to any one of claims 1 to 3,

wherein, in the imaging device configured to image object light reflected or
20 transmitted by respective points on the inspection object,

a first captured image is captured by applying imaging conditions within a range in which desired brightness of regularly reflected light or regularly transmitted light of the object light does not exceed the maximum brightness that can be imaged,

25 a second captured image is captured by applying imaging conditions within a range in which desired brightness of scattered light of the object light is equal to or higher than the minimum brightness that can be imaged,

whether the object light returned from the respective points on the inspection object is regularly reflected light or regularly transmitted light, or

30 scattered light can be determined as being a region ~~of a certain size or larger~~ that

is divided according to a band of brightness thereof, ~~and~~

if the object light is regularly reflected light or regularly transmitted light,
brightness thereof is sensed based on the inclusive relations with the observation
solid angles formed at the respective points on the inspection object, ~~which of the~~
 5 ~~first, second, and third types of variations~~ by the imaging device.

if the object light is scattered light, a variation in ~~the object light is~~
brightness with respect to ~~be used to identify the~~ the scattered light is sensed, and
thereby three-dimensional characteristics of ~~the~~ a surface of the inspection
 object can be specified.

10 7. The inspection and measurement system according to any one of claims 1 to 6,

wherein, in the inspection and measurement lighting device, a half mirror
 configured to change an irradiation direction of the inspection light and to
 15 transmit light from the inspection object so that the light can be imaged by the
 imaging device is provided, and the optical axes of the irradiation solid angles of
 the inspection light at the respective points on the inspection object substantially
 coincide with optical axes of the observation solid angles of the imaging device at
 the respective points on the inspection object.

20 8. An inspection and measurement method for identifying a three-dimensional shape of an inspection object using the inspection system according to any one of claims 1 to 7,

wherein a three-dimensional shape of an inspection object is identified
 25 based on a variation in at least one of ~~brightness of the object light or in~~, shapes
~~and inclines~~ of solid angles ~~of the object light, or in the brightness of the object~~
~~light and the shapes~~, and inclines of the solid angles of the object light.