BESCHWERDEKAMMERN DES EUROPÄISCHEN PATENTAMTS

BOARDS OF APPEAL OF THE EUROPEAN PATENT OFFICE

CHAMBRES DE RECOURS DE L'OFFICE EUROPEEN DES BREVETS

A		B		C	X

File Number: T 60/92 - 3.4.1

Application No.: 87 107 084.3

Publication No.: 0 246 574

Title of invention: Power semiconductor device

Classification: H01L 23/48

D E C I S I O N
of 22 September 1992

Applicant: Kabushiki Kaisha Toshiba

Headword:

EPC Art. 56

Keyword: "Inventive step (yes, after amendment) ; non-obvious adaptation of a known means for a different technical purpose"

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number : T 60/92 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 22 September 1992

Appellant : Kabushiki Kaisha Toshiba
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Decision under appeal : Decision of Examining Division of the European Patent Office dated 13 August 1991 refusing European patent application No. 87 107 084.3 pursuant to Article 97(1) EPC.

Composition of the Board :

Chairman : G.D. Paterson
Members : H.J. Reich
U. Himmler

Summary of Facts and Submissions

I. European patent application No. 87 107 084.3 (publication number 0 246 574) was refused by decision of the Examining Division.

II. The reason given for the refusal was that the subject-matter of Claim 1 of the main request as filed on 6 February 1991 and of Claims 1 of the first and second auxiliary requests as submitted on 16 July 1991 did not satisfy the requirements of Articles 52 and 56 EPC having regard to documents:

D1: EP-A-0 158 749,
D2: US-A-3 837 000,

and the generally known state of the art. The Examining Division in essence took the view that it would be an obvious choice among two alternative forms of pressing electrodes to interpose a soft metal (silver) foil such as known from document D2 between the first pressing electrode and the control electrode of the power semiconductor device known from document D1. Both documents are dealing with the problem of making good and long-lasting pressure contacts to electrodes of high power semiconductor devices, offer two equally well-suited and interchangeable alternatives and contain no indication whatsoever of a technical prejudice against their mutual employment. Moreover, the replacement of the ceramic insulating material in the device of document D1 by widely used mica represents an interchange of two well-known insulating materials within common engineering practice. The argument that higher contact pressures may be achieved with mica would not be convincing.

III. The Appellant lodged an appeal against this decision.

IV. Oral proceedings were held on 22 September 1992, at the end of which the Appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the main request presented during oral proceedings, namely:

Claims: 1 to 5 filed during oral proceedings,
Description: EP-A-0 246 576, column 1, lines 1 to 28, and column 3, line 39 to column 7, line 4; pages 2, 2a, 3, 4, 4a filed during oral proceedings;
Drawings: Figures 1 to 7 of EP-A-0 246 576.

Claim 1 reads as follows:

"1. A power semiconductor device with a solderless contact construction comprising:

a first pressing electrode (13, 33, 43);

a second pressing electrode (2);

a control electrode (1a) provided for a semiconductor element:

a member (14a, 14b; 32a-32d; 42a, 42b) for pressing said first pressing electrode (13, 33, 43) against said control electrode (1a), said pressing member (14a, 14b; 32a-32d; 42a, 42b) being urged towards said first pressing electrode (13, 33, 43) and said control electrode (1a) by said second pressing electrode (2); and

an insulating element (15) for insulating said first pressing electrode (13, 33, 43) from said second pressing electrode (2);

characterized by further including

an annealed foil member (11, 31, 41) formed of a soft metal such as silver, gold or platinum and interposed

between said first pressing electrode (13, 33, 43) and said control electrode (1a), and said insulating element (15) is composed of mica."

Claims 2 to 5 are dependent on Claim 1.

V. In support of his main request, the Appellant made essentially the following submissions:

(a) The first pressing electrode 15 of the closest prior art represented in Fig. 5 of document D1 has the form of a silver plate. The surface of such a solid block has under pressure the same mechanical surface deformation properties as the silver surface (3d) of the conventional Ag- and Ni-plated Cu block (3) indicated as background art in the application; see Figures 1 and 2, page 2, lines 31-34. Therefore, the pressure dependence of the contact resistance of Ag- and Ni-plated block 3 as indicated by the curve combining the crosses in Fig. 5 of the application (see the published application, column 5, lines 15 to 20; column 4, lines 48-50 in combination with the index "with no cap" in Fig 5) is also representative for the pressure dependence of the contact resistance between the first pressing electrode 15 and the control electrode 11 in Fig. 5 of document D1. Hence, Fig. 5 shows that the additional use of a soft silver foil between a first pressing and control electrode allows to lower the asymptotically approached end value of the contact resistance from 0.08 mΩ to 0.05 mΩ also with regard to the device of document D1. This surprising improvement of the closest prior art can be explained by the better mechanical deformability of a foil surface with regard to that of solid block, so that the foil forms a kind of cushion between the first pressing and the control

electrode under the pressure normal to the foil surface.

(b) Silver foil 9 in Fig. 5 of document D2 does not contact a control but a main power electrode, in order to prevent damages of the power electrode and the underlying semiconductor body by mechanical stresses which occur parallel to the foil surface and are caused by a metal supply electrode having a coefficient of thermal expansion different from that of the semiconductor body. Document D2 is silent about the contact-resistance properties of a silver foil. Hence, it would not be obvious from document D2 to use a silver foil on top of a control electrode in order to solve the different problem of the invention, namely to prevent an increase of the contact resistance after long, continuous use.

(c) Furthermore, it would not be obvious to replace the ceramic insulator 17 in Fig. 5 of document D1 by mica. Mica is only known in the field of general electrical engineering and is used in circumstances where heat is a problem. On the basis of the generally known properties of mica, a skilled person would not expect that mica withstands pressure without fatigue deformations for a longer time period than ceramics which creep with time. The simultaneous use of a soft metal foil and mica would have a surprising combination effect on the long-time behaviour of the contact resistance. The use of mica increases the time period in which the insulator thickness and thus the existing contact pressure does not get smaller. Thereby mica increases the time period during which the contact resistance of the control electrode can be maintained on the surprisingly low minimum value of the silver foil

indicated by the curve combining the dots in Fig. 5 of the application. Thus, the combined use of a soft metal foil and mica - as claimed in Claim 1 - co-operates in order to lengthen the lifetime of a power semiconductor device.

VI. At the conclusion of the oral proceedings, the decision was announced that the decision of the Examining Division is set aside and that the case is remitted to the first instance with an order to grant a patent on the basis of the Appellant's main request set out above in paragraph IV.

Reasons for the Decision

1. The subject-matter of present Claim 1 comprises the characteristics of original Claims 1 and 4 and particular constructional features of the embodiment disclosed in Fig. 4 and the corresponding original description, such as in particular the specification of the site of the soft metal foil (11) between the first pressing (13) and control electrode (1a), the use of mica (page 7, line 3) for the insulating element, and the fact that the soft metal foil is annealed (page 6, lines 28 to 30). The amendments of the description are in line with Rules 27(1)(b),(c) EPC. There is therefore no objection under Article 123(2) EPC to the current set of application documents.

2. Novelty

2.1 Document D1 describes an electrode device which comprises the features defined by the wording of the pre-characterising part of Claim 1. This prior art device has no soft metal foil between its control electrode and the

first pressing electrode, and its insulating element is not composed of mica but of ceramics.

2.2 The semiconductor device disclosed in document D2 is not at all provided with a control electrode. The silver foil 9 lies on top of a power electrode 19, 20. The device disclosed in ESR-document EP-A-0 014 761 uses a silver plate wherein an area corresponding to the surface of the control electrode is cut out, so that the silver plate contacts only the power electrode. The remaining documents cited in the European Search Report do not come closer to the subject-matter of Claim 1.

2.3 Thus, the subject-matter of the claim is considered novel in the sense of Article 54 EPC.

3. Inventive step

3.1 Starting from the closest prior art device according to document D1, the objective problem underlying the present invention is to improve the protection of this known power semiconductor element against damage in the case of the increase of the contact resistance at the solderless contact construction of the control electrode after long, continuous use.

3.2 The problem is solved by:

(a) interposing between said first pressing electrode and said control electrode an annealed foil member formed of a soft metal such as silver, gold or platinum, and

(b) composing the insulating element (in the pressure exchange way between first and second pressing electrode) of mica

as is claimed in the characterising part of Claim 1.

3.3 Though the use of a soft metal foil member such as silver foil between a metal electrode layer on a semiconductor body and its solderless contacting metal supply electrode is known from document D2, this known foil is known as a different technical means in structure, mechanical properties and in the technical exploitation of its effects for the following reasons: The known technical problem solved by the known silver foil in the device of document D2 is clearly limited to prevent mechanical damages of a power electrode and a semiconductor body caused by shear forces in the contact surface of two bodies with different thermal expansion; see also point V-(b). Document D2 does not indicate that the known silver foil is annealed, so that the skilled reader must conclude that the known silver foil has a higher mechanical hardness than the annealed foil used in the invention. The essential characteristic of the known solution, however, is a roughened contact surface (9a) of the known foil which surface allows silver particles to be rubbed off by shear forces during temperature changes in use. These silver particles function as a lubricant for the thermal relative movement of the contacting bodies; see D2, column 4, lines 63-68. The known teaching - to use lubricating silver grains in a power electrode interface for avoiding mechanical damage - in the Board's view, gives a skilled person no hint to further soften the known foil volume by annealing and to use its increased volume deformability in order to more effectively conform the foil volume under pressure to the given surface roughness structures of a control electrode and its signal electrode and to thereby minimise the contact resistance in a control line. For these reasons, in the Board's view, it is not obvious for a skilled person to anneal the silver

foil disclosed in document D2 and to use it in the device of document D1 in order to solve a different technical problem, see also decision T 39/82, OJ EPO 1982, 419.

3.4 The Appellant's arguments according to paragraph V-(a) that Fig. 5 of the application also demonstrates a surprising advantage over the closest prior art disclosed in document D1 are plausible. In the Board's view, a skilled person would expect that the contact resistance of the less deformable silver block electrode of document D1 approaches the same minimum end value as a device with an interposed annealed silver foil, but only at much higher pressure values. The fact that the use of an annealed silver foil allows to further reduce the contact resistance in a pressure region where the device with no foil has already a constant end value, contributes to the inventive step in the use of an annealed foil as a means for reducing the electrical resistance of a pressure contact.

3.5 The Appellant's submission in paragraph V-(c) that the longer volume stability of mica with regard to ceramics is not known in the art, is credible. This fact renders the use of mica for the technical purpose of increasing the durability of the control mechanism of a semiconductor device non-obvious.

3.6 For the reasons set out above in paragraphs 3.1 to 3.5, the subject-matter of Claim 1 is considered to involve an inventive step in the sense of Article 56 EPC.

4. Thus, Claim 1 is allowable under Article 52(1) EPC. Dependent Claims 2 to 5 concern particular embodiments of the device claimed in Claim 1 and are, therefore, likewise allowable.

Order

For these reasons, it is decided that:

1. The decision of the Examining Division is set aside.

2. The case is remitted to the first instance with the order to grant a patent on the basis of the main request, i.e.:

Claims:	1 to 5, filed during oral proceedings on 22 September 1992;
Description:	EP-A-0 246 576, column 1, lines 1 to 28, and column 3, line 39 to column 7, line 4; pages 2, 2a, 3, 4, 4a filed during oral proceedings on 22 September 1992;
Drawings:	Figures 1 to 7 of EP-A-0 246 576.

The Registrar: The Chairman:

M. Beer G.D. Paterson