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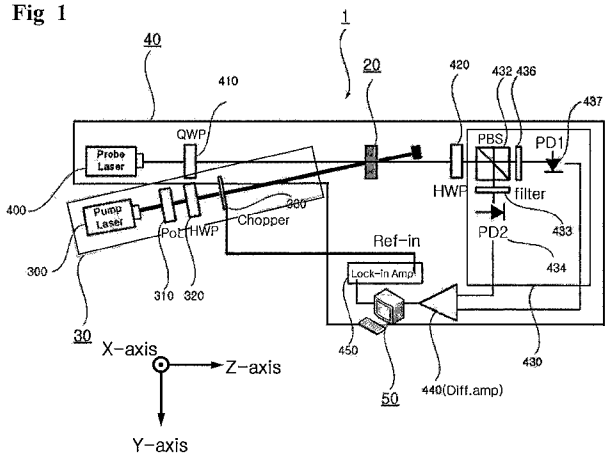
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(54) **Title:** APPARATUS FOR INSPECTING HOMOGENEITY OF THE COEFFICIENT OF THE OPTICALLY INDUCED LINEAR BIREFRINGENCE IN THIN FILM

Fig 1



(57) **Abstract:** The present invention relates to an apparatus for inspecting homogeneity of a nonlinear coefficient in a sample. The apparatus comprises: a scanner arranged with a sample to be inspected and moving it along X and Y directions; a pumping system deriving birefringence by a light Kerr effect for the sample arranged on the scanner; an interferometer measuring the birefringence in the sample; and a control computer calculating the nonlinear coefficient values using the birefringence provided from the interferometer. The control computer receives the birefringence for all positions in the measurement region in the sample from the interferometer while moving the scanner in the X and Y directions along the measurement region in the sample, extracts the nonlinear coefficient values using the birefringence and the light source intensity values of the pumping system, and prepares and provides a 3D image using all the nonlinear coefficient values extracted for the measurement region in the sample. With the present invention, the nonlinear coefficients for the measurement region in the sample being the nonlinear medium are prepared and provided as the image, thereby making it possible to inspect the homogeneity of the nonlinear coefficient value.

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APPARATUS FOR INSPECTING HOMOGENEITY OF THE COEFFICIENT OF THE OPTICALLY INDUCED LINEAR BIREFRINGENCE IN THIN FILM

FIELD OF THE INVENTION

The present invention relates to an apparatus for inspecting homogeneity of the nonlinear coefficient in a sample, and more specifically, to an apparatus for inspecting homogeneity of the nonlinear coefficient in a sample with nonlinear optical characteristics using a scanning homodyne interferometer.

DESCRIPTION OF THE RELATED ART

Studies to manufacture a light based device have variously been attempted in order to overcome a limitation of existing electronic circuit based communication and information processing. One field of the studies implements a nano-sized electro-optical device by a combination of an optical waveguide and a switching device using a medium with a very large optical nonlinear effect. In order to implement the nano-sized electro-optical device, firstly, it is the most important to implement substances with a very large nonlinear optical coefficient. Secondly, the size of the nonlinear medium should be measured and the homogenity of the nonlinear coefficient values in a local area should be inspected. Finally, the processing should be performed at a nano size. Therefore, it is a very important process to easily and rapidly inspect the nonlinear optical homogeneity of a material upon manufacturing the device.

In an aforementioned first step, various apparatuses for measuring the nonlinear coefficient have commonly been used. As the example, there are a Z-scan, an optical Kerr-gate, a Four-wave mixing, a marker fringe, an interferometer, etc. The apparatuses for measuring the aforementioned conventional nonlinear coefficient calculates the nonlinear coefficient by analyzing transmitted or reflected light while

moving or rotating the sample in an optical direction. However, the methods used for the apparatuses for measuring the conventional nonlinear coefficient cannot inspect the homogeneity of the nonlinear coefficient in the local area or require very long inspection time as well as the structure of the apparatus is complicated.

The present invention is to remove the problems. The present invention proposes a scheme capable of inspecting the homogeneity of nonlinearity in the medium in a short time by imaging the nonlinear coefficient value of the medium in the local region with a simple principle.

Throughout this application, several patents and publications are referenced and citations are provided in parentheses. The disclosure of these patents and publications is incorporated into this application in order to more fully describe this invention and the state of the art to which this invention pertains.

DETAILED DESCRIPTION OF THIS INVENTION

An apparatus for inspecting homogeneity of a non linear coefficient in a sample according to the present invention to solve the aforementioned problems can inspect homogeneity of a sample in a local region by generating birefringence by a light Kerr effect in a nonlinear medium, detecting very fine signal by a scanning type homodyne interferometer of a pump-probe scheme, measuring the change in birefringence in the local region by mounting the sample on the scanning apparatus, and imaging the nonlinear coefficient.

To achieve the aforementioned technical problem, an apparatus for inspecting homogeneity of a nonlinear coefficient in a sample being a nonlinear medium comprises: a scanner arranged with a sample to be inspected and moving it along X and Y directions; a pumping system deriving birefringence by a light Kerr effect for the sample arranged on the scanner; an interferometer measuring the birefringence in

the sample; and a control computer calculating the nonlinear coefficient values using the birefringence for each position of the measurement region in the sample provided from the interferometer while moving the scanner along the measurement region in the sample and imaging and providing the nonlinear coefficient values for the measurement region in the sample, whereby the homogeneity of the nonlinear coefficient values can be inspected.

The scanner of the inspection apparatus having the aforementioned feature comprises: a sample table fixing the sample; an actuator (motor, pzt, etc.) moving the sample table into the X and Y directions; and an actuator driver driving the actuator, the actuator driver drives the actuator according to the control signal provided from the control computer to move the sample table in the X and Y directions.

The pumping system of the inspection apparatus having the aforementioned feature comprises: a pump light source; a polarizer disposed on a front of the pump light source but on the same axis of the pump light source and the scanner to polarize beams from the pump light source; a λ/2-wave plate (HWP) disposed between the polarizer and the scanner but on the same axis of the pump light source and the polarizer to phase-delay beams from the polarizer; and a chopper disposed between the λ/2-wave plate and the scanner, the chopper converting and outputting beams from the λ/2-wave plate into pluses in a square wave.

The interferometer of the inspection apparatus having the aforementioned feature comprises: a probe light source outputting a linear polarized beam; a λ/4-wave plate (QWP) disposed on a front of the probe light source but on the same axis of the probe light source and the scanner to phase-delay linear polarized beams from the probe light source and convert them into circular polarized beams; a λ/2-wave plate (HWP) disposed on a front of the scanner to phase-delay oval polarized beams output from the sample; a polarizing sense unit dividing and outputting beams passing

through the λ/2-wave plate into vertical polarized beams and horizontal polarized beams; a differential amplifier receiving the vertical polarized beams and the horizontal polarized beams output from the polarizing sense unit as input signals to amplify and output difference values of the input signals; and a lock-in amplifier locking output signals from the differential amplifier to a reference frequency and amplifying them, the sample being disposed between the λ/4-wave plate and the λ/2-wave plate.

The polarizing sense unit comprises: a polarized beam splitter (PBS)reflecting vertical polarizing components and passing horizontal polarizing components among input beams; a first filter disposed on the same axis with the reflected surface of the PBS and passing the vertical polarizing components; a first optical detector detecting vertical polarized beams passing through the first filter; a second filter disposed on the same axis with a front of the PBS and passing the horizontal polarizing component; and a second optical detector detecting horizontal polarized beam passing through the second filter.

The control computer of the inspection apparatus having the aforementioned feature receives the birefringence for all positions in the measurement region in the sample from the interferometer while moving the scanner in the X and Y directions along the measurement region in the sample, extracts the nonlinear coefficient values using the birefringence and the light source intensity values of the pumping system, and prepares and provides the image using all the nonlinear coefficient values extracted for the measurement region in the sample.

In order to confirm the performance of the apparatus for inspecting the homogeneity of the nonlinear coefficient of the medium according to the present invention, an experiment apparatus used for the induced birefringence measurement

is constituted by a combination of a scanning apparatus including the actuator and a pair of lenses and the homodyne interferometer.

FIGS. 4 and 6 each, which is a measurement result of a nano-composite thin film with a very large nonlinear coefficient value, shows images in a single layer thin film and a multi-layer thin film. Referring to FIG. 4, a region having large optically induced birefringence in a band shape and a region having small birefringence at both sides thereof can be clearly appreciated. The non-homogeneity in the band shape is shown in most samples. Consequently, it can be appreciated that the nonlinear effect of the thin film is non-uniform.

FIGS 5(a) and (b), which show a change in birefringence according to the pumping power at A and B points, show the measurement of the same value as the scanning result. It can be appreciated that when the pumping power is 200mW, each of the optically induced birefringence sizes (Δn) at the A and B positions is 2.2×10^{-5}, 8.7×10^{-7}, that is, the order difference is 10^2.

Reviewing the scanning image of FIG. 6, the image forms a region where the optically induced birefringence is negative, unlike the single layer thin film. In particular, the change in the optically induced birefringence is measured according to the pumping power at one point in the region where the optically induced birefringence is negative. In this case, unlike FIGS. 5(a) and (b) that the optically induced birefringence is linearly increased, it can be observed that the optically induced birefringence first shows a positive value at low power but as the pumping power is raised, the value of the birefringence begins to reduce and when the pumping power is 130mW, the signal of the optically induced birefringence is inverted to a negative value. In other words, it can be observed that the nonlinearity is inverted from a positive number into a negative number according to the pumping power and the transmittance does not show the linear change as well and is reduced

to a maximum 12% and the optically induced birefringence is increased at a point where the linearity is broken.

Therefore, the apparatus for inspecting the homogeneity of the nonlinear coefficient in the sample according to the present invention measures the linear birefringence characteristics by combining the scanning apparatus with the homodyne interferometer capable of very precisely measuring the signal while easily aligning the optical system and images the nonlinear coefficient value in the local region using this, making it possible to easily judge the homogeneity of the nonlinear coefficient or not.

With the present invention, the local region of the nonlinear medium can be inspected easily and rapidly.

The apparatus for the homogeneity according to the present invention generates the birefringence by a precision light kerr effect in the sample being the nonlinear medium, detects very fine signal by the homodyne interferometer of the pump-probe scheme, measures the change in birefringence in the local region by mounting the sample on the scanning apparatus capable of moving the sample in the X and Y directions, and images the nonlinear coefficient, making it possible to inspect the homogeneity in the sample.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a configuration view schematically showing an apparatus 10 for inspecting homogeneity of a nonlinear coefficient according to a preferred embodiment of the present invention.

FIG. 2 is a graph showing induced birefringence according to an output of a pump light source in a sample according to a preferred embodiment of the present invention.

FIG. 3 is a graph showing induced birefringence according to a rotation of a λ/2 wave plate in a nonlinear medium according to a preferred embodiment of the present invention.

FIGS. 4 and 6 each, which is a measurement result of a nano-composite thin film with a very large nonlinear coefficient value, shows images in a single layer thin film and a multi-layer thin film.

FIGS 5(a) and (b) are graphs measuring a change in birefringence according to pumping power at A and B points of FIG. 4, show the measurement of the same value as the scanning result.

FIG. 7 is a graph measuring a change in a optically induced birefringence according to a pumping power at one point in a region where the optically induced birefringence is negative.

<DESCRIPTION FOR KEY ELEMENTS IN THE DRAWINGS>

1: apparatus for inspecting homogeneity of nonlinear coefficient

20: scanner

30: pumping system

300: pump light source

310: polarizer

320: half-wave plate

330: chopper

40: interferometer

400: probe light source

410: quarter-wave plate

420: HWP

430: polarizing sense unit

440: differential amplifier

450: lock-in amplifier

50: control computer

The present invention will now be described in further detail by examples. It would be obvious to those skilled in the art that these examples are intended to be more concretely illustrative and the scope of the present invention as set forth in the appended claims is not limited to or by the examples.

EXAMPLES

Hereinafter, the configuration and operation of an apparatus of homogeneity of a nonlinear coefficient in a sample according to a preferred embodiment of the present invention will be described with reference to the accompanying drawings.

FIG. 1 is a configuration view schematically showing an apparatus 10 for inspecting homogeneity of a nonlinear coefficient according to a preferred embodiment of the present invention. Referring to FIG. 1, the apparatus 1 includes a scanner 20 disposed with a sample to be inspected and moving it along X and Y directions; a pumping system 30 deriving birefringence by a light Kerr effect for the sample; an interferometer 40 measuring a fine change in the birefringence in the sample; and a control computer controlling the operation of the scanner 20 and calculating the nonlinear coefficient values by processing data using the birefringence provided from the interferometer and imaging and providing the nonlinear coefficient values. Hereinafter, the configuration and operation of each component as described above will be described in detail.

The scanner, which fixes the sample, is disposed in an optical-axis direction of the interferometer 40. The scanner includes a sample table fixing the sample; an

actuator moving the sample table into the X and Y directions; and an actuator driver, the actuator driver moving the actuator according to the control signal provided from the control computer in the X and Y directions. Therefore, the control computer of the apparatus according to the present invention can scan the sample disposed on the sample table while moving the scanner in the X and Y directions.

The pumping system includes a pump light source 300; a polarizer 310; a half wave plate 320 (hereinafter, referred to as HWP); and a chopper 330.

Preferably, the pump light source 300 selectively uses laser with various wavelengths according to a kind of a medium. The HWP 320 delays a phase of a polarized beam to control an angle of the polarized beam. The polarizer 310 and the HWP 320 are sequentially disposed on a front of the pump light source 300 so that the beams from the pump light source 300 pass through the polarizer 310 and the HWP 320 and are then supplied to the sample of the scanner 20. The sample of the scanner 20 generates the optical kerr effect by the beams provided from the light source so that an ordinary ray and an extraordinary ray are generated by the birefringence. At this time, the change in the phases of two rays suffering from the birefringence is generated according to the characteristics in the sample disposed on the scanner 10. The birefringence Δn is determined by the difference value of the refractive index (nx) of the ordinary ray and the refractive index (ny) of the extraordinary ray.

The chopper 330 cuts the beams per predetermined time to change the beams provided from the light source into pulse waves in a square wave.

In another embodiment of the pumping system of the present invention further includes a quarter-wave plate (hereinafter, referred to as 'QWP'; not shown) between the pump light source and the scanner, making it possible to change linear polarized beam from the pump light source into a circular polarized beam.

The interferometer 40 measures a degree of a fine change in the birefringence generated from the sample by the pumping system and provides the changed amount of the measured birefringence. The interferometer 40 includes a probe light source 400, a quarter-wave plate (hereinafter, referred to as 'QWP' 410), a HWP 420, a polarization sensing unit 430, a differential amplifier 440, and a lock-in amplifier 450.

Preferably, the probe light source 400 uses laser generating the linear polarized beam according to the kind of the medium.

The QWP 410 rotates the linear polarized beam starting from the light source 400 by 45°from a main axis, thereby generating the circular polarization. The circular polarization from the QWP is incident on the sample disposed on the scanner to generate the phase difference by the characteristics in the sample, so that the circular polarization is converted into an oval polarization.

The HWP 420, which is the half-wave plate, passes the oval polarized beams output from the sample and then divides them into vertical component and horizontal component and is incident on a polarization beam splitter.

The polarization sensing unit 430, which detects the vertical and horizontal polarization components of beams output from the sample by interfering them, includes a first filter 433, a first optical detector 434 detecting beam I1 interfered in the horizontal direction passing through the first filter, a second filter 436, and a second optical detector 437 detecting beam I2 interfered in the horizontal direction passing through the second filter. The polarization beam splitter 432 passes the interfered component I2 in the vertical direction of the beams passing through the HWP 420 to the first filter 433 and passes the interfered component I2 in the horizontal direction to the second filter 436. The component passing through the first filter 433 is detected through the first optical detector 434 and is provided as the first input signal I1 of the differential amplifier 440 and the component passing through the

second filter 436 is detected through the second optical detector 437 and is provided as the second input signal I2 of the differential amplifier 440.

The first optical detector 434 and the second optical detector 437 may use a photo diode receiving light.

The differential amplifier 440 receives the first input signal and the second input signal from the polarization sensing unit 430 and amplifies and outputs the difference (Idiff=I1-I2) of the first input signal and the second input signal received.

The lock-in amplifier 450 receives a reference frequency signal from the chopper 330 and locks the output signal of the differential amplifier 440 to the reference frequency signal and amplifies and outputs it.

The interferometer 40 having the aforementioned configuration makes incidence the circular polarized beam on the sample by passing the linear polarized beam starting from the light source 400 to the QWP 410 aligned at 45° to the main axis. The phase difference optically derived by the sample converts the incident circular polarized beam into the oval polarized beam and the conversion is interfered by the HWP and the PBS at a later stage to amplify and detect the difference of the signal measured by the optical detectors 1 and 2, making it possible to detect the very fine signal. The output signal output from the differential amplifier 440 is provided to the control computer 50 as a signal with an amplified birefringence Δn derived from the sample.

In order to measure the birefringence in the predetermined region in the sample, the control computer 50 provides the control signal for moving the sample table of the scanner 20 in the X and Y directions in the region to be measured. The scanner 20 moves the sample table according to the control signal from the control computer.

The control computer 50 receives the information on the birefringence for all the positions in the measured region in the sample from the differential amplifier 440 in the interferometer 40 and extracts the nonlinear coefficient value γ for the sample using the received information on the birefringence and the intensity value of the pumping light source in the pumping system. The non-linear coefficient value γ is calculated by formulas 1 to 5 using the changed amount of the birefringence and the intensity value of the pumping light source. A Jones matrix may be represented by the formula 1.

[Formula 1]

$$\begin{bmatrix} \cos 2\theta & \sin 2\theta \\ \sin 2\theta & -\cos 2\theta \end{bmatrix} \begin{bmatrix} e^{i\Phi_x} & 0 \\ 0 & e^{i\Phi_y} \end{bmatrix} \frac{1}{\sqrt{2}} \begin{bmatrix} 1+i & 0 \\ 0 & 1-i \end{bmatrix} \frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

where the Jones matrix represents probe light linearly polarized at 45° to the main axis from the right, the quarter-wave plate aligned (θ=0)to the main axis (x-axis), a phase value derived by the pump light, and the half-wave plate aligned to the main axis at θ.

The signal ΔI detected by the differential amplifier in the interferometer may be represented by the formula 2.

[Formula 2]

$$\begin{aligned} \Delta I = I_1 - I_2 &\propto 2\left|E_o\right|^2 \cos 2\theta \sin 2\theta \sin \Delta\Phi \\ &\approx \left|E_o\right|^2 \Delta\Phi \sin 4\theta \qquad (\text{at } \Delta\Phi \ll 1) \end{aligned}$$

where φx, φy, which are the phase values in each direction by the light kerr effect derived from the pump light source, are generated by the pump light.

Therefore, they are called an optically induced phase. Meanwhile, ΔΦ represents the difference.

ΔΦ measured when the half-wave plate is 22.5° from the main axis may be represented by the following formula 3.

[Formula 3]

$$\Delta\Phi \cong \frac{\Delta I}{|E_o|^2} = \frac{2\pi}{\lambda}\Delta nL$$

where L is a thickness in the sample and λ is a wavelength of the probe light source.

The non-linear refractive index (γ) can be obtained from the formulas 4 and 5.

[Formula 4]

$$n = n_0 + \Delta n = n_0 + \gamma I$$

[Formula 5]

$$\gamma = \Delta n / I$$

where n0 is the linear refractive index and I is the intensity of the pump light. n is the refractive index having a portion changed by the intensity of light. Generally, all the things having a portion changed by the intensity of light is referred to as refractive index. n0, which is the linear refractive index, represents a constant value irrespective of the intensity of light among the components of refractive index and Δn, which is the birefringence, generally represents the difference in the refractive index in each direction but in the specification, represents the difference in the refractive index

derived by the pump light source. γ, which is a third order nonlinear refractive index, represents the refractive index component proportional to the intensity of light among the refractive index components.

FIG. 2 is a graph showing induced birefringence according to an output of a pump light source in a sample according to a preferred embodiment of the present invention. As shown in the graph and from the formulas 4 and 5, it can be appreciated that the intensity of signal is linearly increased according to the intensity of pump light.

FIG. 3 is a graph showing induced birefringence according to a rotation of a λ/2 wave plate in a nonlinear medium according to a preferred embodiment of the present invention. This embodiment can determine the size and sign of the nonlinear refractive coefficient in a given medium. It can be appreciated that a sine graph is shown as in the formula 2 and the optically induced phase associated with nonlinear refractive coefficient value is a positive value.

With the aforementioned process, the control computer calculates and images the nonlinear coefficient values for the local positions in the sample while moving the scanner to display them. The homogeneity of the nonlinear coefficient values in the sample can be inspected in a short time through the displayed image.

The preferred embodiments of the present invention are described, but are only by way of example. Therefore, the present invention is not limited to the aforementioned embodiments. It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the inventions. For example, in the embodiments of the present invention, the kind of the light source used for the pumping system and the interferometer can be variously modified in order to improve the performance of the overall system. And, it is to be understood that the differences associated with

these modifications and applications is included in the scope of the present invention defined in the appended claims.

The apparatus for the homogeneity of the nonlinear coefficient in the sample according to the present invention may be used to inspect whether the local nonlinear effect of the nonlinear medium becomes uniform in the process implementing the electro-optical device.

Having described a preferred embodiment of the present invention, it is to be understood that variants and modifications thereof falling within the spirit of the invention may become apparent to those skilled in this art, and the scope of this invention is to be determined by appended claims and their equivalents.

What is claimed is:

1. An apparatus for inspecting homogeneity of a nonlinear coefficient in a sample being a nonlinear medium comprises:

a scanner arranged with a sample to be inspected and moving it along X and Y directions;

a pumping system deriving birefringence by a light Kerr effect for the sample arranged on the scanner;

an interferometer measuring the birefringence in the sample; and

a control computer calculating the nonlinear coefficient values using the birefringence for each position of the measurement region in the sample provided from the interferometer while moving the scanner along the measurement region in the sample and imaging and providing the nonlinear coefficient values for the measurement region in the sample, whereby the homogeneity of the nonlinear coefficient values can be inspected.

2. The apparatus for inspecting homogeneity of the nonlinear coefficient in the sample according to claim 1, wherein the scanner comprises:

a sample table fixing the sample;

an actuator moving the sample table into the X and Y directions; and

an actuator driver driving the actuator, the actuator driver drives the actuator according to the control signal provided from the control computer to move the sample table in the X and Y directions.

3. The apparatus for inspecting homogeneity of the nonlinear coefficient in the sample according to claim 1, wherein the pumping system comprises:

a pump light source;

a polarizer disposed on a front of the pump light source but on the same axis of the pump light source and the scanner to polarize beams from the pump light source; and

a λ/2-wave plate (HWP) disposed between the polarizer and the scanner but on the same axis of the pump light source and the polarizer to phase-delay beams from the polarizer.

4. The apparatus for inspecting homogeneity of the nonlinear coefficient in the sample according to claim 3, wherein the pumping system further comprises a chopper disposed between the λ/2-wave plate and the scanner, the chopper converting and outputting beams from the λ/2-wave plate into pluses in a square wave.

5. The apparatus for inspecting homogeneity of the nonlinear coefficient in the sample according to claim 1, wherein the interferometer comprises:

a probe light source outputting a linear polarized beam;

a λ/4-wave plate (QWP) disposed on a front of the probe light source but on the same axis of the probe light source and the scanner to phase-delay linear polarized beams from the probe light source and convert them into circular polarized beams;

a λ/2-wave plate (HWP) disposed on a front of the scanner to phase-delay oval polarized beams output from the sample;

a polarizing sense unit dividing and outputting beams passing through the λ/2-wave plate into vertical polarized beams and horizontal polarized beams;

a differential amplifier receiving the vertical polarized beams and the horizontal polarized beams output from the polarizing sense unit as input signals to amplify and output difference values of the input signals; and

a lock-in amplifier locking output signals from the differential amplifier to a reference frequency and amplifying them, the sample being disposed between the λ/4-wave plate and the λ/2-wave plate.

6. The apparatus for inspecting homogeneity of the nonlinear coefficient in the sample according to claim 5, wherein the polarizing sense unit dividing and outputting the vertical polarized beams and the horizontal polarized beams of light passing through the sample comprises:

a polarized beam splitter (PBS) reflecting vertical polarizing components to pass horizontal polarizing components among input beams;

a first filter disposed on the same axis with the reflected surface of the PBS to pass the vertical interfered component;

a first optical detector detecting the interfered beam passing through the first filter;

a second filter disposed on the same axis with a front of the PBS to pass the horizontal interfered component; and

a second optical detector detecting the interfered beam passing through the second filter.

7. The apparatus for inspecting homogeneity of the nonlinear coefficient in the sample according to claim 5, wherein the lock-in amplifier locks output signals from the differential amplifier and amplifies them, according to a reference frequency signal input from a chopper of the pumping system.

8. The apparatus for inspecting homogeneity of the nonlinear coefficient in the sample according to claim 1, wherein the control computer receives the birefringence for all positions in the measurement region in the sample from the interferometer while moving the scanner in the X and Y directions along the measurement region in the sample, extracts the nonlinear coefficient values using the birefringence and the light source intensity values of the pumping system, and prepares and provides the image using all the nonlinear coefficient values extracted for the measurement region in the sample.

Fig 1

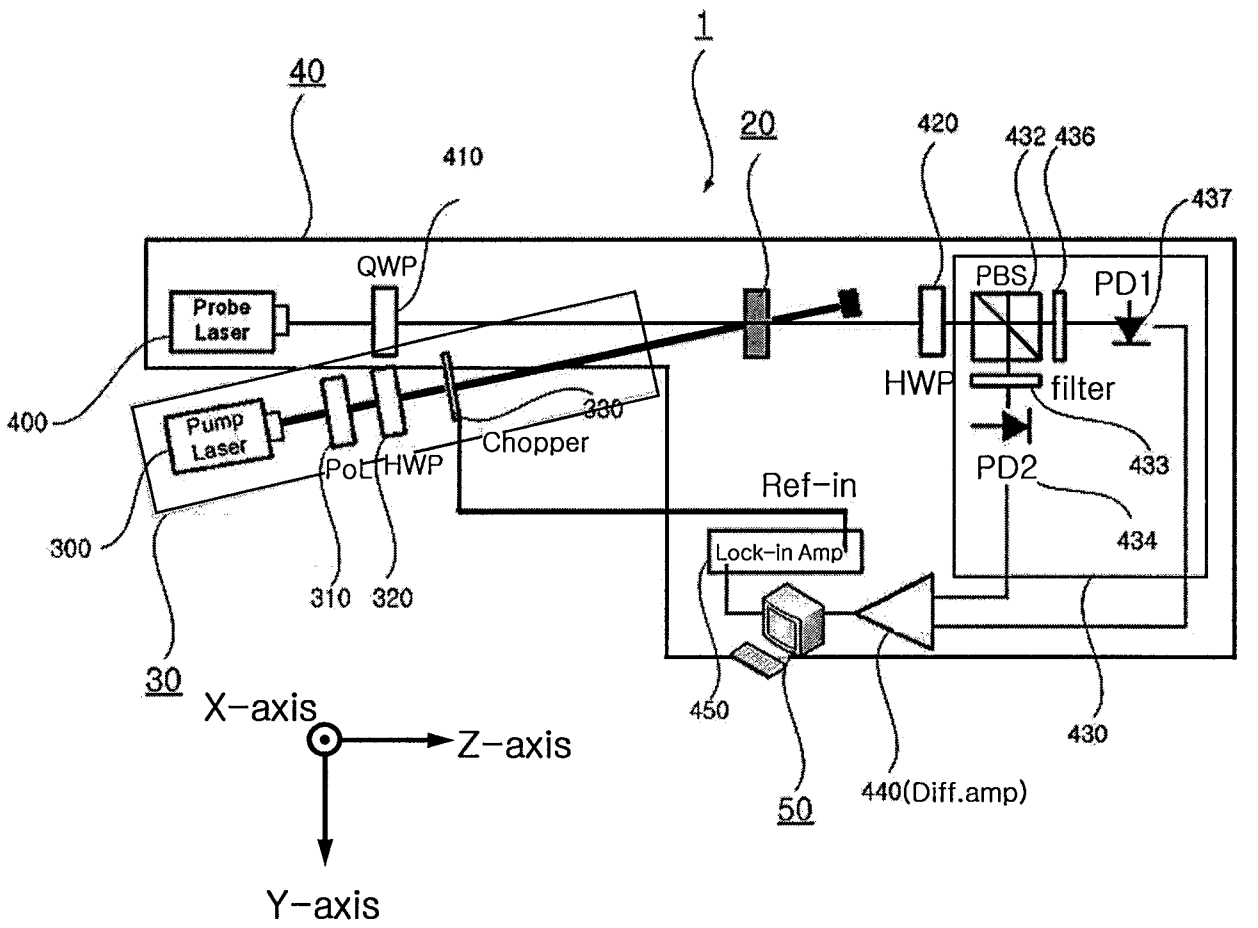

1
40
20
410
420
432
436
437
QWP
PBS
PD1
Probe Laser
400
Pump Laser
330
Chopper
PoL
HWP
HWP
filter
PD2
433
Ref-in
434
300
Lock-in Amp
310
320
30
450
430
X-axis
Z-axis
Y-axis
50
440(Diff.amp)

Fig 2

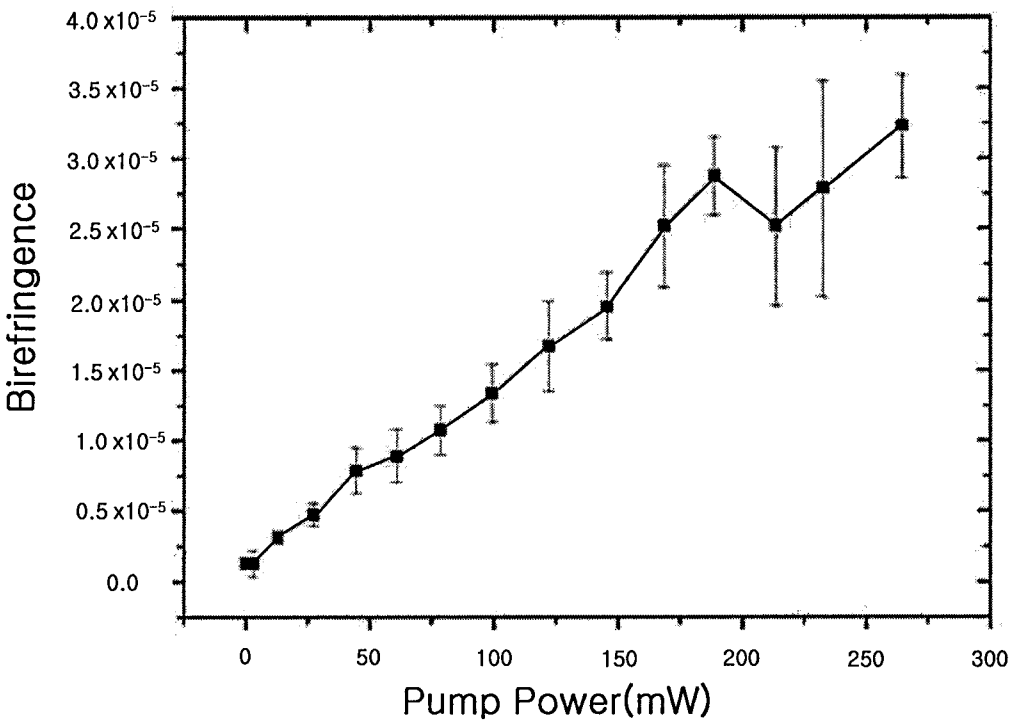

Birefringence
4.0 x10⁻⁵
3.5 x10⁻⁵
3.0 x10⁻⁵
2.5 x10⁻⁵
2.0 x10⁻⁵
1.5 x10⁻⁵
1.0 x10⁻⁵
0.5 x10⁻⁵
0.0
0
50
100
150
200
250
300
Pump Power(mW)

Fig 3

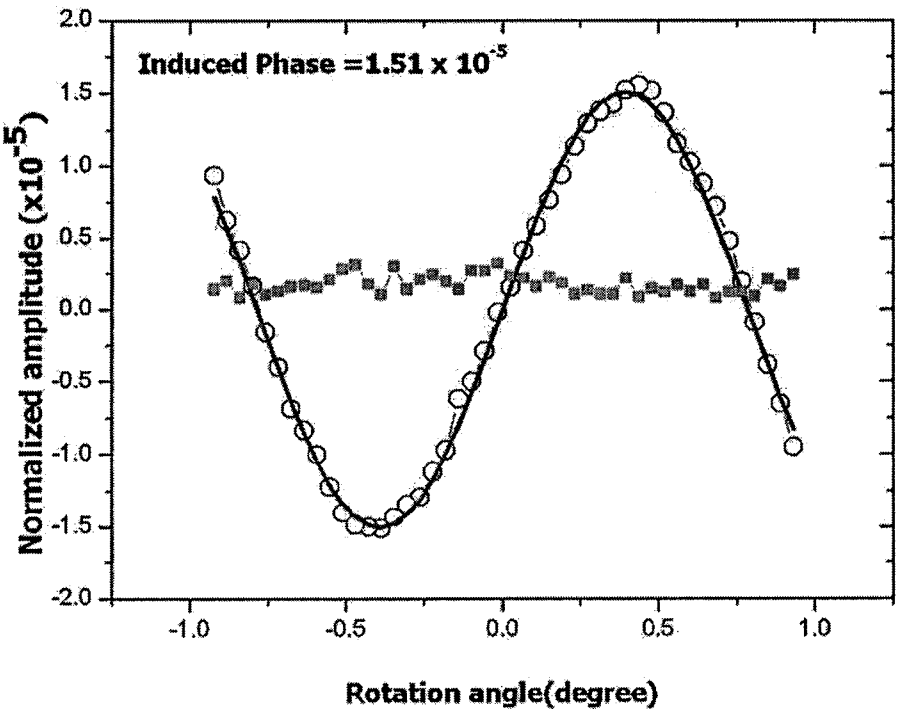

Induced Phase =1.51 x 10⁻⁵
Normalized amplitude (x10⁻⁵)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-1.0
-0.5
0.0
0.5
1.0
Rotation angle(degree)

Fig 4

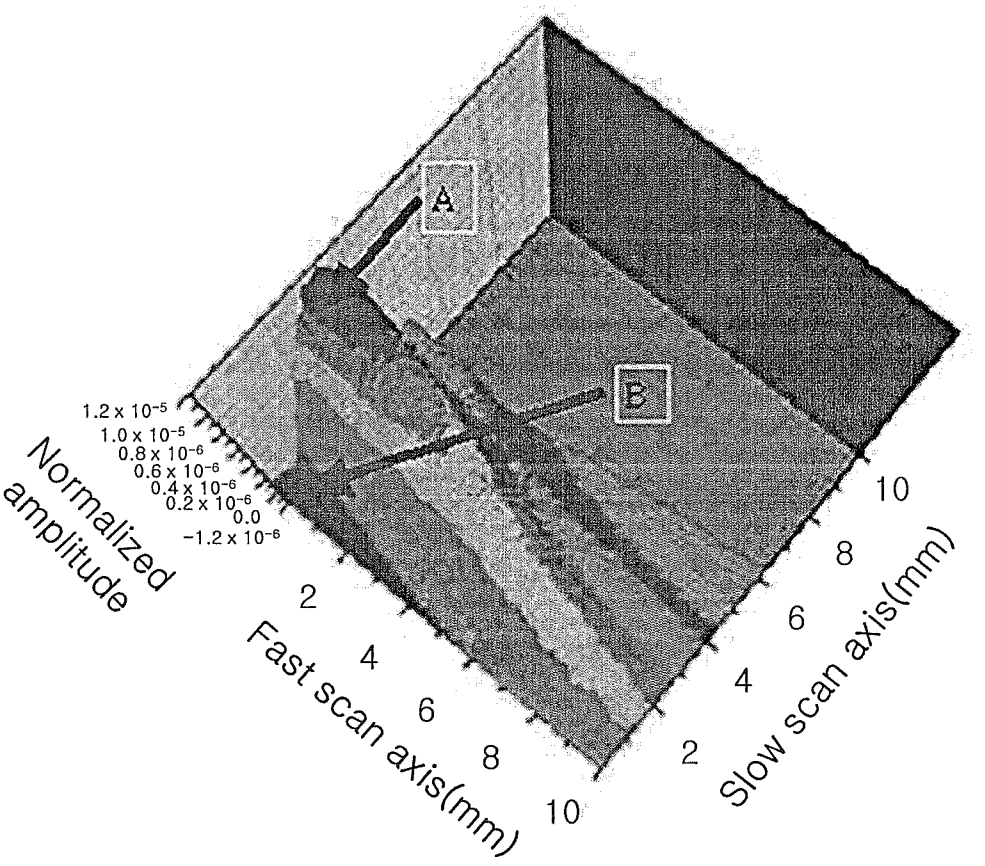
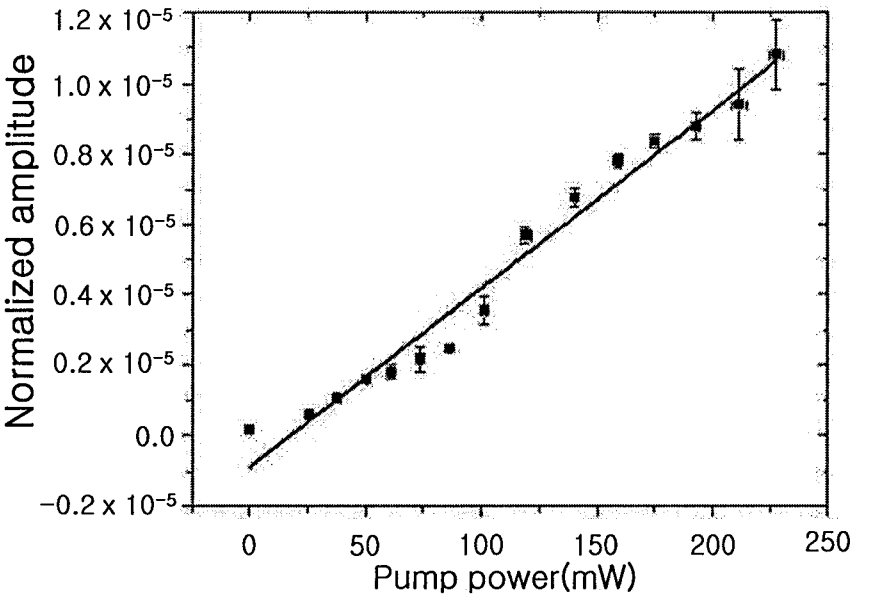
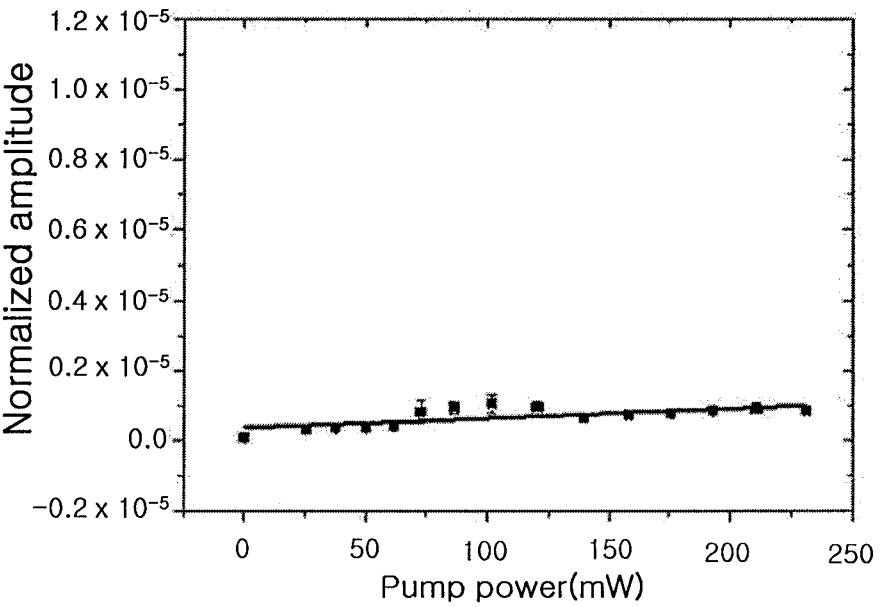

A
B
1.2 x 10⁻⁵
1.0 x 10⁻⁵
0.8 x 10⁻⁶
0.6 x 10⁻⁶
0.4 x 10⁻⁶
0.2 x 10⁻⁶
0.0
-1.2 x 10⁻⁶
Normalized amplitude
2
4
6
8
10
Fast scan axis(mm)
2
4
6
8
10
Slow scan axis(mm)

Fig 5


Normalized amplitude
1.2 x 10⁻⁵
1.0 x 10⁻⁵
0.8 x 10⁻⁵
0.6 x 10⁻⁵
0.4 x 10⁻⁵
0.2 x 10⁻⁵
0.0
−0.2 x 10⁻⁵
0
50
100
150
200
250
Pump power(mW)

(a)


Normalized amplitude
1.2 x 10⁻⁵
1.0 x 10⁻⁵
0.8 x 10⁻⁵
0.6 x 10⁻⁵
0.4 x 10⁻⁵
0.2 x 10⁻⁵
0.0
−0.2 x 10⁻⁵
0
50
100
150
200
250
Pump power(mW)

(b)

Fig 6

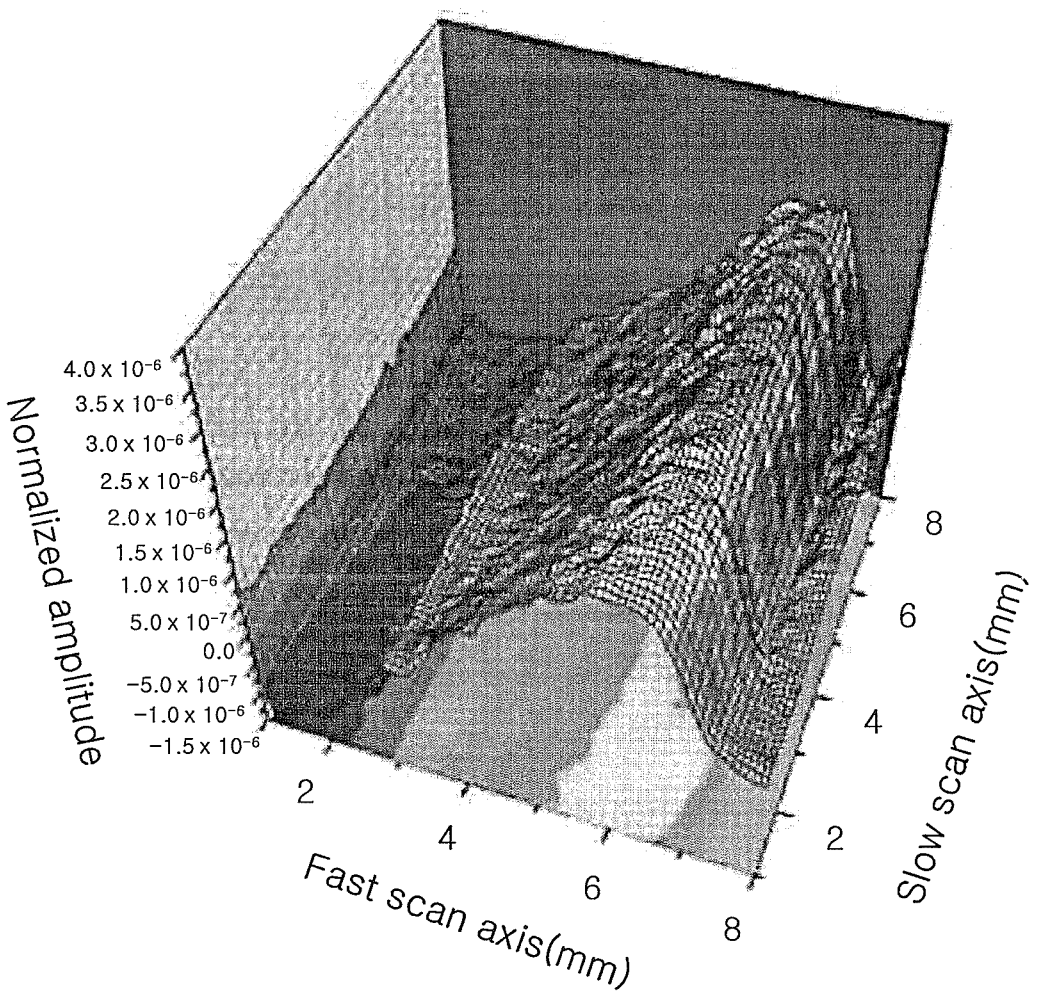
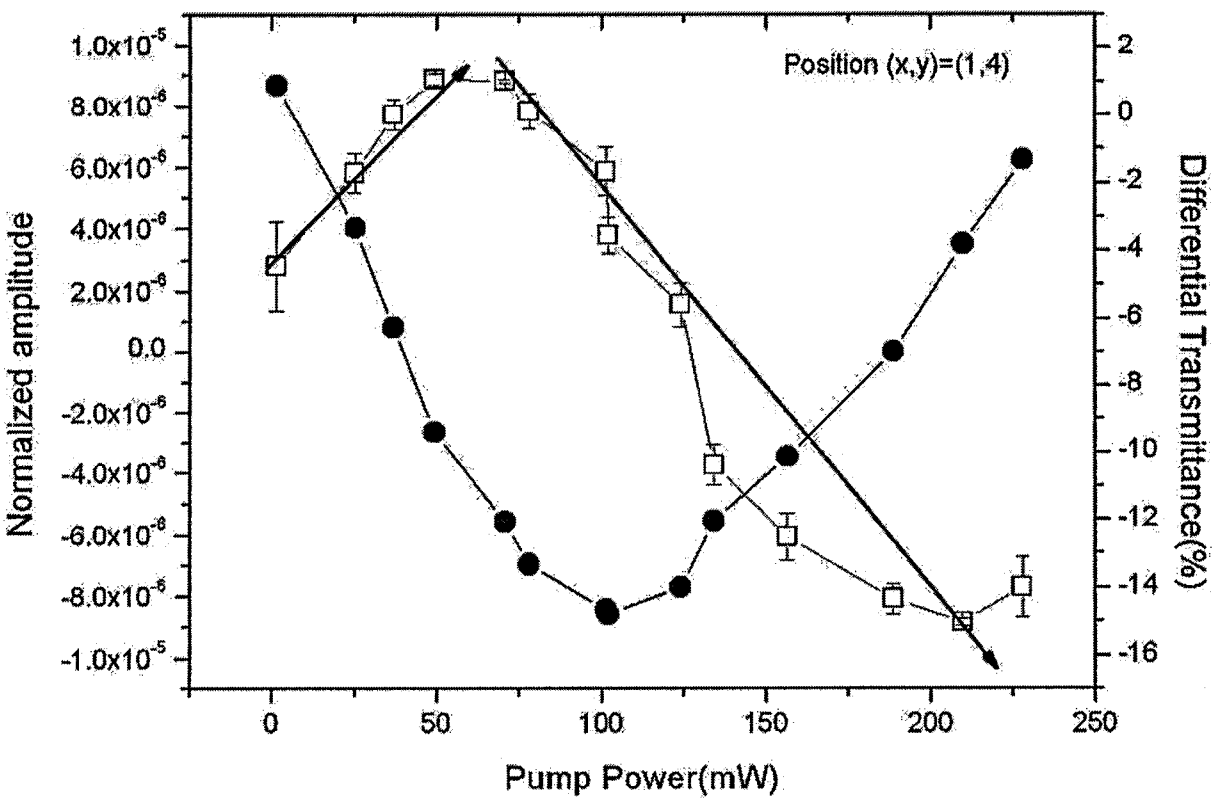

Normalized amplitude
4.0 x 10⁻⁶
3.5 x 10⁻⁶
3.0 x 10⁻⁶
2.5 x 10⁻⁶
2.0 x 10⁻⁶
1.5 x 10⁻⁶
1.0 x 10⁻⁶
5.0 x 10⁻⁷
0.0
−5.0 x 10⁻⁷
−1.0 x 10⁻⁶
−1.5 x 10⁻⁶
2
4
6
8
Fast scan axis(mm)
2
4
6
8
Slow scan axis(mm)

Fig 7


Position (x,y)=(1,4)
Normalized amplitude
Differential Transmittance(%)
Pump Power(mW)
1.0x10-5
8.0x10-6
6.0x10-6
4.0x10-6
2.0x10-6
0.0
-2.0x10-6
-4.0x10-6
-6.0x10-6
-8.0x10-6
-1.0x10-5
2
0
-2
-4
-6
-8
-10
-12
-14
-16
0
50
100
150
200
250

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2008/000670

A. CLASSIFICATION OF SUBJECT MATTER

G01J 3/28(2006.01)i, G01N 33/48(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)

IPC 8 : G01J, G01N

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

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)

"Keywords: scanner, interferometer, birefringence, Kerr effect, homogeneity, nonlinear, coeeficient, polarizer, phase delay"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,333,495 A (HITACHI LTD.) 2 August 1994 See column 11, line 65-column 12, line49, claim 1 and figures 1, 22,24 and 26	1-8
A	WO 01-02839 A1 (NORVATIS AG) 11 January 2001 See claims 1-2 and figure 1	1-8
A	JP 2004-333441 A (OLYMPUS CORP.) 25 November 2004 See claims 1-4 and figure 1-2	1-8
A	KR 10-2007-0012248 A (CANON KABUSHIKI KAISHA) 25 January 2007 See claims 1 and figure 1	1-8

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 JULY 2008 (28.07.2008)	**28 JULY 2008 (28.07.2008)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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