

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44bis)

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| Applicant's or agent's file reference 649202WO01 | FOR FURTHER ACTION | | See item 4 below |
| International application No. PCT/JP2016/072158 | International filing date (<i>day/month/year</i>) 28 July 2016 (28.07.2016) | Priority date (<i>day/month/year</i>) | |
| International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237 | | | |
| Applicant MITSUBISHI ELECTRIC CORPORATION | | | |

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|---|-------------------------------------|---|---------------------|--------------------------|------------|----------|--------------------------|-------------|--|--------------------------|------------|----------------------------|-------------------------------------|-----------|---|--------------------------|------------|-------------------------|--------------------------|-------------|--|--------------------------|--------------|---|
| <p>1. This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 bis.1(a).</p> <p>2. This REPORT consists of a total of 9 sheets, including this cover sheet.</p> <p>In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.</p> | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>3. This report contains indications relating to the following items:</p> <table> <tr> <td><input checked="" type="checkbox"/></td> <td>Box No. I</td> <td>Basis of the report</td> </tr> <tr> <td><input type="checkbox"/></td> <td>Box No. II</td> <td>Priority</td> </tr> <tr> <td><input type="checkbox"/></td> <td>Box No. III</td> <td>Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</td> </tr> <tr> <td><input type="checkbox"/></td> <td>Box No. IV</td> <td>Lack of unity of invention</td> </tr> <tr> <td><input checked="" type="checkbox"/></td> <td>Box No. V</td> <td>Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</td> </tr> <tr> <td><input type="checkbox"/></td> <td>Box No. VI</td> <td>Certain documents cited</td> </tr> <tr> <td><input type="checkbox"/></td> <td>Box No. VII</td> <td>Certain defects in the international application</td> </tr> <tr> <td><input type="checkbox"/></td> <td>Box No. VIII</td> <td>Certain observations on the international application</td> </tr> </table> <p>4. The International Bureau will communicate this report to designated Offices in accordance with Rules 44bis.3(c) and 93bis.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44bis .2).</p> | <input checked="" type="checkbox"/> | Box No. I | Basis of the report | <input type="checkbox"/> | Box No. II | Priority | <input type="checkbox"/> | Box No. III | Non-establishment of opinion with regard to novelty, inventive step and industrial applicability | <input type="checkbox"/> | Box No. IV | Lack of unity of invention | <input checked="" type="checkbox"/> | Box No. V | Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement | <input type="checkbox"/> | Box No. VI | Certain documents cited | <input type="checkbox"/> | Box No. VII | Certain defects in the international application | <input type="checkbox"/> | Box No. VIII | Certain observations on the international application |
| <input checked="" type="checkbox"/> | Box No. I | Basis of the report | | | | | | | | | | | | | | | | | | | | | | |
| <input type="checkbox"/> | Box No. II | Priority | | | | | | | | | | | | | | | | | | | | | | |
| <input type="checkbox"/> | Box No. III | Non-establishment of opinion with regard to novelty, inventive step and industrial applicability | | | | | | | | | | | | | | | | | | | | | | |
| <input type="checkbox"/> | Box No. IV | Lack of unity of invention | | | | | | | | | | | | | | | | | | | | | | |
| <input checked="" type="checkbox"/> | Box No. V | Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement | | | | | | | | | | | | | | | | | | | | | | |
| <input type="checkbox"/> | Box No. VI | Certain documents cited | | | | | | | | | | | | | | | | | | | | | | |
| <input type="checkbox"/> | Box No. VII | Certain defects in the international application | | | | | | | | | | | | | | | | | | | | | | |
| <input type="checkbox"/> | Box No. VIII | Certain observations on the international application | | | | | | | | | | | | | | | | | | | | | | |

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| <p align="center">The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland</p> <p>Facsimile No. +41 22 338 82 70</p> | <p>Date of issuance of this report 29 January 2019 (29.01.2019)</p> |
| | <p>Authorized officer</p> <p align="center">Mineko Mohri</p> <p>e-mail: pct.team8@wipo.int</p> |

PATENT COOPERATION TREATY

TRANSLATION

From the
INTERNATIONAL SEARCHING AUTHORITY

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

To:

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| Date of mailing (day/month/year) | 20.09.2016 |
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| Applicant's or agent's file reference 649202W001 |
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| FOR FURTHER ACTION See paragraph 2 below |
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| International application No. PCT/JP2016/072158 | International filing date (day/month/year) 28.07.2016 | Priority date (day/month/year) |
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| International Patent Classification (IPC) or both national classification and IPC H01L23/48 (2006.01) i, H01L21/52 (2006.01) i |
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| Applicant MITSUBISHI ELECTRIC CORPORATION |
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1. This opinion contains indications relating to the following items:

- Box No. I Basis of the opinion
- Box No. II Priority
- Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- Box No. IV Lack of unity of invention
- Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- Box No. VI Certain documents cited
- Box No. VII Certain defects in the international application
- Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

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|--|------------------------------------|--------------------|
| Name and mailing address of the ISA/JP | Date of completion of this opinion | Authorized officer |
| Facsimile No. | | Telephone No. |

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

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Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:
 - the international application in the language in which it was filed
 - a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).
2. This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))
3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:
 - a. forming part of the international application as filed:
 - in the form of an Annex C/ST.25 text file.
 - on paper or in the form of an image file.
 - b. furnished together with the international application under PCT Rule 13ter.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.
 - c. furnished subsequent to the international filing date for the purposes of international search only:
 - in the form of an Annex C/ST.25 text file (Rule 13ter.1(a)).
 - on paper or in the form of an image file (Rule 13ter.1(b) and Administrative Instructions, Section 713).
4. In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
5. Additional comments:

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| Box No. V | Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement | | |
|---|--|---------------------------|-----|
| 1. Statement | | | |
| Novelty (N) | Claims | <u>1-19</u> | YES |
| | Claims | _____ | NO |
| Inventive step (IS) | Claims | <u>11-12, 15</u> | YES |
| | Claims | <u>1-10, 13-14, 16-19</u> | NO |
| Industrial applicability (IA) | Claims | <u>1-19</u> | YES |
| | Claims | _____ | NO |
| 2. Citations and explanations: | | | |
| <p>Document 1: Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 147342/1979 (Laid-open No. 65650/1981) (New Nippon Electric Co., Ltd.) 01 June 1981, specification, page 1, line 1 to page 4, line 19; fig. 4 (Family: none)</p> <p>Document 2: Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 71677/1980 (Laid-open No. 172938/1981) (NEC Corp.) 21 December 1981, specification, page 2, lines 7 to 12; fig. 1 (Family: none)</p> <p>Document 3: 第 33 表 実用金属および合金の物理的性質, 日本ウエルディングロッド株式会社 [オンライン], 2012 [検索日 09 September 2016], インターネット: <URL: http://www.nihonwel.co.jp/pdf_data/Capter17/alloy%20property.pdf>, 全文, non-official translation (Table 33, Physical properties of practical metals and alloys, NIPPON</p> | | | |

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Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

WELDING ROD CO., LTD. [online], 2012
[retrieval date 09 September 2016],
Internet: <URL:
http://www.nihonwel.co.jp/pdf_data/Capter17/alloy%20property.pdf>, entire text)

Document 4: WO 2015/029186 A1 (MITSUBISHI ELECTRIC
CORP.) 05 March 2015, paragraphs [0010]-
[0012], [0023]-[0025], [0046], fig. 1, 5
(Family: none)

The invention as in claims 1-2, 5, 8, 10, 13-14 and
16 is novel in relation to the documents cited in the
ISR, but does not involve an inventive step in the light
of documents 1 and 2 cited in the ISR.

Claims 1, 8 and 16

Document 1 discloses a thyristor (semiconductor
device) comprising: a copper substrate 12 (corresponds to
the electrode substrate in the invention of the present
application (hereinafter omitted)); a pellet 6
(semiconductor chip) that is attached to the copper
substrate 12 with a solder layer 13 (first solder)
interposed therebetween on the back surface side and that
has a gate 9 and a cathode 10 on the front surface side;
and a plate member 15 made of molybdenum (intermediate
plate mainly made of molybdenum) that is disposed inside
the solder layer 13 and that has a plurality of through
holes 14 (through holes).

When the invention disclosed in document 1
(hereinafter referred to as invention of document 1) and
the invention as in claims 1, 8 and 16 are compared, the

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

inventions differ from each other in the following respects.

Difference 1

In the invention as in claims 1, 8 and 16, a lead frame is attached to the upper surface of the semiconductor chip with the second solder interposed therebetween. Meanwhile, the invention of document 1 does not mention such feature.

Difference 2

In the invention as in claims 1, 8 and 16, the yield strength of the intermediate plate is higher than the yield strength of the electrode substrate and the first solder in the entire usage temperature range of the semiconductor device. Meanwhile, the invention of document 1 does not mention such feature.

The differences are examined below.

Difference 1

Connecting a gate and a cathode to a lead with a solder interposed therebetween is such a well-known, commonly used feature that it is not necessary to cite examples.

Difference 1 is thus not special.

Difference 2

As disclosed in document 2, for example, the yield strength of molybdenum is known to be generally higher than the yield strength of copper. The yield strength of molybdenum being higher than that of solder is such a

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well-known feature that it is not necessary to cite examples.

It is clear that, in document 1, the yield strength of the plate member 15 made of molybdenum is higher than that of the copper substrate 12 and that of the solder layer 13 in general usage environment.

Difference 2 is thus not special.

Claims 2, 10 and 13

The specific usage temperature range, size of the through holes and size of the pellet merely are design matters to be set, as appropriate.

Claim 5

Document 1 (fig. 4) indicates that the gate 9 and the cathode 10 are disposed on the inside relative to the outer circumference of the plate member 15.

Claim 14

Copper and aluminum are well-known, commonly used materials for a conductive substrate.

Therefore, the invention as in claims 1-2, 5, 8, 10, 13-14 and 16 could be easily conceived of by a person skilled in the art on the basis of the inventions disclosed in documents 1 and 2.

The invention as in claims 3-4, 6-7 and 9 is novel in relation to the documents cited in the ISR, but does not involve an inventive step in the light of documents 1-3 cited in the ISR.

Document 3 describes a resin-sealed semiconductor

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device (semiconductor device) in which a semiconductor element 5 (semiconductor chip) is attached to an element attachment substrate 1 (electrode substrate) with a solder 4 (first solder) with an intermediate member 2 (intermediate plate mainly made of molybdenum) that is made of molybdenum, for example, and that is covered by a plating layer 3 (plating film mainly made of nickel) made of nickel, for example, interposed between the substrate and the semiconductor element. Fig. 1 shows a configuration where the intermediate member 2 is disposed inside the solder 4.

Therefore, the invention as in claims 3-4, 6-7 and 9 could be easily conceived of by a person skilled in the art on the basis of the inventions disclosed in documents 1-3.

The invention as in claims 17-19 is novel in relation to the documents cited in the ISR, but does not involve an inventive step in the light of documents 1-4 cited in the ISR.

Document 4 discloses a semiconductor module (semiconductor device), wherein semiconductor chips 7 and 8 (semiconductor chip) are attached to a conductor pattern 4 made of Al, for example, with a solder 6 (first solder) interposed therebetween and wherein the upper surfaces of the semiconductor chips 7 and 8 are connected by an Al wire. Document 4 indicates that the semiconductor module is used in an electric vehicle and that a wide-gap semiconductor (compound semiconductor having carbon) such as silicon carbide is used as the semiconductor chips.

Therefore, the invention as in claims 17-19 could be

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Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

easily conceived of by a person skilled in the art on the basis of the inventions disclosed in documents 1-4.

The invention as in claims 11-12 and 15 is novel and involves an inventive step in relation to the documents cited in the ISR.

None of the documents cited in the ISR discloses or suggests placing an intermediate plate inside a plurality of bumps and using copper as the primary material of the intermediate plate. A person skilled in the art could not easily conceive of such features taking into account common technical knowledge at the time of filing.