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Case Number: T 0422/05 - 3.4.03

Application Number: 96933617.1

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Title of invention:
Semiconductor device

Applicant:
Nakata, Josuke

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 54, 56

Keyword:
"Novelty (yes - after amendment)"
"Inventive step (yes - after amendment)"

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-

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Case Number: T 0422/05 - 3.4.03

D E C I S I O N
of the Technical Board of Appeal 3.4.03
of 17 September 2007

Appellant: Nakata, Josuke
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 18 November 2004 refusing European application No. 96933617.1 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: R. G. O'Connell
Members: V. L. P. Frank
T. Bokor

Summary of Facts and Submissions

I. This is an appeal from the refusal of application 96 933 617 for lack of novelty (Article 54 EPC).

II. Independent claims 1 and 14 are now worded as follows:

"1. A semiconductor device, comprising:
an independent spherical semiconductor (1) element, comprising:
a spherical crystal (2) of p-type semiconductor or n-type semiconductor;
a photovoltaic part (16) which is incorporated onto the surface or onto an area near the surface of said spherical crystal (2);
said photovoltaic part (16) generating photovoltage in association with said spherical crystal (2);
a pair of electrodes (14,15) for the inflow/outflow of current with respect to an outside circuit, one electrode of the pair being on each side of the photovoltaic part (16) and each electrode being on the surface of said spherical crystal (2);
wherein:
said pair of electrodes are mutually separated such that an electrode (14) with one polarity and an electrode (15) with the other polarity are placed so that they are opposite each other with the center of said spherical crystal (2) interposed between the pair of electrodes (14, 15) and such that the inflow/outflow of current with respect to said outside circuit occurs at the top and bottom of the spherical crystal."

"14. A semiconductor device, comprising:
independent spherical semiconductor elements (1), each comprising:
a spherical crystal (2) of p-type semiconductor or n-type semiconductor;
a diffusion layer (6) and a pn junction (7) formed near the surface of said spherical crystal (2);
a pair of electrodes (14, 15) for the inflow/outflow of current with respect to an outside circuit, one electrode of the pair being on each side of said pn junction and each electrode being on the surface of said spherical crystal (2):
wherein:
said pair of electrodes are mutually separated such that an electrode (14) with one polarity and an electrode (15) with the other polarity are placed so that they are opposite each other with the center of said spherical crystal (2) interposed between the pair of electrodes (14, 15) and such that the inflow/outflow of current with respect to said outside circuit occurs at the top and bottom of the spherical crystal."

The remaining claims are dependent claims.

III. The following prior art documents were cited in the examination procedure:

D6: US 2 904 613 A

D7: US 3 350 775 A

IV. The appellant applicant argued essentially as follows:

– Claims 1 and 14 defined the invention as comprising an independent spherical semiconductor element. The spherical semiconductor body disclosed in document D7 was however not an independent element, but was explicitly disclosed as being a part of the solar energy converter of document D6. It was therefore an intermediate product, part of a larger structure, which could not be considered as independent. The present inventor had realized that an independent spherical semiconductor element allowed a high degree of freedom and had excellent generalizability.

– The grid strips disclosed in D7 were narrow strips widely spaced apart. They could not be considered as an electrode to which an external contact could be made. Moreover, they did not allow a touching contact between two spheres. The current flow in D7 was not through the grid strips, but through the annular contact and the bottom electrode. Even if the semiconductor elements disclosed in D7 were submerged in a fluid, as in the first embodiment of the present invention, the current flow would not occur at the top and bottom of the spherical element, but would occur through the whole hemisphere covered by the grid strips.

V. The appellant applicant requests that the decision under appeal be set aside and a patent granted in the following version:

Description: pages 1, 5 to 21, 35 to 38, 45, 46 as filed during oral proceedings before the board, pages 2, 3, 4, 22 to 34, 39 to 44, 47 to 60 as originally filed,

Claims: 1 to 25 as filed during oral proceedings before the board,

Figures: 1 to 35 as originally filed.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments (Article 123(2) EPC)*

Claims 1 and 14 are essentially a combination of claims 1 and 2 and of claims 18 and 20, respectively. The further feature that the inflow/outflow of current with respect to an outside circuit occurs at the top and bottom of the spherical crystal is disclosed on page 25, lines 16 to 20 of the originally filed description.

The description has been adapted to the claims.

The board is therefore satisfied that Article 123(2) EPC is not contravened.

3. *Novelty (Article 54 EPC)*

3.1 In the following analysis reference will be made to claim 1. However, as the subject-matter of claim 14 differs from the one of claim 1 only in the replacement

of the photovoltaic part 16 by a diffusion layer and a pn junction, this analysis applies as well to claim 14.

3.2 Document D7 relates to a process of making solar cells. It discloses a spherical body of semiconductor material 30 of a first conductivity type having formed on part of its surface a region 32 of a second conductivity type forming thus a pn junction. This region extends over the upper hemisphere of the body. An ohmic contact 34 in the form of an annular ring is formed on the border of region 32, as is a plurality of grid strips 36 which covers partly the upper hemisphere. A second ohmic contact 38 is plated at the bottom of the body 30 after the silicon dioxide covering the bottom portion of the spherical body has been removed eg by means of hydrofluoric acid. The contacts 34 and 38 are separated by an annular strip of silicon dioxide 40 and lie on opposite faces of the pn junction (column 3, lines 13 to 55; Figure 5).

3.3 In the view of the board, document D7 discloses using the wording of claim 1 and indicating the corresponding reference signs of Figure 5:

> A semiconductor device, comprising:
> an independent spherical semiconductor element (cf Figure 5), comprising:
> a spherical crystal (30) of p-type semiconductor or n-type semiconductor;
> a photovoltaic part (diffusion layer 32 forming a pn junction on the surface of the sphere) which is incorporated onto the surface or onto an area near the surface of said spherical crystal;

said photovoltaic part generating photovoltage in association with said spherical crystal;
a pair of electrodes (34, 36 and 38) for the inflow/outflow of current with respect to an outside circuit, one electrode of the pair being on each side of the photovoltaic part and each electrode being on the surface of said spherical crystal;
wherein:
said pair of electrodes are mutually separated (by the silicon dioxide ring 40) such that an electrode (34, 36) with one polarity and an electrode (38) with the other polarity are placed so that they are opposite each other with the center of said spherical crystal interposed between the pair of electrodes.

3.4 The appellant applicant argued that the spherical body disclosed in D7 was not an independent element within the meaning of the present invention, as D7 discloses explicitly that it is to be used in the solar cell array disclosed in document D6 (column 3, lines 13 to 15). He argued that the spherical body of D7 was an intermediate product and not foreseen to be used independently as in the present application.

3.5 The board is not persuaded by this argument. Although the spherical body disclosed in D7 is to be used in the solar panels of D6, it is a product by itself and therefore relevant for novelty. This spherical body is not an intermediate product in the chemical sense of being a product which is further completely transformed into another substance, but a part of a more complex device. It is an independent element in the same manner

as the spherical element disclosed in the present application, as it generates a photovoltage under illumination analogously to the claimed element.

3.6 The appellant applicant also argued that the grid strips 36 of D7 could not be considered as an electrode, since it was through the contact ring 34 that contact with an external circuit was made. D7 discloses that the grid rings increased the efficiency of the cell by collecting the current carriers generated at the junction and delivering them to the metallic contact (column 2, lines 17 to 22). A skilled person would therefore never consider the grid strips as electrodes. The electrodes of the device of D7 were therefore the contacts 34 and 38 which did not lie opposite the centre of the sphere as required by claim 1.

3.7 The board is however not persuaded that the term electrode should be given such a restricted meaning. It considers on the contrary that it is the whole conducting structure formed by the annular contact 34 and by the grid strips 36 which injects or removes current carriers from the spherical element disclosed in D7 and sees this structure as a mesh-like electrode similar to the ones used eg in vacuum tubes. In particular, if the spherical element disclosed in D7 were immersed in an electrolyte, as disclosed eg in the first embodiment of the present application, current would flow in and out through the whole structure 34, 36 covering the hemisphere.

3.8 As the appellant applicant correctly pointed out document D7 does not disclose the last feature of claim 1, namely that the inflow/outflow of current with

respect to said outside circuit occurs at the top and bottom of the spherical crystal. In D7 the annular contact 34 and the bottom contact 38 are provided for making contact with an external circuit. This is shown in particular in Figure 5 of D6, which depicts several semiconductor elements connected in parallel *via* contacts 34 and 38. D7 discloses explicitly that the spherical bodies are for the solar panels disclosed in D6 (column 3, lines 13 to 17).

3.9 Even if the spherical element of D7 were immersed in an electrolyte, current would flow through the whole structure formed by the annular contact 34 and the grid strips 36 and not only through the top or bottom of the sphere. The feature in claim 1 that it is the inflow/outflow of current which occurs at the top and bottom of the sphere requires that no flow of current occurs at other sites of the sphere. This would not be the case with the element disclosed in D7.

3.10 As mentioned at the beginning of this analysis, claim 14 differs from claim 1 in that the spherical element comprises instead of the photovoltaic part 16 a diffusion layer 6 and a pn junction 7, the other features being the same. Therefore, the above reasoning applies with equal force to the semiconductor device of claim 14.

3.11 The semiconductor devices according to claims 1 and 14 are considered therefore to be new.

4. *Inventive step (Article 56 EPC)*

4.1 The semiconductor devices according to claims 1 or 14 differ from the device disclosed in document D7 in that the inflow/outflow of current with respect to an outside circuit occurs at the top and bottom of the spherical crystal. This feature allows to line up a plurality of such spheres and to connect them electrically in series giving the designer a great flexibility (the paragraph bridging pages 6 and 7 of the present application). This flexibility in design is illustrated in the embodiments disclosed in the application.

4.2 None of the prior art documents cited in the European search report disclose this feature. The examining division has not made a substantiated objection on inventive step and the board does not see any suggestion in the prior art that would induce the skilled person to modify it in the way disclosed in the present application. Neither does the board consider that the problem of lining up a plurality of spherical semiconductor elements for serial connection could be considered an obvious problem whose formulation would lead the person skilled in the art to the solution specified in claims 1 or 14.

4.3 The semiconductor devices of claims 1 and 14 are therefore considered to involve an inventive step in the sense of Article 56 EPC.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance with the order to grant a patent in the following version:

Description: pages 1, 5 to 21, 35 to 38, 45, 46 as filed during oral proceedings before the board,
pages 2, 3, 4, 22 to 34, 39 to 44, 47 to 60 as originally filed,

Claims: 1 to 25 as filed during oral proceedings before the board,

Figures: 1 to 35 as originally filed.

Registrar Chair

S. Sánchez Chiquero R. G. O'Connell