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D E C I S I O N
of 20 March 1996

Case Number: T 0226/94 - 3.4.1

Application Number: 91113507.7

Publication Number: 0472083

IPC: H01L 39/24

Language of the proceedings: EN

Title of invention:
Method of forming oxide superconducting thin film

Applicant:
SUMITOMO ELECTRIC INDUSTRIES, LIMITED

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no)"
"Main request: analogous use of known technology"
"Auxiliary request: no evidence of contribution to the solution of the problem by the feature added into the auxiliary request"

Decisions cited:
T 0037/82

Catchword:
-

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Case Number: T 0226/94 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 20 March 1996

Appellant: SUMITOMO ELECTRIC INDUSTRIES, LIMITED
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Decision under appeal: **Decision of the Examining Division of the European Patent Office dated 6 October 1993 refusing European patent application No. 91 113 507.7 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: G. D. Paterson
Members: H. J. Reich
J. Y. F. Van Henden

Summary of Facts and Submissions

I. European patent application No. 91 113 507.7 (publication No. 0 472 083) was refused by a decision of the Examining Division.

II. The reason given for the refusal was that the subject-matter of claim 1 filed on 28 December 1992 did not satisfy the requirements of Articles 52(1) and 56 EPC having regard to documents:

D1: EP-A-0 341 520 and
D2: GB-A-2 220 502.

The Examining Division took the following view:

The subject-matter of claim 1 differed from that disclosed in document D1 only in that "the energy distribution in the section of the laser beam is homogenised within 10%". The method of forming a thin film of an oxide superconductor disclosed in document D1 and the invention use an excimer laser (see the description column 5, line 39) for scattering target material onto a substrate. It is well known in the art that excimer lasers have a very non-uniform local energy density distribution within their output beam cross section. This leads to unsatisfactory results inter alia in the laser assisted deposition of metals and compounds as disclosed in document D2, page 1, paragraph 3. Document D2, Figure 1 and page 2, paragraphs 3 and 4 discloses as well to overcome the deposition drawbacks involved with the non-uniformity of the laser beam by an intensity homogeniser system in form of a biprism which corresponds exactly to the only one homogenising means disclosed in the present application. A skilled person who intends to form superconducting films according to

the method of document D1, has therefore a clear motivation to use the biprism of document D2 in order to achieve a homogenised laser beam in the method described in document D1 and to thereby remove deposition drawbacks. In view of the identity of the means applied, the known biprism will clearly homogenise the energy distribution of the laser beam within 10% as claimed.

III. The appellant lodged an appeal against this decision. In the statement of grounds of appeal the appellant maintained the rejected version of claim 1 as its main request and filed an auxiliary request, claim 1 of which comprised the additional feature: "slowly cooling said thin film at a cooling rate of 20°C/min."

IV. In a communication accompanying a summons to oral proceedings the Board informed the appellant of its provisional view that the subject-matter of claim 1 of the main request may be held to be obvious, since droplet type deposits can easily be observed in practice by SEM (Scanning Electron Microscopy) control and avoided within a routine optimisation of the laser beam parameters when introducing the homogeniser disclosed in document D2 into the path of the laser rays used in document D1. Claim 1 of the auxiliary request appeared not to satisfy Article 56 EPC, since the Examples 1 and 2 of the present invention and the comparative example disclosed in the description, use all the same cooling rate of 20°C/min, so that there is no evidence that the claimed cooling rate results in an unexpected improvement of the superconducting properties of the deposit.

V. In response to the communication of the Board and for preparing oral proceedings the appellant filed on 4 March 1996 a new amended main request.

Claim 1 of the **main request** as filed on 4 March 1996 reads as follows:

"1. A method of forming a thin film of an oxide superconductor on a substrate (4) by laser ablation, comprising the steps of:

(a) using a laser beam which has an energy density distribution which suddenly changes from the maximum level to the zero level at each edge of the beam width;

(b) homogenizing the energy distribution in the section of said laser beam within 10%;

(c) applying said laser beam onto a target (6); and

(d) forming said thin film on said substrate (4) arranged to face said target (6)."

Claim 1 of the **auxiliary request** filed with grounds of appeal dated 8 February 1994 reads as follows:

"1. A method of forming a thin film of an oxide superconductor on a substrate (4) by laser ablation, comprising the steps of:

homogenizing energy distribution in the section of a laser beam within 10%;

applying said laser beam onto a target (6);

forming said thin film on said substrate (4) arranged to face said target (6); and

slowly cooling said thin film at a cooling rate of 20°C/min."

Claims 2 and 3 of the main and auxiliary requests are dependent on the respective claim 1.

VI. Oral proceedings were held on 20 March 1996, at the beginning of which the appellant was informed of the Board's view that not only the measures in steps (b) of claim 1 of the main request but also those in step (a)

are considered to be disclosed in document D2. During oral proceedings the appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the main request with claims 1 to 3 filed on 4 March 1996 or on the basis of the auxiliary request with claims 1 to 3 filed with grounds of appeal dated 8 February 1994.

VII. In support of these requests the appellant submitted essentially the following arguments:

(a) Feature (a) as introduced into claim 1 of the new main request concerns the "local" energy density distribution of the laser beam and is disclosed in Figure 4 of the application.

(b) The inventors have found that a conventionally deposited thin film may contain droplet-like particles which deteriorate the superconducting properties of the film. The droplet formation and a decomposition of the material in the deposit are due to the lower energy level in the marginal region of the laser spot. Contrary to the middle position thereof, the target surface in the marginal region is not brought to a super-heated state at a temperature of more than 2 000C° but can only melt and decompose the target. The inventors have found that the properties of superconducting films can be surprisingly increased when ensuring that within the total laser spot the energy distribution is homogenised with 10%. Thereby, the total target surface within the laser spot is brought to a superheated state and atoms are non-equilibriumly emitted so that the deposited films have the chemical composition of the target.

(c) In the method disclosed in document D1 the energy density within the laser spot must necessarily be above 3 J/cm^2, see column 5, lines 33 to 36. Document D1 does not contain any hint that at such energy densities the properties of the superconducting film could be even more improved or that the laser energy distribution could be of any interest.

(d) Document D2 is directed to a laser beam homogeniser, but gives no hint to make use of the disclosed transmissive biprism in laser ablation of superconducting films. Moreover, document D2 is silent about the problems encountered in the particular technical field of superconductors. The field of superconducting films is the only relevant one for the person skilled in the art of the present invention. Thus, a skilled person does not have any incentive to refer to document D2.

(e) Examples 1 and 2 of the present invention disclose an energy density of 1.5 J/cm^2; see column 4, lines 26, 27 and 54. Hence, the invention leads to the surprising result, that the claimed homogenising of the local energy distribution allows to reduce the necessary energy density on the target surface to half the value disclosed in document D1.

(f) A cooling rate of 20°C/min for the deposited thin film is nowhere disclosed, outside a skilled person's normal activities and contributes significantly to the superconducting properties of the product according to the invention. Identical cooling rates for the Examples 1 and 2 of the

invention and for the comparative example have only been selected in order to isolate the positive effect of the homogenisation of the local energy distribution within the laser spot.

VIII. At the conclusion of the oral proceedings, the decision was announced that the appeal is dismissed.

Reasons for the Decision

1. *Inventive step - claim 1 - main request*

1.1 From the closest prior art disclosed in document D1 there is known (in the wording of claim 1 of the main and auxiliary requests).

"A method of forming a thin film of an oxide superconductor (see document D1, title and column 4, lines 28 to 33) on a substrate (12 in the figure) by laser ablation, comprising the steps of:
(c) applying said laser beam (7) onto a target (8), and
(d) forming said thin film (11) on said substrate arranged to face said target."

1.2 Starting from document D1 the objective problem underlying claim 1 is to provide a method of forming a thin film using laser ablation, which method can form an oxide superconductor thin film having excellent superconducting properties, in particular to provide a method which avoids droplet type deposits within the film, which droplets extremely deteriorate the film quality; see the description column 1, line 56 to

column 2, line 2 and column 2 lines 15 to 21. In the Board's view, droplet type deposits in thin films can easily be observed in practice during the usual routine control of manufactured superconducting films by imaging the product in a scanning electron microscope when stepwise optimising the experimental parameters of the film forming process. Hence, no contribution to inventive step is to be found in the definition of the above problem.

1.3 The above problem is solved by

"(a) using a laser beam which has an energy density distribution which suddenly changes from the maximum level to the zero level at each edge of the beam width; and

(b) homogenizing the energy distribution in the section of the laser beam within 10%."

Measures (a) and (b) are known from Figure 1 of document D2. A skilled person derives from Figure 1 of document D2 and from Figure 3 of the application an identical technical information: A biprism cuts the entering laser beams into two halves and overlaps the two halves in such a way that at some distance from the biprism the linear surface of the cut forms the outer limit of the beam and that the former lateral slopes of the beam with declining energy density overlap each other in the centre of the deflected beam. Figure 1 of document D2 and Figure 4 of the invention show lateral intensity slopes of the beam which are analogous in shape. As the result of the chosen distance between biprism and target both slopes cross each other on the target at the half-value of the maximum intensity. From such identity of the applied technical means follows inevitably, that also in the prior art the energy is homogenized within 10%; see document D2, page 2, last paragraph.

1.4 The appellant is not followed in his opinion according to paragraph VII-(d) above. In the Board's view, a person skilled in forming superconductor films by laser ablation would observe a technical development in laser technology in view of finding hints for solving problems in the superconductor field. Document D2 mentions on page 5, paragraph 3 explicitly the processing of workpieces by a homogenised beam and thus guides to laser ablation of solid material. Hence, document D2 is regarded to belong to a neighbouring technical field of a person skilled in depositing thin superconducting films. The general statement in document D2, page 1, paragraph 3 of "unsatisfactory" results with non-uniform excimer laser beams in the laser assisted deposition of compounds gives a skilled person at least an incentive to test the usefulness of the intensity homogeniser disclosed in document D2, in a laser beam for ablating superconducting films. Such test is regarded to fall within the normal technical development of the superconductor art.

1.5 A skilled person will easily find out that the teaching of document D1, i.e. to keep the laser energy density on the target above 3 J/cm^2 (see also paragraph VII-(c) above), aims at avoiding droplet type deposits resulting from a too low temperature of target regions. A skilled person is able to understand that at constant spot area the intensity gradient at the edges of the laser beam increases with an increasing absolute value of the beam intensity. It is evident to the skilled person that thereby the target area which emits droplets, will be reduced. Therefore, an increase in the steepness of the edges of the beam - such as caused by an increase of the beam intensity - can be expected to lower the area of laser spot regions having too low temperature, and to thereby reduce the concentration of droplet type deposits in the formed film. In the Board's view,

excimer laser beams will have also at energy densities above 3 J/cm^2 a non-negligible lateral slope at their edges and no ideal rectangular intensity profile. Hence, a skilled person is regarded to be able to recognise that "the sudden intensity change from maximum level to zero level at the beam edge" as disclosed in Figure 1 of document D2 would allow to completely avoid any regions of too low temperature within the laser spot on the target. For the above reasons, the Board considers a skilled person to have a clear technical motivation to use the biprism disclosed in Figure 1 of document D2 in the beam path 7 of the superconductor material ablating excimer laser disclosed in the Figure of document D1. Therefore, the appellant's argument according to paragraph VII-(c) is regarded not to be relevant.

1.6 The energy density values disclosed in document D1 are clearly integral values which are valid for the total laser spot. Since the homogeniser (biprism) of document D2 allows to decouple the steepness of the beam edges from the absolute intensity values of the energy maximum in the centre of the beam - contrary to the appellant's view in paragraph VII-(e) - a skilled person will not be surprised by the fact that the use of such homogeniser allows to manufacture droplet-free deposits at lower values of the energy density than according to the method disclosed in document D1.

1.7 A necessary target temperature of more than 2 000°C for maintaining the chemical composition of the target material in the deposit on the substrate is neither part of the subject-matter of claim 1 nor is it disclosed in the description of the present application. Hence, the appellant's argument according to paragraph VII-(b) above is regarded not to be relevant.

1.8 As set out in detail above, a skilled person is held to arrive at the subject-matter of claim 1 in an obvious way by making analogous use of measures (a) and (b) as disclosed in document D2 in the method disclosed in document D1.

2. For the above reasons, in the Board's judgment, the subject-matter of claim 1 of the main request does not involve an inventive step, and claim 1 is not allowable pursuant to Article 52(1) and 56 EPC. Claims 2 and 3 of the main request fall because of their dependence on claim 1.

3. *Inventive step - claim 1 - auxiliary request*

3.1 Claim 1 of the auxiliary request adds to the essential subject-matter of claim 1 of the main request the measure of

"slowly cooling said thin film at a cooling rate of 20°C/min".

3.2 The appellant's submission that this cooling rate contributes significantly to the superconducting properties of the product according to the invention must be regarded as a mere allegation. There is no evidence in the original description or even on file that the claimed cooling rate results in any improvement of the superconducting properties of a deposit and thereby contributes to the solution of the problem set out in paragraph 1.2 above.

3.3 According to the normal practice of the EPO, in assessing the inventive step of a combination of features consideration must be given to a feature only if the applicant has provided evidence that it contributes, either independently or in conjunction with one or more of the other features, to the solution of the problem set in the description; see also T 37/82 OJ EPO 1984, 71.

3.4 In view of this lack of evidence, claim 1 of the auxiliary request is regarded to be obvious for the reasons set out in detail in paragraph 1.1 to 1.8 above.

4. Therefore, claim 1 of the auxiliary request does not involve an inventive step in the sense of Article 56 EPC and is for this reason not allowable pursuant to Article 52(1) EPC. Claims 2 and 3 of the auxiliary request fall because of their dependence on claim 1.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

M. Beer G. D. Paterson