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D E C I S I O N
of 25 July 2000

Case Number: T 0477/96 - 3.4.3

Application Number: 90108847.6

Publication Number: 0398164

IPC: H01L 39/14

Language of the proceedings: EN

Title of invention:

Method of fabricating oxide superconducting film

Patentee:

SUMITOMO ELECTRIC INDUSTRIES, LTD.

Opponent:

Siemens AG

Headword:

Laser deposition/SUMITOMO

Relevant legal provisions:

EPC Art. 56

Keyword:

"Inventive step (yes) - Experience gained from everyday life not relevant to the technical field of the invention"

Decisions cited:

-

Catchword:

-



Case Number: T 0477/96 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 25 July 2000

Appellant: Siemens AG
(Opponent) Postfach 22 16 34
D-80506 München (DE)

Representative: -

Respondent: SUMITOMO ELECTRIC INDUSTRIES, LTD.
(Proprietor of the patent) 5-33, Kitahama 4-chome
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Representative: Winter, Brandl, Fürniss, Hübner, Röss
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Decision under appeal: Decision of the Opposition Division of the
European Patent Office posted 7 May 1996
rejecting the opposition filed against European
patent No. 0 398 164 pursuant to Article 102(2)
EPC.

Composition of the Board:

Chairman: R. K. Shukla
Members: G. L. Eliasson
M. J. Vogel

Summary of Facts and Submissions

I. This appeal lies from the decision of the opposition division dated 7 May 1996 rejecting the opposition against European Patent No. 0 398 164 pursuant to Article 102(2) EPC.

Claim 1 as granted reads as follows:

"1. A method of fabricating an oxide superconducting film comprising:
a first deposition step of applying a laser beam (2) to a target (1) of an oxide superconductive material for depositing atoms and/or molecules scattered from said target (1) on a first portion (4) of a substrate (3) under atmosphere containing oxygen; and
a second deposition step of moving said substrate (3) for depositing atoms and/or molecules scattered from said target (1) on a second portion of said substrate (3), being different from said first portion (4) of said substrate (3), under atmosphere containing oxygen, so that film formation is performed on said second portion of said substrate (3), while said first portion (4) of the substrate (3) previously subjected to film formation is oxygen-annealed to enable incorporation of sufficient oxygen,
said first and second deposition steps being alternately repeated."

Claim 2 as granted is dependent on claim 1.

II. An opposition was filed by the appellant (opponent) on the grounds of lack of inventive step (Article 100(a) EPC) having regard to the prior art documents:

D1: Applied Physics Letters, No. 53, 17 October 1988, pages 1557 - 1559;

D2: US-A-4 420 385;

D3: Applied Physics Letters, No. 54, 15 May 1989, pages 2035 - 2037;

D4: JP-A-64-72 418 and corresponding abstracts;

D5: EP-A-0 167 383;

D6: Applied Physics Letters, vol. 51, 24 August 1987, pages 619 - 621;

D7: JP-A-64-72 427 and corresponding abstracts; and

D8: JP-A-64-12 427 and corresponding abstracts.

III. In the decision under appeal, the opposition division held that the technical problem addressed by the patent in suit related to incorporation of sufficient oxygen in an oxide superconducting film under the condition of a relatively fast formation of the film, and not to the problem of depositing an oxide superconductor film on a substrate having a large area, as suggested by the opponent. The opposition division found in particular that none of the cited prior art disclosed the feature of sequentially depositing the oxide superconductor film in different regions of the same substrate.

IV. The appellant filed the notice of appeal on 15 May 1996, paying the appeal fee the same day. The statement of the grounds of appeal was filed on 17 July 1996.

V. During the oral proceedings held on 25 July 2000, the parties made the following requests:

The appellant requested that the decision under appeal be set aside and that the European patent No. 0 398 164 be revoked.

The respondent requested that the appeal be dismissed and that the patent be maintained as granted.

VI. The appellant made essentially the following arguments in support of his requests:

(a) The objective technical problem addressed by the patent in suit cannot be related to increasing the deposition speed, since claim 1 does not contain any features that would solve such a problem. On the contrary, the requirement in claim 1 that the first and second deposition steps are alternately repeated will rather slow down the overall deposition process. Therefore, the objective technical problem was to provide a method for depositing an oxide superconductor on a substrate having a large surface.

(b) Since laser ablation can only be carried out on a small area, this technique can be used for depositing an oxide superconductor on a substrate having a large area only by sequentially depositing the superconductor film on smaller subregions of the substrate. Such an approach is

however obvious to the skilled person, since it is known from everyday life: Thus, in painting a surface having an area beyond what can be covered with a single stroke of a brush, the surface has to be coated with paint by sequentially painting one subregion of the surface after the other. It is also generally known from this practice that the regions just painted would immediately start drying while further subregions are being painted, and also that the painting process can be repeated in order to obtain a thicker coat of the paint.

- (c) Document D1 already shows a mechanism for transporting substrates within the reactor chamber, albeit only for changing substrates, and teaches that an oxygen atmosphere may be present during the deposition stage. In the light of the above-mentioned elementary skills known from painting a surface, the skilled person would not see any major difference between a mechanism for moving two substrates or one for moving a single, large substrate. Thus, it would be obvious for the skilled person to modify the already present substrate transport mechanism into one that transports a single substrate in such a manner that one region after the other of the single substrate is moved to and from the region of the reactor chamber where the deposition takes place.

- (d) Document D2 also teaches the principle of alternately repeating the steps of depositing a film and subjecting the just deposited film to oxidation until the desired thickness of the film has been obtained. Also here it is immediately apparent to the skilled person that larger

surfaces could as well be coated by repeating the depositing and oxidation steps.

Moreover, it is disclosed in document D7 that a thick film of superconducting oxide can be formed by alternately repeating the steps of deposition and oxygen annealing of thin films. Thus, in the light of the teaching of documents D2 and D7, alternate repetition of the steps of deposition and oxygen annealing of thin films was an obvious modification of the process of document D1.

VII. The respondent argued essentially as follows:

- (a) It is not the primary object of the present invention to provide a method for coating large surfaces, but rather to minimize the overall time to form an oxide superconductor film. Thus, all arguments made by the opponent relating to large area substrates are irrelevant.

- (b) None of the cited prior shows that the deposition step and reaction or annealing steps are carried out *simultaneously* on the *same* substrate. In particular, documents D2 and D7 only disclose a repeated deposition of material on the entire surface of one single substrate. It is not disclosed in document D2 that a partial surface of a substrate may be coated with aluminum while another partial surface of the same substrate is subjected to oxygen annealing. Moreover, the process described in D2 is not suitable for high speed film formation, because no time is saved as the different steps of the manufacturing method are performed in succession.

- (c) As to the teaching of document D1, the respondent disagrees that two separate substrates would be considered by a skilled person to be equivalent to two surface areas of a large single substrate. D1 only discloses that a plurality of substrates can be successively brought into the active portion of the reactor chamber where each substrate is treated only once. Thus, there is no indication in D1 to treat the substrates repeatedly. On the contrary, document D1 teaches that first *all* the substrates are deposited with a film and subsequently the substrates are cooled down simultaneously by flowing oxygen into the chamber.

Reasons for the Decision

1. The appeal meets the requirements of Articles 106 to 108 and Rule 64 EPC, and is therefore admissible.
2. *Novelty*
 - 2.1 In the appeal proceedings, only documents D1, D2, D3, and D7 were cited by the parties.
 - 2.2 Document D1 discloses growth of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ films on a substrate using a laser beam to evaporate atoms from a target made of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ (cf. Figure 1; abstract). This technique is also known in the art as "laser ablation". It is observed that the presence of oxygen gas with a partial pressure between 0.3 and 0.6 mbar during the deposition is necessary for obtaining growth of crystalline films. It is furthermore shown in Figure 1 that several substrates can be mounted on substrate holders in the deposition chamber allowing several

substrates to be deposited in sequence, without opening the deposition chamber. After the deposition is concluded, pure oxygen is introduced into the deposition chamber and the substrates are cooled down.

2.3 The method of claim 1 differs from that of document D1 firstly in that the deposition step and the annealing step are carried out simultaneously at different portions of the same substrate, whereas in document D1, the deposition is carried out on the entire substrate(s) and is followed by the introduction of pure oxygen in the process chamber to cool down the substrate. Furthermore, the steps of depositing and annealing the film on different portions of the same substrate are repeated, whereas in document D1, the deposition of the film on the substrate is carried out without interruption in a single step until the desired final thickness of the oxide superconductor film is obtained.

2.4 Document D2 discloses a process of depositing aluminum oxide comprising the steps of sputter depositing a thin film of pure aluminum on a substrate in the presence of an inert gas, followed by the step of moving the substrate to a reaction zone of the process chamber where the aluminum is oxygen annealed. These steps are repeated to obtain the desired thickness of the aluminum oxide film.

2.5 The method of claim 1 differs from that of document D2 in that an oxide superconductor is deposited using laser ablation on target made of the oxide superconductor, whereas the method of document D2 is directed to deposition of aluminum oxide using sputtering on a target made of pure aluminum.

Furthermore, although several substrates can be processed at the same time in the apparatus of document D2, the entire surface of each substrate is exposed to the same deposition or annealing treatment.

- 2.6 In document D3, the role of oxygen atmosphere during laser ablation deposition of YBaCuO is investigated, where in particular the ejection velocities of the ablated species from a target made of YBaCuO as a function of the oxygen pressure are observed. No details are however given in document D3 as to the actual deposition of the YBaCuO film on a substrate.
- 2.7 Document D7 discloses deposition of YBaCuO films using vapor deposition, i.e. a different technique from that used in the patent in suit. The steps of depositing and oxygen annealing are repeated until the desired thickness of the superconductor film is obtained. It appears however that the YBaCuO film is always deposited on the entire surface of the substrate at each deposition step.
- 2.8 The subject matter of claim 1 is therefore new within the meaning of Article 54 EPC.

3. *Inventive step*

- 3.1 The Board agrees with the parties that document D1 represents the closest prior art, since it concerns deposition of the same type of material (oxide superconductor) using the same technique of deposition (laser ablation in the presence of an oxygen atmosphere) as the method of claim 1.
- 3.2 In view of the differences as described under point 2.3

above with respect to the prior art method disclosed in document D1, the objective technical problem addressed by the present invention therefore relates to reducing the overall time required for fabricating an oxide superconductor film using laser ablation, while at the same time ensuring that sufficient oxygen is incorporated in the oxide superconductor film. This problem is in particular relevant when a high deposition rate is chosen (cf. also column 2, lines 11 to 14 of the patent in suit).

- 3.2.1 The appellant argued that the technical problem as stated in the patent in suit, i.e. to deposit an oxide superconductor film with a high oxygen content at a high deposition rate, could not be taken as the objective technical problem, since features essential for achieving a high deposition rate, such as laser frequency, temperature and pressure are not specified in claim 1 of the patent in suit (see point VI(a) above). The objective technical problem, therefore, must relate to the deposition using laser ablation of oxide superconductor films on substrates having large surfaces.

- 3.2.2 Contrary to the submissions of the appellant, the Board agrees with the respondent that the patent in suit does not address the problem of depositing an oxide superconductor film with a high oxygen content at a high deposition rate, but rather the problem as stated under point 3.2 above, i.e. to reduce the overall time for fabricating an oxide superconductor film while ensuring that sufficient oxygen is incorporated in the oxide superconductor film. Furthermore, the problem as stated under point 3.2 above is solved by the method of claim 1, since the method requires that the deposition

step and annealing step are carried out simultaneously at different portions of the substrate, thus making the process more efficient. These steps are repeated so that for each step, a relatively thin oxide superconductor film is formed which requires a relatively short oxygen annealing time to incorporate sufficient oxygen in the film.

Moreover, as discussed in the patent in suit, it was known in the art that the limiting factor in attaining a short overall time for fabricating an oxide superconductor film was not related to finding process parameters for increasing the deposition rate, but rather the difficulty in incorporating sufficient oxygen in the film when a high deposition rate is chosen, thus causing the need for a subsequent oxygen annealing step which increases the overall fabrication time (cf. column 1, line 54 to column 2, line 7). Therefore, contrary to the submissions of the appellant, the deposition parameters for the laser ablation are not considered to be essential for solving the problem addressed by the patent in suit.

3.3 The apparatus shown in Figure D1 has a mechanism for moving the substrates to and from the region of the reaction chamber where the deposition takes place. The deposition in the apparatus of document D1 is however always carried out on the entire surface of each substrate positioned in the deposition region of the reaction chamber, in contrast to the claimed method, where only a limited portion of a substrate is subjected to deposition. Also, it appears that the methods of the other cited documents D2, D3, and D7 all concern processes where the oxide superconductor film is deposited on the entire substrate surface in one

step followed by another treatment of the whole substrate, such as oxygen annealing or cooling.

3.4 Therefore, the Board finds that there was no hint or suggestion in the prior art to modify the process of document D1 in such a manner so as to deposit sequentially an oxide superconductor film on different portions of the same substrate, and to anneal in oxygen the deposited film on a portion of the substrate while the oxide superconductor film is being deposited on a different portion of the substrate.

3.5 The appellant argued that a skilled person faced with the task of using the method described in document D1 for depositing substrate with large surfaces would arrive at the claimed method in an obvious manner using a combination of the teaching of documents D2 or D7 and his knowledge from activities such as painting large surfaces (cf. point VI(b) above): It is generally known that a painter faced with the task of painting a large surface would sequentially paint portions of the surface while, at the same time, the paint on the already painted portions dries. It is also commonly known to be advantageous to repeat the painting of the surface several times instead of using a single, thick layer of paint. The skilled person equipped with this general knowledge would thus be able to modify the process of document D1 in a routine manner to arrive at the method of the patent in suit.

3.5.1 As stated under point 3.2 above, the objective technical problem of the patent in suit does not relate to the deposition of an oxide superconductor film on large substrate, but rather to reduce the overall time to form such an oxide superconductor film, while at the

same time ensuring that sufficient oxygen is incorporated in the film.

The Board agrees with the appellant that the person skilled in the field of oxide superconductor films is likely to be aware of the basic technique involved in painting large surfaces. However, the technical considerations underlying the formation of an oxide superconductor film using laser ablation are completely different from those involved in painting a large surface in view of the different technical problems. Thus, for example, a paint is usually deposited on a surface in the form of a suspension, where the paint afterwards has to dry. An oxide superconductor film deposited using laser ablation, on the other hand, does not have to dry, but requires instead an oxygen-enriching treatment, such as exposure to an oxygen atmosphere. In the Board's view, therefore, the skilled person would not consider the basic knowledge about painting large surfaces to be of any relevance in the formation of an oxide superconductor film by laser ablation.

- 3.6 Therefore, in the Board's judgment, the subject matter of claim 1 involves an inventive step within the meaning of Article 56 EPC and therefore meets the requirements of Article 52(1) EPC for being patentable.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar:

The Chairman:

D. Spigarelli

R. K. Shukla