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D E C I S I O N
of 26 September 2000

Case Number: T 1036/98 - 3.4.2

Application Number: 92916231.1

Publication Number: 0593667

IPC: G01J 3/30, G01N 21/63, G01N 21/84

Language of the proceedings: EN

Title of invention:
Measurement of material properties with optically induced phonons

Applicant:
Massachusetts Institute of Technology

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 54, 56, 89, 123(2)

Keyword:
"Novelty and inventive step (yes, after amendment)"

Decisions cited:
-

Catchword:
-

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Case Number: T 1036/98 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 26 September 2000

Appellant: MASSACHUSETTS INSTITUTE OF TECHNOLOGY
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 16 April 1998 refusing European patent application No. 92 916 231.1 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: E. Turrini
Members: A. G. Klein
B. J. Schachenmann

Summary of Facts and Submissions

I. European patent application No. 92 916 231.1 (International publication No. WO 93/01 476) was refused by decision of the Examining Division, on the ground that its subject-matter was not patentable in view of the following documents:

D1: Journal of Applied Physics, vol. 67, No. 7, 1 April 1990, pages 3362 to 3377; J. S. Meth et al.: "Experimental and theoretical analysis of transient grating generation and detection of acoustic waveguide modes in ultrathin solids";

D3: Applied Physics Letters, vol. 55, No. 17, 23 October 1989, pages 1783 to 1785; A. Harwit et al.: "Transient grating dynamics in $Cd_{1-x}Mn_xTe$ diluted magnetic semiconductor superlattices"; and

D4: Applied Physics Letters, vol. 60, No. 6, 10 February 1992, pages 692 to 694; A. R. Duggal et al.: "Real-time characterization of acoustic modes of polyimide thin-film coatings using impulsive stimulated thermal scattering".

The Examining Division held that the claimed subject-matter was distinguished from the device and method disclosed in document D1 in that

(A) the probe beam was reflected from the surface of the sample instead of being transmitted therethrough; and in that

(B) the analyser was adapted **selectively** to analyse the diffraction signal formed by the transient surface ripple morphology.

Distinguishing feature (A) did not however contribute to inventive step since in the art of optical analysis of samples, the uses of reflected probe beams and of transmitted probe beams were equally known, as was evidenced for instance by the contents of document D3.

Distinguishing feature (B) did not validly benefit from the claimed priority, since it had no basis in the priority document. Therefore, document D4 which was published after the priority date of the present application but before its international filing date belonged to the state of the art. Since the claimed subject-matter was anticipated by the contents of document D4, it was not new within the meaning of Article 54(1) EPC.

II. The appellant (applicant) appealed against the decision, requesting that it be set aside and that a patent be granted on the basis of a set of claims filed during an interview held on 17 July 2000, of which claims 1 and 12, the only independent claims, read as follows:

"1. An apparatus for measuring the properties of a sample (20) of material, comprising a first, excitation, source (24, 26, 28) for producing excitation radiation adapted to impinge upon said sample of material, said excitation radiation comprising pulsed radiation composed of at least two component beams (32, 34) which interfere within said sample, each incidence of interference of said

excitation radiation being sufficient to induce transient phonons in said material which give rise to a transient, time dependent diffraction grating, and further comprising a detection system for detecting, by diffraction of radiation, said diffraction grating, said detection system including: a second, probe, source (42) operatively arranged to direct incident probe radiation (48) from the probe source towards said sample, a detector (58) positioned to detect a diffraction signal from said probe source radiation as diffracted by said diffraction grating and an analyzer (64) for analyzing said diffraction signal, characterized in that the detection system is adapted operatively to detect a transient, time dependent, periodic ripple morphology of alternating peaks and valleys on a surface of said sample, the ripple morphology forming said diffraction grating, that the probe source is operatively arranged to direct incident probe radiation at an angle of incidence towards said surface and in that the detector is operatively arranged to detect a diffraction signal reflected by said surface and formed by said transient ripple morphology."

"12. A method for measuring the properties of a sample (20) of material, comprising the steps of: impinging a pulse of excitation radiation on said sample, said excitation radiation being composed of at least two component beams (32, 34) which interfere within said sample, the component beams being selected such that each incidence of interference is sufficient to induce transient phonons in said sample which give rise to a transient time dependent diffraction grating, detecting said diffraction grating by diffraction of radiation by directing incident probe radiation (48) towards said sample and detecting a diffracted signal diffracted by

said diffraction grating and analyzing said diffraction grating by analyzing said detected diffracted signal to measure properties of the sample, characterized in that the step of impinging a pulse of radiation comprises directing the incident probe radiation at an angle of incidence on said surface, in that the step of detecting comprises detecting a transient time dependent ripple morphology of alternating peaks and valleys on a surface of said sample, said ripple morphology forming said diffraction grating and in that the step of analyzing comprises analyzing said surface ripple morphology by analyzing the diffracted signal reflected by said surface ripple morphology."

III. In support of his request the appellant submitted that the present application related to an apparatus for and to a method of measuring properties of a sample of material by using two pulsed beams of excitation radiation which interfered in the sample so as to induce transient phonons and spatially periodic variations in the density of the sample material, resulting in a Bragg diffraction grating. A probe beam was diffracted by said grating to form a diffraction signal which was detected by a detector and analysed by an analyser. Such method and apparatus were known, for example from document D1.

The method and apparatus of the present application differed from those of the prior art in that it was a surface ripple morphology, acting as a diffraction grating, which was detected as it reflected the probe beam rather than a transmitted diffraction signal.

The invention was based on the insight that the interfering excitation beams did not only generate a transient optical pattern inside the sample, as

resulting from a time-dependent oscillation of the index of refraction, but also a surface ripple morphology of such nature that it could be used to measure properties of the material. Detecting this surface morphology enabled using a **reflected** probe beam, which had several advantages:

- the probe beam radiation was substantially not absorbed by the sample,

- the sample could be exchanged without the need for selecting a new probe wavelength,

- the probe beam could have a larger power and measuring with high time resolution became possible.

In document D1, the probe beam was incident normal to the sample and transmitted through it, and the analysis and interpretation of the signal from the detector was based upon a model of what was happening **inside** the material being examined. That model did not in any way take into account, nor attempt to interpret, "periodic ripple morphology of alternating peaks and valleys on a surface of the sample".

Document D3 did not relate to the observation of the effect of acoustic phonons. It only described the measurement of time dependent properties of electronic excited states (i.e. "electron and hole charge carriers") and how these properties were affected by temperature.

Reasons for the Decision

1. The appeal is admissible.

2. In compliance with the requirement of Article 123(2) EPC, the European patent application was not amended so as to contain subject-matter extending beyond the content of the application as filed.

In particular, independent claims 1 and 12 in substance correspond to independent claims 1 and 22 as originally filed, with the further indication that the probe source is operatively arranged to direct incident probe radiation at an angle of incidence towards the surface of the sample, as is disclosed e.g. lines 13 to 17 on page 16 of the description and shown in Figures 2 and 3 of the application as originally filed.

The feature of dependent claim 7 according to which the probe radiation is continuous or has a pulse duration at least as long as the duration of the time dependent ripple morphology was disclosed originally in lines 23 to 26 on page 17 and in lines 22 to 25 on page 21 of the description.

The remaining dependent claims are derived from corresponding original dependent claims.

The description was merely adapted to the amended version of the claims, and supplemented with a short summary of the relevant contents of the prior art, in compliance with the requirements of Rule 27(1)(b) and (c) EPC.

3. *Validity of the priority right*

The feature of the **selective** analysing of the diffraction signal, on which the Examining Division had founded its objection against the validity of the priority right, was deleted from the independent claims 1 and 12.

The remaining features of the independent claims, and the features set out in the dependent claims, except for the feature of dependent claim 19, in the Board's view were adequately disclosed in US patent application No. 07/726 759, from which the present European patent application claims priority.

The present European patent application therefore validly benefits from the filing date of the priority application, namely the 8 July 1991, for the invention set out in claims 1 to 18.

Dependent claim 19 defines a method as claimed in any of claims 12 to 18, further comprising determining from said diffraction signal the adhesion of said sample on a substrate surface. Such determination of the quality of adhesion of the sample on a substrate surface was not disclosed in the priority application, as was admitted by the appellant in his letter dated 19 June 2000.

The invention set out in dependent claim 19, considered in conjunction with any of claims 12 to 18, thus only benefits from the actual filing date of the European patent application, which is the 8 July 1992.

4. *Novelty of the subject-matter of claim 1*

4.1 Document D1 relates to the detection of transient gratings formed within ultrathin solids as a result of the interference of two picosecond laser pulses overlapping in a sample, using an apparatus as set out in the preamble of claim 1 (see in particular page 3362, left-hand column, line 25 to line 14 of the right-hand column, Figure 1 on page 3363 and page 3364, right-hand column, lines 31 to 48).

In this known apparatus, the probe radiation is brought in normal to the sample, and it is the transmitted diffraction signal which the detector receives.

In contrast the probe source of the apparatus of present claim 1 and the detector are arranged so as to detect a diffraction signal reflected by said surface, as produced by a transient, time dependent, periodic ripple morphology of alternating peaks and valleys on the surface, as is set out in the characterising portion of the claim.

4.2 Document D3 is dedicated to the analysing of the dynamics of carriers (electrons and holes) in semiconductor superlattices, using a picosecond transient grating optical technique in a reflection geometry. In this technique, it is the decay in time by diffusion and recombination of a carrier density grating induced onto the surface of an **optically opaque** system which is detected, rather than a transient, time dependent, periodic ripple morphology of alternating peaks and valleys, as is induced on a surface of a sample by a transient grating produced by optical interference within the sample. In addition, the excitation and probe radiations are generated from a

single laser source, rather than by two distinct sources as in the apparatus of present claim 1 (see document D3, page 1783, the abstract and lines 1 to 37; and Figure 1 on page 1784).

4.3 The other citations on the file published prior to the priority date claimed for the present application do not come closer to the subject-matter of claim 1 which, accordingly, is novel within the meaning of Article 54 EPC.

5. *Inventive step of the subject-matter of claim 1*

5.1 Like the present application document D1 is dedicated to the assessment of the effect of transient gratings produced by the interference of radiation pulses within a sample, as is detected by analysing a probe radiation directed to the sample. This document therefore constitutes the closest prior art, as was acknowledged also by the Examining Division.

The claimed apparatus is distinguished from this closest prior art essentially in that the probe source and detector are arranged so as to detect a diffraction signal as reflected by the sample surface.

The Board has no reason to question the appellant's submission that using the detector in a reflection geometry allows for the specific detection of the ripple morphology formed at the surface of the sample, without regard in particular to the absorption of probe radiation by the sample. This inter alia reduces sample heating, which can easily damage thin samples, and allows for the interchanging of samples without the need for selecting corresponding new probe laser wavelengths (see page 3, lines 8 to 30 of the present

description).

Thus the technical problem underlying the invention can be seen, inter alia, in relieving the constraints set by the closest prior art technique in terms of the power of, and wavelength selection for, the probe radiation.

5.2 Document D1 is expressly dedicated to the detection of acoustic modes within solids, using a radiation probe transmitted therethrough. The Board cannot find in this document any clear hint at monitoring instead the probe radiation in a reflection geometry.

In particular, whilst a passage of the document actually refers to thermal expansion causing the surface to corrugate, it also explicitly states that the corrugation is not large, and that it does not modify the acoustic waveguide modes (Lamb waves) detected within the sample (see page 3367, right-hand column, third paragraph).

This statement would not however suggest that mere detection of the ripple morphology induced onto the surface of the sample, by observing the probe radiation in a reflection geometry rather than by transmission as taught by document D1, could still achieve useful information on the properties of the sample material, whilst allowing for a higher power of the probe radiation and an increased flexibility in the selection of its wavelength.

5.3 The detection of transient surface gratings by reflection is indeed known from document D3, as was stressed by the Examining Division.

Document D3 is not however dedicated to the detection of acoustic waveguide modes within radiation transmitting solids, as is addressed by document D1. It only relates to the analysis of carrier recombination and diffusion at the surface of an optically opaque systems.

The skilled person therefore in the Board's opinion had no obvious reason to envisage combining the probe reflection technique disclosed in document D3 with the remaining apparatus features of document D1, if not with the benefit of hindsight.

5.4 For these reasons, the subject-matter of claim 1 is considered to involve an inventive step within the meaning of Article 56 EPC.

6. *Patentability of the subject-matter of claims 2 to 18*

The above conclusion in respect of novelty and inventive step equally applies to the subject-matter of independent claim 12 which in substance recites the same limitations as independent claim 1, in terms of a method for measuring the properties of a sample of material, and to the subject-matter of dependent claims 2 to 11 and 13 to 18, by virtue of their appendence to independent claims 1 and 12 respectively.

7. *Patentability of the subject-matter of dependent claim 19*

The subject-matter of dependent claim 19 does not benefit from the priority date claimed in the present application (see point 3 above).

In respect of this subject-matter, document D4

published on 10 February 1992 is to be considered as forming part of the relevant prior art. This document discloses all the features of independent claims 1 and 12 as was admitted by the appellant (see page 692, last paragraph to page 693, first paragraph).

Neither document D4, nor any of the other citations on the file however hint at the interest of using the detection of a transient, time dependent diffraction grating as results from the interference of optical radiation within a sample for determining the degree of adhesion of a film sample on a substrate, as is taught by the present patent application (see page 57 of the description).

For these reasons the subject-matter of claim 19 is also new and inventive within the meaning of Articles 54 and 56 EPC.

8. For the above reasons, the present patent application and the invention to which it relates meet the requirements of the Convention, and grant of a patent can be decided, accordingly (Article 97(2) EPC).

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 with the order to grant a patent with the following documents:

Claims: 1 to 19 filed during the interview of 17 July 2000.

Description: pages 10, 11 and 13 to 62 as published;
pages 1, 1a, 5, 6 and 7 as filed with the letter of 19 June 2000, received on 23 June 2000;
pages 3, 4, 8, 9, 12 and 63 as filed with the letter of 25 January 1994, received on 26 January 1994;
pages 2 and 2a as filed with the letter of 9 November 1995, received on 13 November 1995.

Drawings: sheets 1/24 to 24/24 as published.

The Registrar: The Chairman:

P. Martorana E. Turrini