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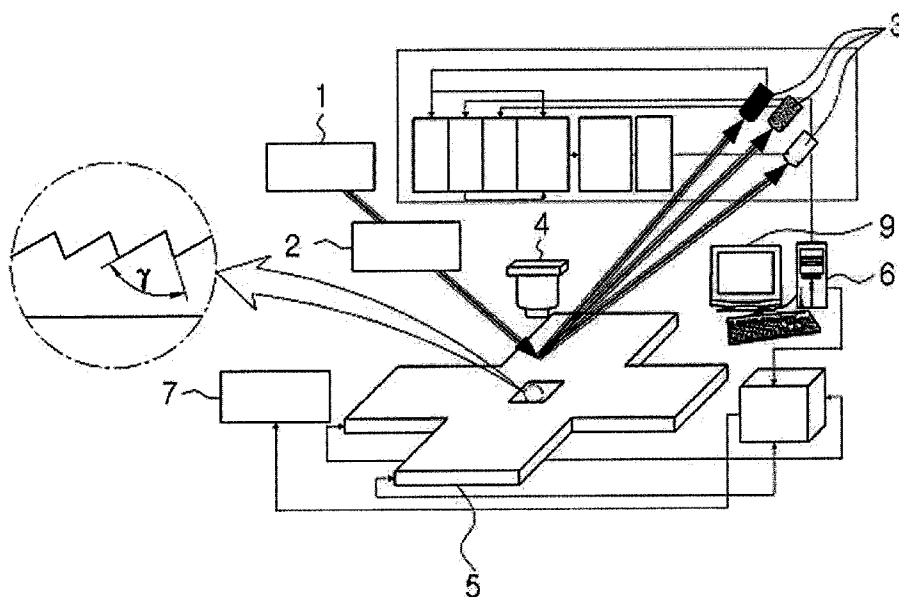
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(54) Title: THREE DIMENSIONAL SURFACE ILLUMINATION MEASURING APPARATUS FOR MICRO OPTICAL ELEMENT ARRAY



(57) Abstract: The present invention relates to a surface illumination measuring apparatus for measuring three-dimensional surface illumination of micro optical element array by employing a wideband laser. The apparatus includes a laser disposed parallel to an object to be measured at a predetermined angle, for radiating a laser beam of a wideband wavelength onto the object, and optical detection units for detecting a direct reflection beam that is directly reflected from the to-be-measured object, a diffracted and interfered beam that is diffracted and interfered from the to-be-measured object, and a scattered beam that is scattered from the to-be-measured object.

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**THREE DIMENSIONAL SURFACE ILLUMINATION MEASURING APPARATUS
FOR MICRO OPTICAL ELEMENT ARRAY**

5 【Technical Field】

The present invention relates, in general, to a three-dimensional surface illumination measuring apparatus for micro optical element array and, more particularly, to a surface illumination measuring apparatus for micro optical element
10 array by employing a wideband laser.

【Background Art】

The applications of and demands for micro-optic arrays that are regularly formed on a substrate increased rapidly in
15 various related industry fields, such as a variety of displays. Therefore, it is necessary to measure the uniformity and three-dimensional shape of the micro-optic array at high speed.

More particularly, it has been known that the performance of micro-optics formed on the panel in order to increase the
20 external emission efficiency of LED, large-sized display devices, and so on is dependent on the uniformity and precision of its shape. Therefore, a technique for high-speed total inspection is very important.

That is, it is evident that test and measuring techniques
25 capable of saving the process expenses, which are incurred in

subsequent processes depending on whether failure exists in the substrate and the uniformity of the substrate, are necessarily required.

To maintain the degree of precision in measuring while
5 solving a low measurement speed and accompanied possible mechanical damage occurring in an existing contact type measuring method, it is required that a new measuring concept and related technology, which can significantly increase the measuring speed, be developed.

10 Techniques for maintaining existing micro-optics arrays with high precision and performing measurement at high speed on a substrate processed in a large area have not been known so far. Meanwhile, a technique capable of measuring a nano structure formed on a substrate accurately using an electron
15 microscope, etc. in order to analyze the shape of the structure in a three-dimensional manner can be applied to the present measurement technically.

However, as well known in the art, most materials used for optical devices are made of a non-conducting substance. It
20 is therefore impossible to directly apply the above-mentioned electron microscope technology. To solve the problem, it is required for a surface of an optical device to have conductivity by coating a metallic material on the surface of the optical device. However, it makes it impossible a total
25 inspection necessarily required for the quality management of

products due to destructive disadvantages and characteristics in measurement, but only inspection through sampling is possible.

Surface profilers used to measure the surfaces of
5 existing materials are also another possible candidates that are applicable to measure the shapes of the micro-optics array. The surface profilers can be largely classified into a contact type and a non-contact type. The non-contact type method includes a atomic force microscopy, an optical profiler based
10 on an optical interference phenomenon, and so on. The contact type method includes a stylus method that is widely used.

Of the above techniques, the stylus method includes measuring a three-dimensional shape of a surface by measuring up and down movements of a stylus according to windings of a
15 material surface using a LVDT (Linear Variable Differential Transformer) sensor. The measuring method is advantageous in that measurement precision is about 1 nm, but is disadvantageous in that a sufficient speed cannot be obtained, which is the limit of the contact type measuring technique.

20 Furthermore, in a micro-optics array having a very large curvature, not only the probe tip may be damaged, but also a surface of an object to-be-measured may be severely damaged due to the size and strength of the tip. Therefore, it is considered that there are lots of problems in directly
25 applying the measuring method to the micro-optics array (an

object to be measured) of the present invention.

The non-contact type surface measuring techniques include an atomic force microscopy (AFM) technique. The atomic force microscopy technique is based on the principle of measuring the shape of an object to be measured using attraction force between atoms on the probe and the object, which is generated as a nano probe approaches the object. Meanwhile, the measuring technique is very excellent in terms of precision to the extent that even a location of one atom can be measured, but has lots of technical limits in measuring a wide area at high speed.

More particularly, a contact type/non-contact type measuring method employing a probe, which is also called "atomic force microscopy (AFM)", is very excellent in measurement resolution power in principle, but has a very low measurement speed. For the purpose of expansion into a large area of the measuring method, the method has a technical and economical problem in which an expensive scanning stage, which has a sufficient degree of flatness and can be applied to a wide area, must be overcome.

Therefore, it has been known that it is very difficult to apply the atomic force microscopy measurement principle without change in measuring and evaluating a micro-optics array that is fixed to the next-generation display panel, etc., which must be expanded to a high-speed and large area.

A non-contact type surface shape measuring technique is an optical profiler method of shaping a surface of a target object in a three-dimensional manner by making light incident on the surface of the object and reading a difference between
5 the phases of reflected light employing an optical interference property.

The non-contact type surface shape measuring technique is a technique for measuring a thin film having a very thin thickness or a microstructure. It has been known that this
10 technique is very suitable for measuring a relatively uniform thin film in a relatively wide area, but is very difficult to apply to a micro-optics array with very severe change within several μm . More particularly, the size of a tip of a micro-optics array formed on a surface of an up-to-date display
15 device has a curvature radius of 100 nm or less, of which value is lower than an optical diffraction limit. Accordingly, it is impossible to apply the non-contact type surface shape measuring technique to the micro-optics array.

Meanwhile, a surface illumination measuring apparatus
20 using a conventional laser generally uses a short wavelength laser. Therefore, in order to measure surface illumination of an optical element array, a laser having a wavelength corresponding to that of the optical element array must be used. In this case, in the case of an optical element array
25 having a material, which allows for surface measuring, using

different wavelengths, a laser must be replaced with a laser a
corresponding wavelength. Therefore, problems arise because
lots of replacement and installation time are taken and the
cost is increased since a laser having a different wavelength
5 must be prepared.

【Disclosure】

【Technical Problem】

Accordingly, the present invention has been made keeping
10 in mind the above problems occurring in the prior art, and an
object of the present invention is to provide a three-
dimensional surface illumination measuring apparatus of a
micro-optics array, in which it can measure a three-
dimensional shape of each micro-optics in a large area at high
15 speed and can also measure the degree of uniformity on a test
sample at high speed by using a well-known optical diffracted
and interfered beam phenomenon while maintaining a spatial
measurement precision of an optical diffraction limit degree
in order to overcome a problem of an precision measuring
20 technique for application to an existing micro-optics, etc.,
i.e., a problem occurring at a destructive or very low
measurement speed.

Another object of the present invention is to provide a
three-dimensional surface illumination measuring apparatus of
25 a micro-optics array, in which it can measure surface

illumination of micro-optics arrays having various materials by using a laser of a wideband wavelength.

Still another object of the present invention is to provide a three-dimensional surface illumination measuring apparatus of a micro-optics array, in which it allows for measurement with high precision by excluding a laser beam scattered by a to-be-measured object.

Further another object of the present invention is to provide a three-dimensional surface illumination measuring apparatus of a micro-optics array, in which it can measure three-dimensional surface illumination in real-time.

【Technical Solution】

To achieve the above objects, a three-dimensional surface illumination measuring apparatus for micro optical element array according to the present invention provides, including a laser disposed parallel to an object to be measured at a predetermined angle, radiation of a laser beam of a wideband wavelength onto the object, and optical detection units for detecting a direct reflection beam that is directly reflected from the to-be-measured object, a diffracted and interfered beam that is diffracted and interfered from the to-be-measured object, and a scattered beam that is scattered from the to-be-measured object, of the illuminated laser beam.

A value calculated by the following equation is applied

to allow a microcomputer to calculate surface illumination with elimination the effect due to the scattered laser beam intensity:

$$R = (B - C) / (A - C)$$

5 where A is an intensity of a directly reflected laser beam

B is an intensity of first-order diffract ion spot of laser beam.

C is an intensity of a scattered laser beam by a
10 scattering source of a to-be-measured object.

The object has its three-dimensional surface illumination measured at the same time when the object is conveyed by a stage.

The apparatus further includes an A/D converter that
15 converts the laser beams detected by the optical detection units into electrical signals, and a microcomputer that calculates three-dimensional surface illumination using a program to analyze the electrical signals converted by the A/D converter.

20 The apparatus further includes a CCD camera disposed over the object, for monitoring a measured surface of the object in real-time.

The apparatus further includes a display that displays the three-dimensional surface illumination value calculated by the
25 microcomputer.

A three-dimensional surface illumination measuring method for micro optical element array accounts for another aspect of the present invention, including the steps of (a) allowing a laser, which is disposed parallel to a to-be-measured object at a
5 predetermined angle, to radiate a laser beam of a wideband wavelength onto the object, (b) allowing optical detection units to detect a direct reflection beam that is directly reflected from the to-be-measured object, a diffracted and interfered beam that is diffracted and interfered from the to-
10 be-measured object, and a scattered beam that is scattered from the to-be-measured object, of the illuminated laser beam, (c) allowing an A/D converter to convert the laser beams detected by the optical detection units into electrical signals, and (d) allowing a personalcomputer, which is
15 programmed using the electrical signals converted by the A/D converter, to calculate three-dimensional surface illumination.

The method further includes the step of (e) displaying the three-dimensional surface illumination value calculated in the step (d) on a display.

20 The calculation step by the microcomputer is corrected using a standard material.

The object has its three-dimensional surface illumination measured at the same time when the object is conveyed by a stage.

25 A CCD camera disposed over the object monitors a measured

surface of the object in real-time.

【Advantageous Effects】

In the present invention, the degree of uniformity of a
5 shape for micro optical element array can be measured and
evaluated in a large area at high speed in the most convenient
manner by sensing the intensity of a spot of a laser beam,
which is generated by 1-st order or high order diffraction on
the basis of 0th-order (direct reflection) of an incident laser
10 beam of conventional diffraction phenomenon.

The apparatus of the present invention includes a laser
beam directional optical system that decides spatial
resolution by limiting the range of measurement of a laser
beam as a light source, optical detection units that measure
15 the intensity of diffracted beam spots, a handler on which a
sample is loaded automatically, a stage that can control a to-
be-measured object accurately, a microcomputer in which data,
which have been shaped by calculating operating and
measurement values of the optical detection units, are
20 programmed, and so on.

Therefore, according to the present invention, not only
the degree of uniformity at a panel of a wide area in which
micro optical element array are formed, but also the shape of
each micro optical element array can be measured at high speed
25 in such a manner that a X-ray principle that has been long

applied in a field that can measure the magnitude of an atom,
etc., with super precision is expanded to an electromagnetic
wave of a visible ray region, a diffraction laser beam pattern
detected by measuring points of a laser beam that is
5 diffracted and interfered in micro optical element array
arranged regularly is recognized, and the laser beam pattern
is inversely converted.

It can be considered that the technique of the present
invention, in which the intensity of light directly diffracted
10 from a substrate is used as measurement values, is very
important because the application to micro optical element
array on the substrate, which has been invented in order to
overcome an efficiency-lowering inducing phenomenon in which
light is generated within a light emission device, such as LED,
15 proceeds within a medium in a wave-guide form and then
disappears, and to improve emission efficiency, has direct
information on an amount of externally radiated light.

【Description of Drawings】

20 Further objects and advantages of the invention can be
more fully understood from the following detailed description
taken in conjunction with the accompanying drawings in which:

FIG. 1 is a view showing the construction of a three-
dimensional surface illumination measuring apparatus for micro
25 optical element array according to the present invention;

FIG. 2 is a view showing the results measured by a atomic force microscopy method for micro optical element array;

FIG. 3 illustrates expected forms of a one-dimensional array for illustrating the measurement principle;

5 FIG. 4 illustrates the principle of a phenomenon in which the intensity of a spot of a diffracted beam is changed depending on variation in a blaze angle;

FIG. 5 are photographs of spots of a diffracted and interfered beam, which are monitored in a reflected region
10 when a laser beam having a wavelength of 633 nm is irradiated on a substrate in which an array is formed in micro optical element array as shown in FIG. 2;

FIG. 6 is a flowchart illustrating the operation of an operating system of an optical profiler according to the
15 present invention; and

FIG. 7 illustrates the results of measuring the ratio of the beam intensities of directly reflected and first-diffracted laser spots with respect to a variety of samples.

<Description on Reference Numerals>

- 20 1: laser
2: laser beam focusing apparatus
3: optical detection unit 4: CCD camera
5: stage 6: microcomputer
7: sample handler 8: A/D converter
25 9: display

[Mode for Invention]

A three-dimensional surface illumination measuring apparatus for micro optical element array according to the present invention will now be described in detail with
5 reference to the accompanying drawings.

FIG. 1 is a view showing the construction of a three-dimensional surface illumination measuring apparatus for micro optical element array according to the present invention. FIG. 2 is a view showing the results measured by a atomic force
10 microscopy method for micro optical element array. FIG. 3 illustrates expected forms of a one-dimensional array for illustrating the measurement principle. FIG. 4 illustrates the principle of a phenomenon in which the intensity of a spot of a diffracted beam is changed depending on variation in a blaze
15 angle. FIG. 5 are photographs of spots of a diffracted and interfered beam, which are monitored in a reflected region when a laser beam having a wavelength of 633 nm is irradiated on a substrate in which an array is formed in micro optical element array as shown in FIG. 2. FIG. 6 is a flowchart
20 illustrating the operation of an operating system of an optical profiler according to the present invention. FIG. 7 illustrates the results of measuring the ratio of the beam intensities of directly reflected and first-diffracted laser spots with respect to a variety of samples.

As shown in the drawings, the three-dimensional surface illumination measuring apparatus for micro optical element array according to the present invention includes a laser 1 for irradiating a laser beam of a wideband wavelength on an object to be measured; optical detection units 3 for detecting a direct reflection beam that is directly reflected from the to-be-measured object, a diffracted and interfered beam that is diffracted and interfered from the to-be-measured object, and a scattered beam that is scattered from the to-be-measured object, of the illuminated laser beam; an A/D converter 8 for converting the detected laser beams into electrical signals; and a microcomputer 6 for calculating three-dimensional surface illumination a program programmed based on the converted electrical signals.

The laser 1 is disposed at a predetermined angle in parallel to the to-be-measured object and radiates a laser beam. The laser beam is focused by a laser beam focusing apparatus 2 and is then illuminated. The laser 1 is adapted to radiate a laser beam of a wideband wavelength.

If the laser 1 radiates a laser beam having a wideband wavelength as described above, surface illumination for micro optical element array made of a variety of materials can be measured. That is, it is possible to measure surface illumination of not only micro optical element array of a specific material from which diffracted and interfered beams

are generated by a short wavelength, but also micro optical element array of various materials from which diffracted and interfered beams are generated by a long wavelength.

It is preferred that a CCD camera 4 for monitoring a surface of the to-be-measured object in real-time be further disposed over the to-be-measured object.

The diffraction-interference principle of the present invention will be described as follows.

In the case where laser beams having various wavelengths are focused on a surface of a to-be-measured object and are reflected from the surface, patterns of laser beam spots having a variety of shapes as shown in FIG. 5 are formed by means of a diffraction-interference phenomenon by micro optical element array existing on a surface of a test sample as shown in FIG. 2.

Spatial locations of the spots are decided by a pattern of a regular micro optical element array existing on the surface of the to-be-measured object disposed at a measurement location. Therefore, if the image is inversely transformed, physical information about the location of each element can be obtained.

Meanwhile, the intensity at each spot with respect to such diffracted light can be decided by a degree in which laser light is inclined from the surface of an object constituting each optical element, i.e., the degree of

the substrate (i.e., the blaze angle γ) can be calculated by the following equation 2.

$$\gamma = \tan^{-1}(2h/a) \quad \text{--- [Equation 2]}$$

where a is the pitch of the array and h is the height of
5 an interested array. An example in which such discussion is applied to typical values used for the process of the substrate, which is generally commercialized in a light emission device, such as LED, is shown in FIG. 2. That is, when a pitch between micro optical element array is 4 μm and
10 heights of micro optical element array are 0.7, 1.0, and 1.3 μm , angles in which lateral faces of the arrays are inclined from a substrate are 19, 27, and 33 degrees, respectively. It can be said that such discussion significantly suggests a degree of measurement precision in substantial measurement.

15 In other words, when the ratio of the intensity of diffracted light is measured precisely, very high measurement precision can be obtained from the measurement value. It is possible to measure and evaluate an optical characteristic of micro optical element array having variation of 100 nm or less
20 and to significantly improve the quality and process precision of the substrate.

The optical detection units 3 detect a direct reflection beam that is directly reflected from the to-be-measured object, a diffracted and interfered beam that is diffracted and
25 interfered from the to-be-measured object, and a scattered

beam that is scattered from the to-be-measured object, of the illuminated laser beam.

The A/D converter 8 serves to convert the laser beams detected by the optical detection units 3 into electrical
5 signals.

The microcomputer 6 calculates three-dimensional surface illumination using a program based on the electrical signals received from the A/D converter 8.

It is preferred that the program used by the
10 microcomputer 6 be set so that it is corrected using a standard material. It is also preferred that the three-dimensional surface illumination measuring apparatus of the present invention further include a display 9 for displaying three-dimensional surface illumination values calculated by
15 the microcomputer 6.

In the present invention, the optical diffraction profiler shown in FIG. 1 was fabricated. An experiment of measuring an optical characteristic of micro optical element array directly formed on the sapphire substrate and directly
20 comparing the measured optical characteristic and the result of measuring a physical shape by the atomic force microscopy method was performed.

An intensity (A) of a spot of a laser beam that was directly reflected, an intensity (B) of a spot of a laser beam
25 that was firstly diffracted, and the intensity (C) of laser

light that was scattered due to micro-scratch occurring on the process substrate and the scattering source were first measured at high speed using three different optical detectors.

An accurate ratio between the intensity of first-order diffracted beam spot and the intensity of zeroth-order diffracted beam spot that was directly reflected can be expressed in the following equation 3 so as to remove the effect of an amount of scattered light, which is considered to be included in the intensity of each light in the same manner.

$$R = (B - C) / (A - C) \quad \text{--- [Equation 3]}$$

In the present invention, a method of directly calculating analog signals without digitizing the measured values A, B, and C measured from the optical detector was adopted. After the calculation is finished based on equation 3, the values are stored in the computer.

It is considered that the above-mentioned measuring process is not limited to a phenomenon by micro optical element array so that the whole diffraction phenomenon is performed on an area to which the laser on micro optical element array is connected, but is an average phenomenon by the sum of them.

Therefore, if the size of a microelement is not much smaller than the optical diffraction limit, the diffraction phenomenon by the sum of them continues to increase. It is thus possible to measure elements of 100 nm in size.

Furthermore, since the illumination areas of the laser beam can be reduced up to the optical diffraction limit, a spatial measurement precision can be maintained to about several hundreds of nm.

5 It is necessary to change the location of a sample and load the sample automatically in order to perform a method of measuring a very good precision, spatial resolution power, and a ratio of variation in the height of micro optical element array on a wide substrate as well as one point at high speed.
10 To this end, the superprecision stage 5 and the superprecision handler as shown in FIG. 1 are adopted in the optical diffraction profiler system of the present invention.

 In order to control the location of a sample, store measurement values at respective locations, and analyze the
15 values, a flowchart as shown in FIG. 6 was completed.

 In more detail, the measuring system mainly includes an optical diffraction profiler measuring system and a control board for controlling the optical diffraction measuring system. Hardware including the optical detector, the laser, the
20 optical device for transferring and focusing a beam, the stage for conveying a sample, the sample handler 7 for automatically converting the driving unit and the sample, the calculation unit for calculating the signals, and so on, and hardware for changing the location and type of a sample were constructed of
25 software capable of interpreting values that were calculated

from control and optical signals on a computer and displaying the values. It was possible to obtain the intensity of sufficiently large numbers and measuring points at high speed by operating the hardware and software systematically and sequentially.

In order to obtain a practical application example using the optical diffraction measuring apparatus constructed above, an experiment was performed on a substrate having a diameter of 2 inches, in which micro optical element array is formed in array form, as shown in FIG. 7.

A first column of FIG. 7 shows the measurement results of the atomic force microscopy on surfaces around the centers of six different samples. As a result of analyzing heights near the centers, which were obtained based on the measurement results, the heights of micro optical element array, which were distributed at the centers of the sample, were 1.49, 1.53, 1.34, 1.70, 2.06, and 2.12 μm in average. It can be seen that a pitch between micro optical element array is relatively the same.

A third column of FIG. 7 shows the results of measuring a ratio between the intensities of spots of laser beams that were directly reflected and first-order diffracted in two lines, which were spaced apart by 10 mm, of a surface area of a sample having a 2-inch diameter using the optical diffraction profiler proposed by the present invention.

In this case, the value of the ratio was shown as a log function form in order to make apparent variation in FIG. 7. Furthermore, the measuring points were measured at a distance of 5 mm and were shown as filled circles and squares. It is
5 evident that the results show that a difference by variation in the height occurring on the process in each part on the sample surface is very severe. This clearly shows variation of distributions in each part of a plasma etching process used in the process. It can be seen that although such variation is
10 taken into consideration, the results measured in the present invention are almost identical to variation of the heights measured by the atomic force microscopy.

That is, FIG. 7 shows that a measurement value by the optical diffraction profiler, through which micro optical
15 element array having the lowest height could be confirmed, on a sample of 1.34 μm , i.e., a third sample has the lowest value, whereas measurement values on fifth and sixth samples having the highest height have high values in the whole surface of the substrate.

20 In other words, as described in the above theoretical study, the measuring technique using the optical diffraction profiler proposed in the present invention is a technique capable of measuring variation in the heights very precisely when micro optical element array have almost the same shape
25 and are located at the spaces.

Meanwhile, the above-mentioned measuring techniques are very simple in their measuring methods and apparatuses in comparison with the existing measuring methods, such as the contact type measuring method such as stylus, a measuring
5 method of measuring variation in optical phases using the interference phenomenon, and a measuring technique based on attraction between atoms. It is thus possible to increase a measurement speed while maintaining a high degree of precision of the optical diffraction limit degree.

10 The improvement of the measurement speed can solve the problems, such as the non-uniformity of the quality, which may occur by measuring and testing only several selected samples, an increase of the product cost depending on an expensive post-process using a substrate having a bad process quality,
15 and the like.

Furthermore, the simplification of the technique of the present invention can be applied directly to a fixed line for fabricating micro optical element array. It is therefore expected that the whole fixed speed and fixed precision of a
20 product can be improved significantly. These advantages are possible because the present technique is a non-contact type and a non-destructive type method unlike other contact type and electron microscope measuring techniques, etc.

Furthermore, the present technique may be expanded and
25 applied to an example in which variation and degree of an

optical property of a surface processed together with a three-dimensional physical structure of the following micro optical element array is managed. That is, as mentioned earlier, the optical diffraction-interference phenomenon occurring in micro
5 optical element array includes all information about variation in a three-dimensional optical characteristic, i.e., a refractive index, as well as the regularity of each microelement and a degree deviated from the regularity.

The phenomenon completely complies with an x-ray
10 diffraction phenomenon monitored in an x-ray region depending on spatial distributions in which atoms are arranged regularly. The theoretical analysis method regarding diffraction in the x-ray region has already been firmly established. It is therefore possible to measure variation in the regularity,
15 location, and optical properties of each microelement with very high precision by measuring an image about the intensity of a higher-order diffraction beam diffracted by a laser beam based on the theoretical analysis and then inversely converting the measured image. It means that the measuring
20 technique may be applied to intagliated optical elements as well as bossed micro optical element array, and all micro optical element arrays fabricated by changing the refractive index within an optical element.

In conclusion, the present invention is concerned with a
25 technique that can overcome the problem in the precision

measuring technique that was intended to apply to existing micro optical element array, etc., such as a problem occurring in a destructive object or a very low measurement speed. It is first required to develop a technique for increasing the speed in developing techniques capable of maintaining measurement precision relatively without change and overcoming the limit, while solving the fundamental problems occurring in the contact type measuring method, such as a low measurement speed and its attendant mechanical damage.

To overcome the technical problems, the present invention proposes a new measuring technique employing the diffraction-interference property by micro optical element array that has not been applied in the prior art. The technique can maintain simplification in measurement while maintaining measurement precision up to optical diffraction limit spatially. It is therefore possible to increase the speed of measurement significantly and to accomplish a non-destructive characteristic by maintaining non-destructive measurement. The optical diffraction profiler may be applied to measure optical characteristics and spatial three-dimensional shapes of micro optical element array, which have different optical characteristics and a variety of shapes, at high speed with high precision even before and after the space and between the spaces, by converting bossed and intagliated or refractive index in the future.

【Industrial Applicability】

As described above, the three-dimensional surface illumination measuring apparatus of micro optical element array according to the present invention has the following
5 advantages. Not only a three-dimensional shape of each micro optical element array, but also the uniformity on a sample in a large area can be measured at high speed while maintaining spatial measurement precision of an optical diffraction limit degree. Furthermore, surface illumination of micro optical
10 element array made of various materials can be measured using a laser of a wideband wavelength. It is thus possible to reduce purchase and installation time of an additional laser. In addition, measurement of high precision is possible by excluding laser beams scattered by an object to be measured.
15 By controlling the process based on real-time measurement and analysis, the quality of a product can be improved. Furthermore, the cost, which is incurred by managing the quality of a substrate before a subsequent expensive product process can be saved significantly.

【CLAIMS】**【Claim 1】**

A three-dimensional surface illumination measuring apparatus for micro optical element array, the apparatus
5 comprising:

a laser disposed parallel to an object to be measured at a predetermined angle, for radiating a laser beam of a wideband wavelength onto the object; and

optical detection units for detecting a direct reflection
10 beam that is directly reflected from the to-be-measured object, a diffracted and interfered beam that is diffracted and interfered from the to-be-measured object, and a scattered beam that is scattered from the to-be-measured object, of the illuminated laser beam.

15 **【Claim 2】**

The apparatus of claim 1, wherein a value calculated by the following equation is applied to allow a microcomputer to calculate surface illumination so that the scattered laser beam is excluded:

20
$$R = (B - C) / (A - C)$$

where A is an intensity of a directly reflected laser beam

B is an intensity of a firstly diffracted laser beam

C is an intensity of a scattered laser beam by a
25 scattering source of a to-be-measured object.

【Claim 3】

The apparatus of claim 2, wherein the object has its three-dimensional surface illumination measured at the same time when the object is conveyed by a stage.

5 **【Claim 4】**

The apparatus of any one of claims 1 to 3, further comprising:

an A/D converter that converts the laser beams detected by the optical detection units into electrical signals; and

10 a microcomputer that calculates three-dimensional surface illumination using a program programmed based on the electrical signals converted by the A/D converter.

【Claim 5】

The apparatus of claim 4, further comprising a display
15 that displays the three-dimensional surface illumination value calculated by the microcomputer.

【Claim 6】

The apparatus of claim 4, further comprising a CCD camera
disposed over the object, for monitoring a measured surface of
20 the object in real-time.

【Claim 7】

A three-dimensional surface illumination measuring method of micro optical element array, the method comprising the steps of:

25 (a) allowing a laser, which is disposed parallel to a to-

be-measured object at a predetermined angle, to radiate a laser beam of a wideband wavelength onto the object;

(b) allowing optical detection units to detect a direct reflection beam that is directly reflected from the to-be-measured object, a diffracted and interfered beam that is diffracted and interfered from the to-be-measured object, and a scattered beam that is scattered from the to-be-measured object, of the illuminated laser beam;

(c) allowing an A/D converter to convert the laser beams detected by the optical detection units into electrical signals; and

(d) allowing a microcomputer, which is programmed using the electrical signals converted by the A/D converter, to calculate three-dimensional surface illumination.

15 **【Claim 8】**

The method of claim 7, further comprising the step of (e) displaying the three-dimensional surface illumination value calculated in the step (d) on a display.

【Claim 9】

20 The method of claim 7 or 8, wherein the calculation step by the microcomputer is corrected using a standard material.

【Claim 10】

 The method of claim 9, wherein the object has its three-dimensional surface illumination measured at the same time when the object is conveyed by a stage.

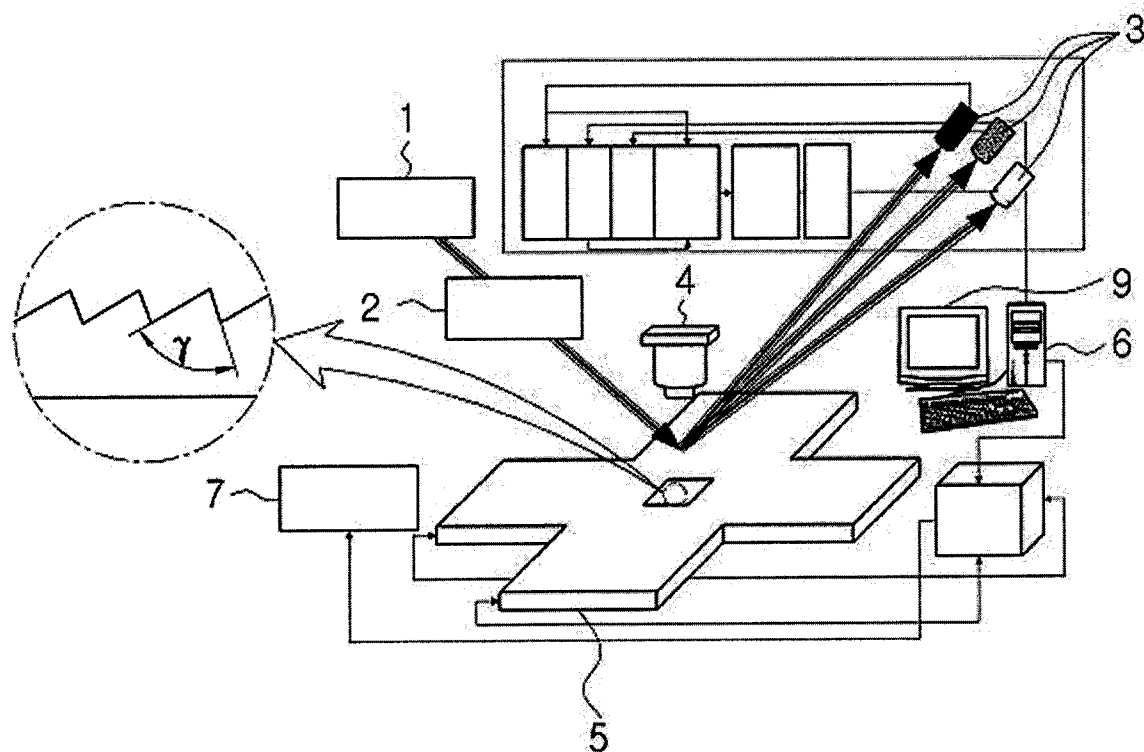
25

【Claim 11】

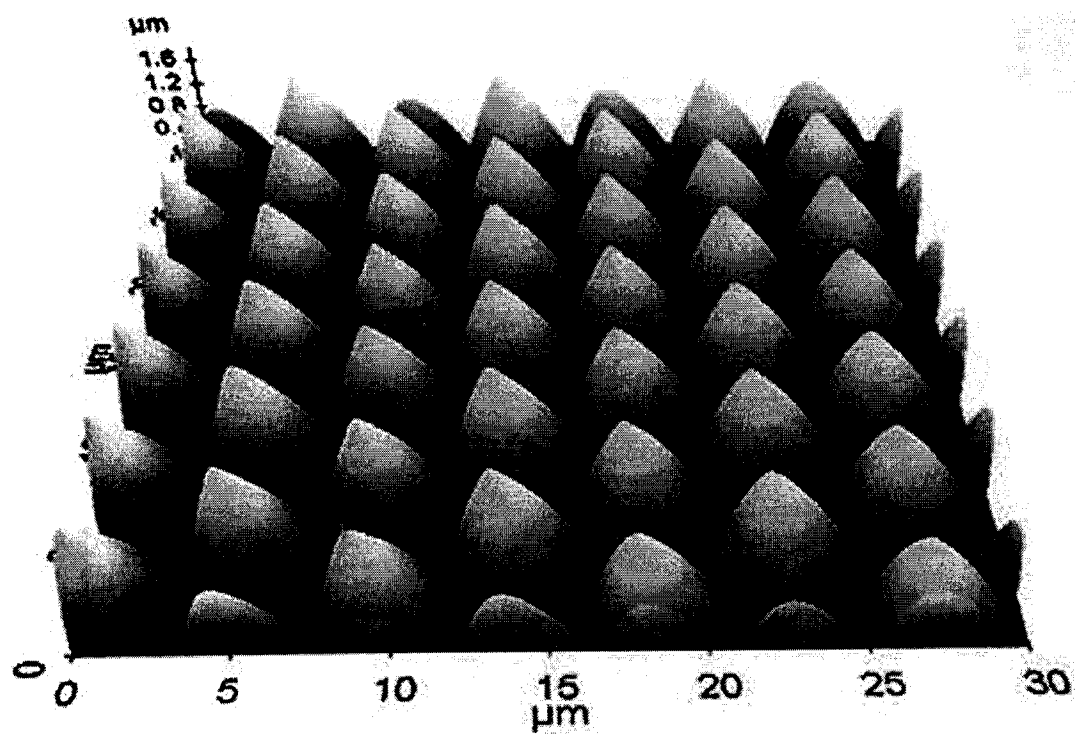
The method of claim 10, wherein a CCD camera disposed over the object monitors a measured surface of the object in real-time.

【DRAWINGS】

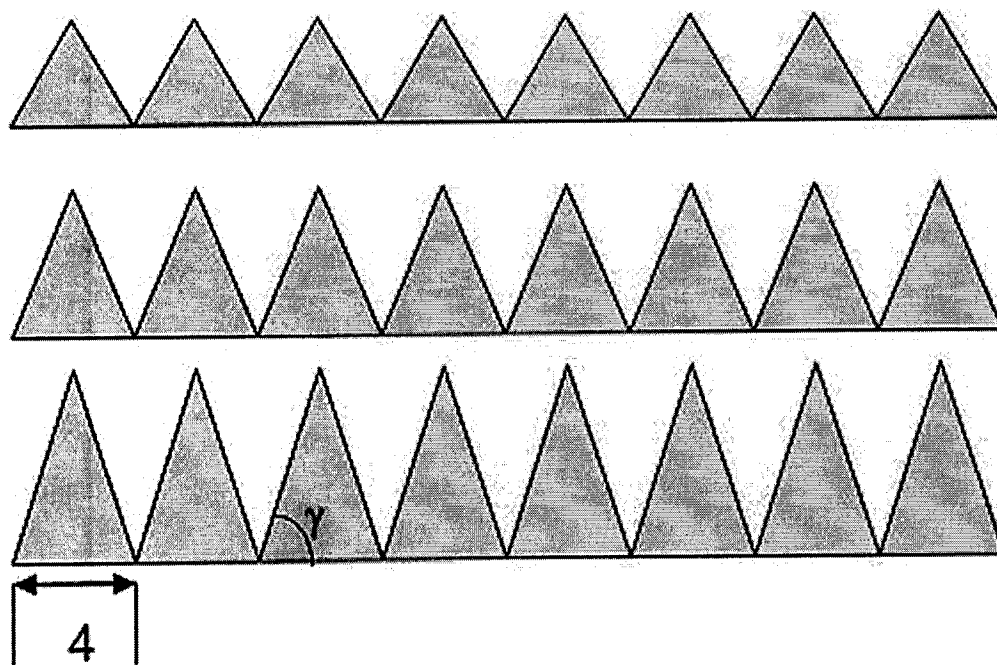
【Figure 1】



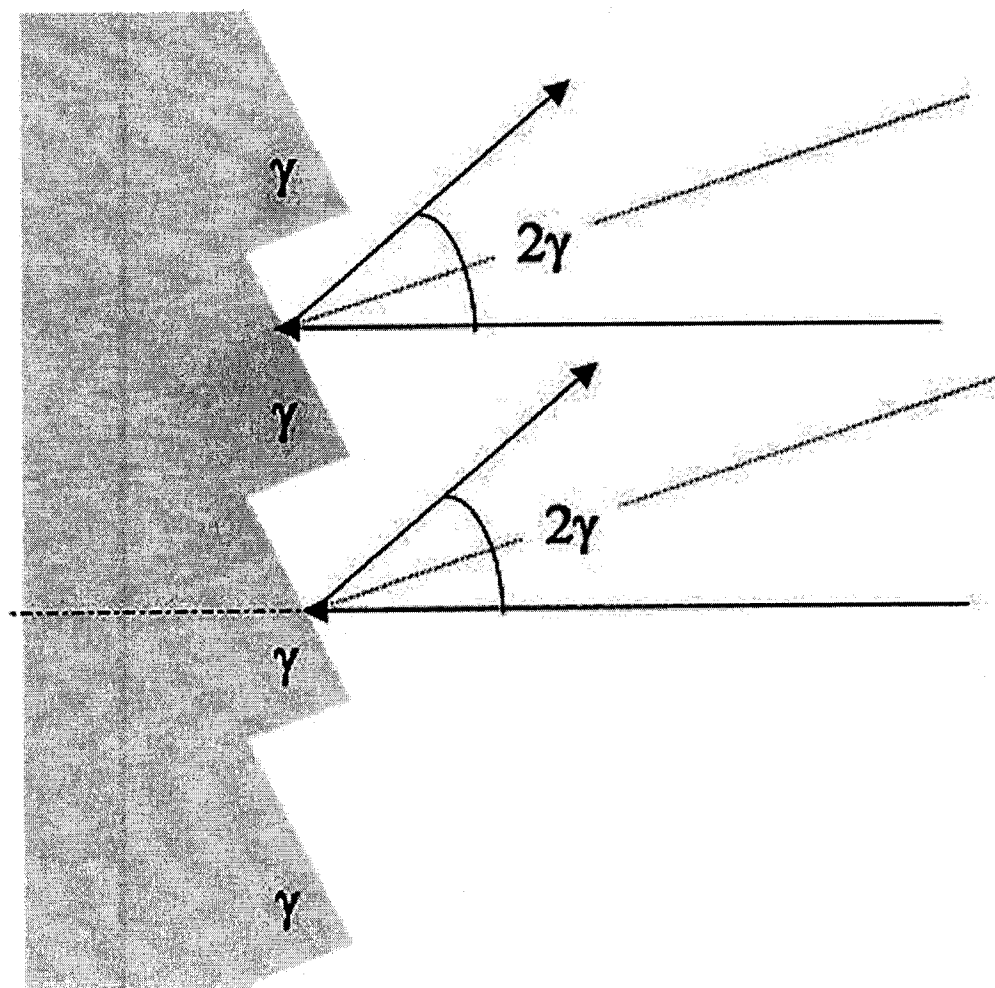
[Figure 2]



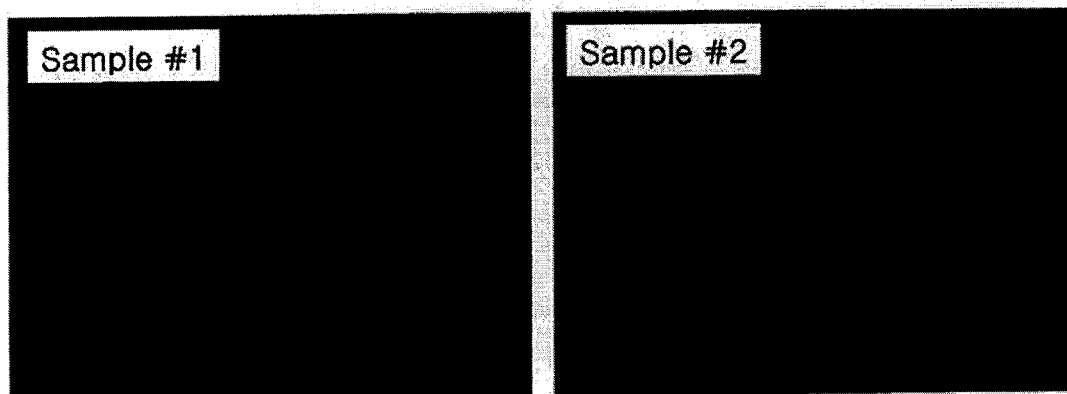
【Figure 3】



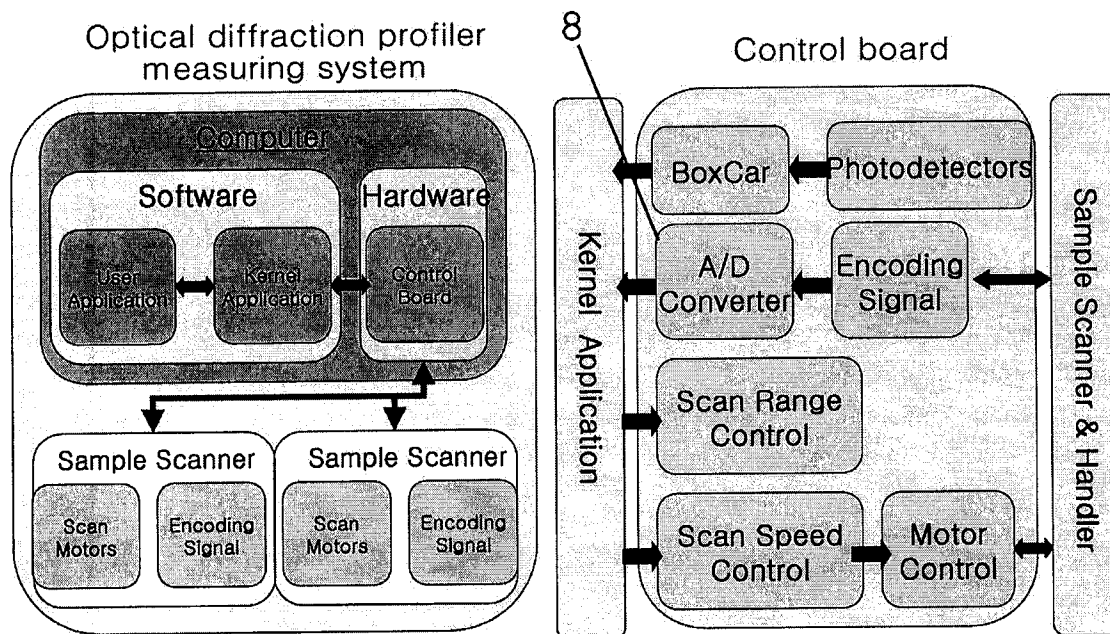
【Figure 4】



【Figure 5】

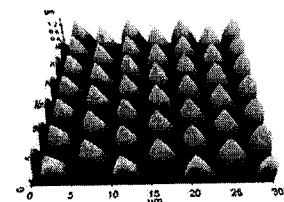


【Figure 6】

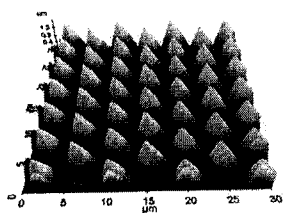
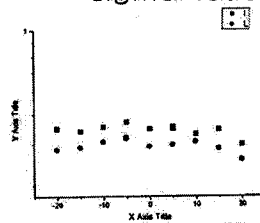


[Figure 7]Atomic force
microscopy photograph

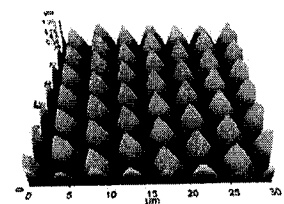
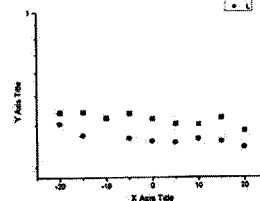
Measured height

Measure diffraction light
signal ratio

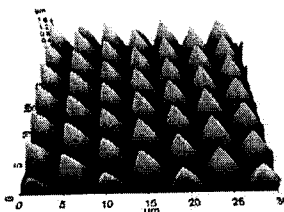
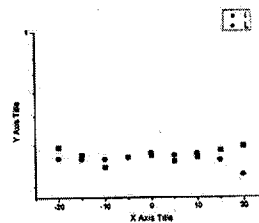
1.48 ~ 1.50



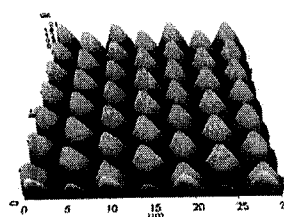
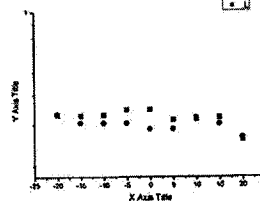
1.52 ~ 1.55



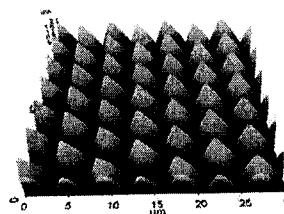
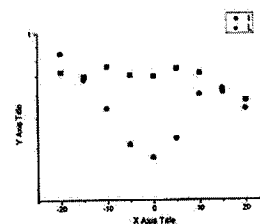
1.31 ~ 1.37



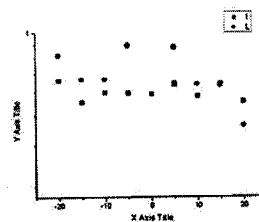
1.69 ~ 1.71



2.04 ~ 2.08



2.12 ~ 2.12



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2006/003052**A. CLASSIFICATION OF SUBJECT MATTER***G01B 11/30(2006.01)i*

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01B 11/30, G01N 21/21, 21/88, H01S 3/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Patent and application for inventions since 1975

Korean Utility Models and applications for Utility Models since 1975

Japanese Utility Models and applications for Utility Models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKIPASS(KIPO internal)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 02-32207 A (NIPPON STEEL CORP.) 2 February 1990 see the p. 1 and figs. 1, 2	1, 4-8
Y	JP 04-176143 A (NEC CORP.) 23 June 1992 see the p. 1 and figs. 1, 2	1, 4-8
A	JP 11-287642 A (ADVANTEST CORP.) 19 October 1999 see the pp. 1, 2 and fig. 1	1-11

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

30 NOVEMBER 2006 (30.11.2006)

Date of mailing of the international search report

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Telephone No. 82-42-481-5498



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2006/003052

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member(s)Publication
date

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