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# Datasheet for the decision of 11 October 2016

**Case Number:** T 1060/11 - 3.4.03

**Application Number:** 03744009.6

**Publication Number:** 1484800

**IPC:** H01L29/06, H01L33/00, H01J1/312, H01J9/02

**Language of the proceedings:** EN

**Title of invention:**
QUANTUM DEVICE

**Applicant:**
Panasonic Corporation
Koshida, Nobuyoshi

**Headword:**

**Relevant legal provisions:**
EPC 1973 Art. 54(1), 54(2), 56
EPC Art. 52(1)
EPC 1973 R. 71(2)
RPBA Art. 15

**Keyword:**
Inventive step - (no)

**Decisions cited:**

**Catchword:**

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**Beschwerdekammern**
**Boards of Appeal**
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**Case Number: T 1060/11 - 3.4.03**

# D E C I S I O N
# of Technical Board of Appeal 3.4.03
# of 11 October 2016

| | |
|---|---|
| **Appellant:** (Applicant 1) | Panasonic Corporation<br>1006, Oaza Kadoma<br>Kadoma-shi<br>Osaka 571-8501 (JP) |
| **Appellant:** (Applicant 2) | Koshida, Nobuyoshi<br>3-12-8 Midori-cho,<br>Koganei-shi<br>Tokyo 184-0003 (JP) |
| **Representative:** | dompatent von Kreisler Selting Werner -<br>Partnerschaft von Patent- und Rechtsanwälten mbB<br>Deichmannhaus am Dom<br>Bahnhofsvorplatz 1<br>50667 Köln (DE) |
| **Decision under appeal:** | **Decision of the Examining Division of the European Patent Office posted on 7 December 2010 refusing European patent application No. 03744009.6 pursuant to Article 97(2) EPC.** |

**Composition of the Board:**

| | |
|---|---|
| **Chairman** | G. Eliasson |
| **Members:** | S. Ward |
| | T. Bokor |

## Summary of Facts and Submissions

I. The appeal is against the decision of the Examining Division refusing European patent application No. 03 744 009 on the ground that the claimed subject-matter was not new within the meaning of Article 54(1) and (2) EPC.

II. In the statement of grounds of appeal the appellant requested that the decision under appeal be set aside and that a patent be granted "based on the enclosed set of claims 1 to 11".

III. The following documents are referred to in this decision:

D1: EP 1 096 532 A1
D5: EP 0 989 577 A2

IV. The Board issued a summons to oral proceedings and an accompanying communication under Article 15(1) RPBA in which a provisional opinion was expressed that the subject-matter of claim 1 differed from the closest prior art (the embodiment of Fig. 3 in document D1) only in the feature that "said carbon thin film has a thickness of 5 nm or less". The Board expressed doubts whether this feature could constitute a basis for acknowledging an inventive step, and stated that at oral proceedings "the appellant will be invited to explain why a carbon thin film thickness of less than 5 nm is considered to be inventive."

V. The appellant filed a letter of reply to the summons dated 11 July 2016 stating only the following: "Neither applicants nor the signatory will attend the oral proceedings."

VI. Oral proceedings before the Board were held in the absence of the appellant.

VII. Claim 1 reads as follows:

*"A quantum device comprising:*
*a lower electrode;*
*a silicon layer formed on said lower electrode, said silicon layer including a number of nanocrystalline silicons to induce a quantum effect in response to an electric field applied thereto, and*
*a surface electrode, formed on said silicon layer, said surface electrode having a carbon thin film to be in adhesive contact with the nanocrystalline silicons, wherein*
*said carbon thin film prevents peeling, aggregation or oxidation of the surface electrode or prevents impurities for being mixed or adsorbed into said silicon layer,*
*wherein said carbon thin film has a thickness of 5 nm or less, and*
*wherein an electric field applied between said lower electrode and said surface electrode acts on said silicon layer."*

VIII. The appellant's arguments may be briefly summarised as follows:

The quantum device according to the present invention was characterized by the presence of four different layers, namely a lower electrode, a silicon layer formed on said lower electrode followed by a carbon thin film and a surface electrode as upper layer. Thus the carbon thin film was placed between the surface electrode and the silicon layer.

The carbon thin film according to the present invention furthermore was characterized in that it had a thickness of 5 nm or less. The purpose of said carbon thin film was to prevent peeling, aggregation or oxidation of the surface electrode or to prevent impurities from being mixed or adsorbed into the silicon layer.

In the contested decision it was stated that, even though not explicitly disclosed in reference D1, the mere presence of the carbon thin film above the silicon layer implied that the same technical effects were obtained as for the carbon thin film of the present application. However, no evidence or arguments but just a repetition of the purpose of the carbon thin film according to the present invention was given.

Furthermore, in the first embodiment of D1 (paragraph [0008]) the carbon region was a thin film deposited on the thin film metal electrode. In the embodiment of paragraph [0009] the carbon region was distributed within the thin film metal electrode. Neither of these locations corresponded to that of the carbon thin film according to the present invention.

In a third embodiment (paragraph [0010]) it was described that the carbon region is a thin film deposited under the thin film metal electrode and thus, was to be seen as the same location as that of the carbon thin film according to the present invention.

Nevertheless, none of the three options above disclosed the presence of a carbon thin film having a thickness of up to 5 nm.

The purpose of the device according to reference D1 was to restrict the diode current Ips, therefore the place of the carbon region was not limited at all as long as it existed in the current circuit. Accordingly, there was no need for the carbon region according to reference D1 to be in contact with the nano silicon layer. Thus, the carbon region according to the reference Dl might be provided on top or under or inside the thin film metal electrode.

On the other hand, the purpose of the specific carbon thin film layer having a thickness of 5 nm or less, according to the present invention was to enhance coverage and adhesion of the surface electrode to the silicon layer. Accordingly, the purpose of the present invention and in particular the purpose of a thin film carbon layer according to the present invention was quite different to that of reference D1. Thus, the assumption of the Examining Division that the carbon region according to reference D1 implied the same technical effects as obtained for the carbon thin film according to the present invention was unjustified and without proper basis on the teaching of reference D1 or any other references cited during the examination procedure.

## Reasons for the Decision

1. The appeal is admissible.

2. As announced in advance, the duly summoned appellant did not attend the oral proceedings. According to Rule 71(2) EPC 1973, the proceedings may nevertheless continue without a duly summoned party, that party then

being treated as relying only on its written case. As the present case was ready for decision at the conclusion of the oral proceedings (Article 15(5) and (6) RPBA), the voluntary absence of a party was not a reason for delaying the decision (Article 15(3) RPBA).

3. *Closest prior art*

The closest prior art is considered to be the embodiment of document D1 depicted in Fig. 3 and described in paragraph [0025]; it is therefore necessary to determine which features of claim 1 are disclosed in this embodiment.

4. *Silicon layer*

4.1 Claim 1 of the present application defines the following feature:

- *"a silicon layer formed on said lower electrode, said silicon layer including a number of nanocrystalline silicons to induce a quantum effect in response to an electric field applied thereto".*

The corresponding feature in document D1 is a "porous semiconductor layer 13", and the question therefore arises whether this anticipates the claimed feature.

4.2 According to document D1 (paragraph [0038], [0047]) the porous semiconductor layer 13 is formed by anodic treatment of silicon in a mixture of hydrogen fluoride solution and ethanol, a Pt electrode being used as the cathode, and light irradiation being performed during the anodization. Essentially the same method is used in the "nanocrystallization process" of the present application (page 23, third paragraph).

Furthermore, the porous silicon layer of document D1 comprises minute pore channels and "residual Si skeletons" with dimensions "in a range from the number of tens to hundreds of Si atoms" (paragraph [0037], final sentence, and paragraph [0039]), i.e. from about 1 nm to tens of nm (the radius of a silicon atom is 0.117 nm).

It is also noted in this regard that neither in examination nor in appeal has the appellant-applicant disputed that the porous semiconductor layer of document D1 may be identified with the claimed silicon layer, nor has it been disputed that the porous semiconductor layer of document D1 would produce the claimed effects in response to an applied electric field.

4.3 For the above reasons, the Board considers that document D1 discloses the feature of claim 1 cited under point 4.1, above.

5. *Position and effect of the carbon thin film*

5.1 Claim 1 of the present application also defines a surface electrode:

- *"having a carbon thin film to be in adhesive contact with the nanocrystalline silicons, wherein said carbon thin film prevents peeling, aggregation or oxidation of the surface electrode or prevents impurities for being mixed or adsorbed into said silicon layer".*

5.2 Document D1 discloses a carbon thin film 40 which, in the embodiment of Fig. 3, is sandwiched between the

porous silicon layer and an outer thin film metal electrode 15.

The appellant is correct in pointing out that in other embodiments of document D1 the carbon thin film or region is positioned elsewhere (deposited on the outer face of the thin film metal electrode 15 in Fig. 1, or distributed within the thin film metal electrode in Fig. 2). This is, however, irrelevant, since it is the embodiment of Fig. 3 which is considered to be the closest prior art, and this embodiment undoubtedly discloses a layer arrangement corresponding to that of claim 1 of the present application.

5.3 The appellant also argues that the purpose of providing a carbon thin film in document D1 is to restrict the diode current Ips (see paragraph [0057]), and not to achieve the claimed effects of preventing "peeling, aggregation or oxidation of the surface electrode" or preventing "impurities for [from?] being mixed or adsorbed into said silicon layer".

The relevant question, however, is not whether the carbon thin film of document D1 is provided in order to produce the effects listed in claim 1, but whether this film would, in practice, give rise to these effects. The question is one of fact, not of intent.

The contention of the appellant that the Examining Division has produced "no evidence or arguments" in this respect does not appear to be accurate, but even if it were true, it misses the point. Fig. 3 of document D1 and claim 1 of the present application relate to the same arrangement of a carbon thin film located between the silicon layer and the upper surface electrode, and it is for the appellant to produce

"evidence or arguments" to explain why the same feature would not have the same technical effects.

5.4 In any event, the claimed feature sets out a list of alternative technical effects separated by "or", and hence if the carbon layer of document D1 can be said to provide any one of these effects, then the feature is anticipated. Since the carbon layer depicted in Fig. 3 is adjacent to the silicon layer, at the very least it would prevent, to some extent, impurities from entering the silicon layer.

5.5 Hence, for the above reasons, the Board considers that document D1 discloses the claimed feature cited under point 5.1.

6. *Distinguishing feature*

The sole difference between claim 1 and the embodiment of Fig. 3 of document D1 is therefore the following:

- *"said carbon thin film has a thickness of 5 nm or less"*.

7. *Problem and solution*

7.1 Limiting the thickness of the carbon thin film to 5 nm or less appears to be presented as a solution to the problem of achieving a satisfactory level of electron emission, or suppressing its deterioration (page 7, lines 16-22; page 16, lines 4-7).

7.2 According to established case law, the definition of the objective problem normally starts from the problem described in the application, a reformulation of the problem only being necessary if, for example,

examination shows that the problem posed is not solved by the claimed features, or if the prior art used to define the problem is found to be inappropriate (see "Case Law of the Boards of Appeal of the European Patent Office", 8th edition, 2016, I.D.4.3.2).

7.3 According to the present application, the surface electrode should generally be as thin as possible (page 3, lines 19-22), for example about 10 nm (page 16, lines 8-9). The Board's understanding is that this is required to allow the electrons to be "emitted to the vacuum space after readily tunneling through the surface electrode 7" (page 18, lines 17-21).

7.4 In the case of the present invention, the electrons would have to tunnel through both layers of the composite upper electrode (carbon thin film plus overlying surface electrode), and hence it must be presumed that it is the total thickness of this composite electrode which should be minimized to facilitate electron emission.

It is not seen how the problem of ensuring satisfactory electron emission could be solved merely by setting the thickness of the carbon thin film to be less than 5 nm, without placing any restriction on the total thickness of the surface electrode, nor is this explained in the application or in the submissions of the appellant.

Claim 1 includes embodiments in which, while the thickness of the carbon thin film is not greater than 5 nm, the overall thickness of the surface electrode may be tens or hundreds of nm, or more. Such embodiments would clearly not represent solutions to the problem of achieving an adequate level of electron emission.

7.5 Other effects are mentioned in the description and in claim 1, in particular prevention of peeling, aggregation or oxidation of the surface electrode or prevention of impurities from being mixed or adsorbed into said silicon layer. However, it is again not plausible, nor does it appear to be suggested in the application or by the appellant, that these effects follow simply as a direct consequence of the choice of 5 nm as the upper limit for the thickness of the carbon thin film.

7.6 In the absence of any clear, specific problem solved by the distinguishing feature, the problem can only be seen as a general one, such as finding a suitable thickness for the carbon thin film of document D1.

7.7 Document D1 does not disclose the thickness of the carbon thin film 40, the metal thin film 15 or the combination of the two. However, suitable values for the total thickness of the surface electrode are known from similar devices disclosed in the prior art. For example, document D5 (a patent family member of "Japanese Patent No. 2966842" cited on page 1 of the description of the present application) discloses a surface electrode formed of gold with a thickness of "about 10 nm" (paragraphs [0031], [0069]), which appears to be sufficiently thin to allow the required tunneling (paragraph [0043], final sentence).

It would therefore be obvious for the skilled person to select a thickness of about 10 nm for the combined layers 15 and 40 of document D1, and it would remain merely to distribute this thickness between the two component thin films of carbon and metal.

Selecting thicknesses of, for example, 4 nm for the carbon film and 6 nm for the metal film would result in an arrangement falling within the ambit of present claim 1, whereas a choice of 6 nm for the carbon film and 4 nm for the metal film would not. It is not, however, apparent from the application that any particular technical effect would be provided by the first arrangement but not by the second, nor can any reason be seen why the first arrangement should be considered to constitute an inventive selection.

The Board therefore judges that it has not been convincingly demonstrated that the feature of an upper limit of 5 nm represents anything more than an arbitrary selection between evident alternatives which does not involve an inventive step.

7.8 Finally, for completeness, the Board believes that the lack of any defined lower limit for the thickness of the carbon thin film also precludes the acknowledgement of an inventive step.

The carbon thin film of the present invention may have any thickness which does not exceed 5 nm, and hence the claimed device may include carbon thin films having thicknesses lying between 0 and 1 nm. Far from being the solution to a problem, working in this range results, according to the application, in a deterioration of the electron emission characteristic (page 30, lines 5-21). Hence such embodiments cannot be considered inventive.

As a result, the subject-matter of claim 1 as a whole does not involve an inventive step, as it does not conform to the generally accepted legal principle that everything falling within a valid claim has to be

inventive (see "Case Law of the Boards of Appeal of the European Patent Office", 8th edition, 2016, I.D.1).

7.9 In the light of the foregoing, the Board judges that the subject-matter of claim 1 does not involve an inventive step within the meaning of Article 52(1) EPC and Article 56 EPC 1973.

**Order**

**For these reasons it is decided that:**

The appeal is dismissed.

The Registrar: The Chairman:

S. Sánchez Chiquero G. Eliasson

Decision electronically authenticated