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**Datasheet for the decision  
of 6 September 2006**

**Case Number:** T 0728/04 - 3.2.02

**Application Number:** 97306547.7

**Publication Number:** 0832597

**IPC:** A61B 3/12

**Language of the proceedings:** EN

**Title of invention:**

Ellipsometer

**Applicant:**

Heidelberg Engineering Optische Messsysteme GmbH

**Opponent:**

-

**Headword:**

-

**Relevant legal provisions:**

EPC Art. 123(2), 56

**Keyword:**

"Inventive step (yes, after amendments)"

**Decisions cited:**

-

**Catchword:**

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Case Number: T 0728/04 - 3.2.02

**D E C I S I O N**  
of the Technical Board of Appeal 3.2.02  
of 6 September 2006

**Appellant:** Heidelberg Engineering Optische  
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**Representative:** Johnstone, Helen Margaret  
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**Decision under appeal:** Decision of the Examining Division of the  
European Patent Office posted 22 January 2004  
refusing European application No. 97306547.7  
pursuant to Article 97(1) EPC.

**Composition of the Board:**

**Chairman:** T. Kriner  
**Members:** M. Noel  
A. Pignatelli

## Summary of Facts and Submissions

I. European patent application No 97 306 547.7 was refused by the examining division on 2 January 2004 principally on the ground that the claimed subject-matter lacked inventive step under Article 56 EPC vis à vis the prior art documents:

D1: "Handbook of optics", Vol. II, ed. M. Bass, second edition 1995, McGraw-Hill, Inc., pages 27.1-27.27: "Ellipsometry"

D3: "Spatially resolved birefringence of the retinal nerve fiber layer assessed with a retinal laser ellipsometer", Applied Optics, Vol. 31, No 19, 1.7.1992, pages 3730-3735, and

D4: US-A-5 521 705

II. The appellant (applicant) lodged an appeal against this decision by notice of appeal received on 18 March 2004 and paid the appeal fee on the same day. A statement of grounds was filed on 21 May 2004, along with amended sets of claims.

III. Oral proceedings were held on 6 September 2006 during which the appellant filed a sole request replacing all the requests previously filed.

The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of claims 1 to 13, description and drawings as filed during oral proceedings.

IV. Claim 1 reads as follows:

"A system for in-vivo measurement of optical characteristics of a birefringent material which comprises:

a polarizing unit (12) comprising a light source (16) for generating a light beam, said light beam being directed along a path, a first polarizer (20) mounted on said path (18) for passing plane-polarized light from said light source (16) along said path (18), a first electro-optical cell (22) for creating a phase shift  $\tau_1$  and a second electro-optical cell (26) for creating a phase shift  $\tau_2$ , to sequentially generate four beams of light having a preselected polarization state  $(\tau_1, \tau_2)$ , each beam having a polarization state of  $(0,0)$ ,  $(\lambda/4,0)$ ,  $(0,\lambda/2)$  or  $(\lambda/4,\lambda/2)$ , and said first and second electro-optical cells (22,26) selectively change said polarization state of said plane-polarized light;

an analyzing unit (14) comprising a first electro-optical cell (40) for creating a phase shift  $T_1$  and a second electro-optical cell (42) for creating a phase shift  $T_2$ , to receive a reflection of each said beam of light, said analyzing unit (14) using a preselected detection state  $(T_1, T_2)$  of  $(0,0)$ ,  $(\lambda/4,0)$ ,  $(0,\lambda/2)$  or  $(\lambda/4,\lambda/2)$  to measure four light intensity states for each said beam, a second polarizer (44) mounted on said path (18,38) for passing said reflected light from said second analyzer electro-optical cell (42) along said path (18,38), and a detector (54) for receiving said light from said second polarizer (44) to detect said light intensity state of each said light beam;

electronic processor means (56) connected to said first and second electro-optical cells (22,26) of said polarizing unit (12), and said first and second

electro-optical cells (40,42) of said analyzing unit (14), said electronic processor means (56) concertedly varying said polarization state of said polarizing unit (12) with said detection state of said analyzing unit (14) such that the analyzing unit (14) receives at each preselected detection state a reflection of the beam of light generated by the polarizing unit (12) at a plurality of the preselected polarization states to determine said intensity states for sixteen linearly independent states of polarization; and

computer means (58) for using said measured intensity states to establish an optical characteristic for the material, said computer means (58) further using said plurality of intensity states to determine the optical characteristics of the system."

- V. In the appellant's view, the amendments to the claims were made to clarify the distinction of the invention over the prior art. The present invention performed a different function from the systems disclosed in the prior art documents, in a different way, to achieve a different result. More specifically, none of the cited documents disclosed or suggested the use of two switchable pairs of electro-optical cells positioned before and after the sample, respectively, in order to directly generate the 16 parameters required to calculate the Mueller matrix for a particular portion of the birefringent material. The claimed subject-matter, therefore, involved an inventive step.

## Reasons for the Decision

1. The appeal is admissible.
2. *Amendments*

The subject-matter of claim 1 refers to a system for in-vivo measurement of optical characteristics of a birefringent material, comprising a polarizing unit, an analyzing unit, electronic processor means and computer means.

The polarizing unit is partly supported by a combination of features taken from claims 1 and 2 as originally filed. Additionally, the features according to which four beams of light having a preselected polarization state are sequentially generated, each beam having a polarization state of  $(0,0)$ ,  $(\lambda/4,0)$ ,  $(0,\lambda/2)$  or  $(\lambda/4,\lambda/2)$ , are supported by features from the original claims 7 and 18 and by the application as filed (version as published) column 4, lines 27-32 and col. 8, lines 35-37.

The features defining the analyzing unit are formed by a combination of features taken from the original claims 5, 7 and 18, and by features supported by the application as filed, col. 4, lines 37-40 and col. 8, lines 37-41.

The electronic processor means are defined by a combination of features taken from original claim 10 and from the application as filed. In particular, the features according to which the processor means are concertedly varying the polarization states of the

polarizing unit with the detection states of the analyzing unit so as to receive a reflected beam at a plurality of preselected polarization states, are supported by column 5, lines 5-12 and col. 8, lines 30-36.

The computer means used for determining the optical characteristics of the material and of the system, are supported by the original claim 1 and the application as filed, col. 4, lines 20-22 and col. 7, lines 56-58.

Dependent claims 2, 3, 4, 5, 6, 7, 8, 10, 13 are identical to original claims 3, 4, 6, 7, 8, 9, 11, 12, 15, respectively. Claim 9 which is characterized by the use of Pockels cells, is supported by the application as filed, col. 4, lines 25 and 33 and col. 16, lines 20-22. Claim 11 is supported by original claim 13 supplemented by optical elements referred to on col. 6, lines 50-52. Claim 12 is formed by a combination of features taken from original claim 14 and from the application as filed, col. 5, lines 20-30 and col. 6, lines 50-52.

The description has been amended in accordance with the new set of claims and by a reference to the relevant prior art documents.

Therefore, the amendments made to the present application fulfil the requirements of Article 123(2) EPC.

3. *Inventive step*

- 3.1 Document D3 represents the closest prior art. D3 is cited in document D1 under the reference 151 (page 27.22) because it applies the same principle, illustrated by Figure 19 of D1, of a dual rotating-retarder Mueller-matrix photopolarimeter to transform the state of polarization of light upon reflexion by a sample. The ellipsometer of D1 uses symmetrical polarizing and analyzing optics with intermediate rotating quarter-wave retarders therebetween. In D3 it is used as retinal laser ellipsometer to determine the Mueller matrices of the retina and further to determine if the retinal nerve fibers are responsible for the retinal birefringence observed.

More specifically, D3 discloses (see Figure 2 and text referred to) a system for measurement of optical characteristics of a birefringent material such as the retina. It comprises a polarizing unit consisting of a light source (He-Ne laser) for generating a light beam and a polarizer P for obtaining linearly polarized light, which is then modulated by a first rotating quarter-wave plate Q1. After deflection the light beam is focused on a retinal point of the eye. For each measuring point the light reflected from the retina is first separated by a beam splitter BS and then passed through an analyzing unit comprising a second rotating quarter-wave plate Q2 and a linear analyzer A followed by a detector D so as to form a polarization detection unit. The electrical signal received from the detector is sampled and digitized (ADC) and processed in a micro-computer which calculates the 16 elements of the Mueller matrix, i.e. the polarization properties and



hence the optical characteristics of the material at the measuring location. From the measurements at various locations the distribution of the birefringent properties, i.e. the regions of birefringent inhomogeneity in the material can be identified.

3.2 With respect to the disclosure of D3, the subject-matter of claim 1 differs essentially by the use of a polarizing unit having two electro-optical cells, an analyzing unit comprising two electro-optical cells, and processor means for concertedly varying the polarization states of said polarizing and analyzing units in order to determine intensity states for 16 independent states of polarization, whereby to determine the optical characteristics of the material and of the system by the computer means.

3.3 The above-mentioned structural and functional differences of the system as claimed represent the solution to the underlying problem of providing a system for the in-vivo measurement of optical characteristics of a birefringent material which is easy to use and requires only extremely short measurement times (see patent application, top of column 4).

According to the present solution the pair of electro-optical cells forming the polarizing unit is used to create a beam of light having successively four polarization states which in turn may subsequently be analyzed and processed by the computer means.

Therefore, by using a polarizing unit and an analyzing unit each having a pair of electro-optical cells, as

claimed in claim 1, it is possible to simply and directly obtain the 16 elements of the Mueller matrix.

3.4 Instead, the system of D3 operates in a different way from that of the present invention. Unlike the present solution which uses a pair of electro-optical cells to sequentially produce four different, discrete polarization states, D3 uses a first rotating quarter-wave plate to continuously vary the polarization of light reaching the sample and a second quarter-wave plate, rotating five times faster than the first quarter-wave plate, to analyze the reflected light. The result is a continuous signal which must be sampled 256 times and processed via Fourier transformation to finally produce the 16 parameters required to calculate the Mueller matrix (see page 3731, right column and page 3732, first paragraph of the left column). This procedure appears to be complicated and time-consuming. Moreover, the ellipsometer cannot be used in-vivo as it is. A number of improvements still would be needed in an attempt to apply it clinically, e.g. to the cornea or the lens, as explained at the end of D3 (see "summary"). Therefore, the disclosure of D3 does not suggest the solution as claimed.

3.5 Document D4 relates to a polarized light microscope for measuring polarization properties in the examination of structural anisotropies such as birefringence. The illustrated embodiments are restricted, however, to transmission microscopes in which, unlike the present application, the illuminating and imaging light beams are on opposite sides of the sample to be examined. According to Figures 1 and 2, D4 uses only one pair of electro-optical cells (Pockels cells) as retarders,

either in the polarizing unit or in the analyzing unit, in combination with a circular analyzer and associated control equipment in order to perform polarized light microscopy and analyze the data. Therefore, D4 fails to teach or suggest the use of two pairs of electro-optical cells simultaneously in both the polarizing and the analyzing units to directly produce the 16 parameters required to calculate the Mueller matrix. Besides, there is no mention or suggestion in D4 of the possibility of using Mueller matrices at all for analyzing the birefringence in the samples.

- 3.6 Since D4 is not concerned with obtaining the data for a Mueller matrix to analyze a sample, a person skilled in the art looking to improve the system of D3 would not arrive at the solution as claimed by combining the teachings of D3 and D4.

Therefore, the subject-matter of claim 1 involves an inventive step over the prior art documents. As a consequence, claims 2 to 13 which depend thereon are also acceptable.

**Order**

**For these reasons it is decided that:**

1. The decision under appeal is set aside.
  
2. The case is remitted to the first instance department with the order to grant a patent in the following version: claims 1 to 13, description and drawings as filed during oral proceedings.

The Registrar:

The Chairman:

V. Commare

T. Kriner