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Datasheet for the decision of 9 July 2008

Case Number: T 0039/03 - 3.4.02

Application Number: 99100131.4

Publication Number: 0911885

IPC: H01L 31/18

Language of the proceedings: EN

Title of invention:
Improved columnar-grained polycrystalline solar cell and process of manufacture

Applicant:
GE Energy (USA) LLC

Opponent:
-

Headword:
-

Relevant legal provisions:
-

Relevant legal provisions (EPC 1973):
EPC Art. 76(1), 123(2), 52(1)

Keyword:
"Amended claims: no extension beyond the divisional and parent application as originally filed"
"Novelty and inventive step: yes"

Decisions cited:
G 0001/05

Catchword:
-

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0039/03 - 3.4.02

D E C I S I O N
of the Technical Board of Appeal 3.4.02
of 9 July 2008

Appellant: GE Energy (USA) LLC
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 8 August 2002 refusing European application No. 99100131.4 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: A. Klein
Members: M. Stock
C. Rennie-Smith

Summary of Facts and Submissions

I. The present European application No. 99 100131.4 was filed as a divisional application to the earlier European application No. 93 116 174.9. The applicant and appellant has appealed against the decision of the examining division refusing the present divisional application on the ground that none of a main and three auxiliary requests then on file met the requirements of the EPC 1973. The examining division inter alia reasoned that the present divisional application did not comply with Article 76(1) EPC 1973 because it extended beyond the content of the earlier application. Reference was made to the following documents:

D1: DE 35 36 743 A

D2: Norman et al.: "Solar Grade Si Substrates by the Powder-to-Ribbon Process", The Conference Record of the 171th IEEE Photovoltaic Specialists Conference, 1 May 1984, Kissimee, Florida, USA, pages 1382-1384

D3: US-A-3 953 876

II. In an interlocutory decision the present Board in a different composition stated that the application did not meet the requirements of Article 76(1) EPC 1973 1 and that it was considered as an important point of law whether a divisional application as originally filed not meeting the requirements of Article 76(1) EPC 1973 can be amended accordingly in the course of the examination procedure in order to meet these

requirements. The Board decided to refer this question to the Enlarged Board.

III. The case has been decided by the Enlarged Board in G 1/05 with the outcome that a divisional application extending at its filing date beyond the content of the parent application is nonetheless a valid application which may be amended later to bring it in conformity with Article 76(1) EPC 1973 1973.

IV. Taking into account the decision of the Enlarged Board the present Board continued the appeal proceedings by its communication dated 5 September 2007. The Board stated that the present divisional application should not only meet the requirements of Article 76(1) but also those of Article 123(2) EPC 1973 and should neither be extended beyond the content of the parent application nor of the divisional application as filed. Several extensions were discussed in detail.

V. With letter dated 14 March 2008 the appellant submitted an amended set of claims and provided arguments in support of it.

VI. In an annex to the summons to oral proceedings requested by the appellant the Board expressed its opinion that there was no support in the original documents for the minority carrier diffusion length being greater than 40 microns without the minimum grain size dimension being at least two times the minority carrier diffusion length, see divisional application as published, column 3, paragraph 0014, and column 9, lines 50 to 56, and parent application as published,

claim 7. For the discussion of novelty and inventive step the following documents were introduced:

D4: The Conference Record of the 19th IEEE Photovoltaic Specialists Conference 4 May 1987, New Orleans, Louisiana, US, pages 1486-1487, Harris et al. "The production of silicon layers on graphite for photovoltaic use"

D5: IEEE Electron Devices Letters, vol. 12, no. 8, August 1991, Law et al. "Self-consistent Model of Minority Carrier Lifetime, Diffusion Length, and Mobility"

VII. By letter dated 4 July 2008 the appellant filed an auxiliary request directed to claims amended by the inclusion of the above feature "the minimum grain size dimension being at least two times the minority carrier diffusion length".

VIII. In the oral proceedings on 5 July 2008, the appellant requested that the auxiliary request be the only request. Reference was made to the following documents filed by the applicant in the examination procedure and cited as "items".

Item 1: Two Figures designated as "Prior Art" and "Subject Invention"

Item 4: Article by Eyer et al

Item 6: Article by Norman et al. (The copy handed out at the oral proceedings was marked as "Item #7")

Item 7: Article by Sarms et al

Claim 1 under consideration reads as follows:

1. A silicon sheet having a major top surface and a major bottom surface, said sheet comprising columnar grains each having a columnar axis, characterized in that:
- said grains have an average grain size in the range of 100 to 1000 microns in extent;
- the columnar axes of said columnar grains in the sheet extend from the major top surface to the major bottom surface;
- said sheet has a thickness in the range of from 350 to 1000 microns; and
- the minority carrier diffusion length is greater than 40 microns and the minimum grain size dimension is at least two times the minority carrier diffusion length.

Reasons for the Decision

1. *Article 76(1) and 123(2) EPC 1973*

1.1 The range of the average grain size of 100 to 1000 microns specified in claim 1 is disclosed in identical formulation in the parent application, see e.g. A-publication, column 8, lines 41 to 45, and the present divisional application, see A-publication, column 8, lines 5 to 8. The range 350 to 1000 microns of the thickness of the sheet is indicated in the parent application at column 8, lines 24 to 26 and the

divisional application at column 7, lines 47 to 49. The last feature in claim 1, according to which the minority carrier diffusion length is greater than 40 microns and the minimum grain size dimension is at least two times the minority carrier diffusion length, is found in the parent application, column 3, lines 36 to 38, and the divisional application, column 3, lines 28 to 30.

1.2 Therefore it is evident that the subject-matter of claim 1 as amended does not extend beyond the content of the parent and divisional application as originally filed.

1.3 This is also true for the dependent claims:

Claim 2: see divisional application, column 7, lines 34 to 37 and parent application, column 8, lines 10 to 13;

Claim 3: see divisional application, column 7, lines 20 to 21 and parent application, column 7, lines 53 to 54;

Claim 4: see divisional application, original claim 8 and parent application, original claim 3;

Claim 5: see divisional application, original claim 11 and parent application, original claim 13.

2. *Article 52(1) EPC 1973*

2.1 Novelty

2.1.1 None of the documents cited discloses all features indicated in present claim 1.

2.1.2 D1, see the abstract, discloses silicon sheets, which are grown from powder by pressing and recrystallisation. The sheets are 300 to 1000 microns thick, see claim 8, and have a coarse structure of grains which have a size of about 500 microns, see column 5, lines 6 to 9. Even though sheet thickness and grain size fall within the claimed ranges, there is no disclosure of any columnar structure. From item 4, which has two authors in common with D1, it can be gathered from Figure 1 that, if grains were considered as columns, the axes of the columns would be in the sheet plane, i.e. parallel to the major top and bottom surfaces, and not perpendicular thereto. Moreover, the minority carrier diffusion length is neither mentioned in D1 nor in item 4.

2.1.3 In D2 silicon sheets ("ribbons") grown by a powder-to-ribbon process are described which are 300 microns thick and have elongated, columnar crystals 1-3 mm wide, see page 1382, right-hand column, first three lines. However, the consultation of document item 6 which is by the same authors and is like D2 related to a powder-to-ribbon electron-beam recrystallisation process, shows in Figure 2b) that the axes of the columnar grains extend generally in the moving direction of the zone melting, i.e. in the sheet plane, and not from the major top surface to the major bottom surface as is defined in present claim 1.

2.1.4 D3, see Figures 3 and 4 and column 7, lines 9 to 13, discloses a silicon sheet - the substrate 17 can be removed (see column 6, lines 16 to 21) - having columnar grains (crystallites) the diameter of which is

10 microns in average. This value is an order of magnitude smaller than the minimum of the average grain size defined in present claim 1. A sheet thickness of 150 microns can be derived from D3, which is also outside the claimed range of 350 to 1000 microns.

2.1.5 D4 describes silicon layers on graphite substrates. It was found that, when melted silicon solidifies on the substrate, the grain boundaries extend in a direction which is perpendicular to the interface between silicon and the substrate. Even if this were considered as a columnar structure, which is questionable in view of the mean grain size reported, i.e. "1.00 mm long by 3.1 mm wide", the structure in D4 is not a sheet as claimed, because the silicon layer is bound to the substrate.

2.1.6 D5, see Abstract, is related to a self-consistent model of the minority-carrier lifetime, diffusion length and mobility for bipolar devices in general. There is no specific disclosure of a silicon sheet in the meaning of present claim 1.

2.1.7 Therefore the silicon sheet according to present claim 1 is new over the prior art according to any of documents D1 to D5, cf. Article 54(1) and (2) EPC 1973.

2.2 Inventive step

2.2.1 In view of its low efficiency (below 1%) and the fragile structure of a sheet, which is only 150 microns thick, the sheet of D3 is not a practically usable device and therefore is unsuitable as closest prior art in spite of its columnar structure, the columns of

which are 10 microns in diameter, i.e. an order of magnitude lower than the minimum average grain size claimed.

2.2.2 Therefore, D2 is more suitable as closest prior art. The subject-matter of present claim 1 differs from this prior art in that the grains have an average grain size in the range of 100 to 1000 microns, the columnar axis of the columnar grains extending from the major top surface to the major bottom surface, whereas in D2 elongated, columnar grains are formed which are 1 to 3 mm wide and the axes of which extend in the plane of the sheet. The appellant pointed out that, in D2 the emphasis is put on larger grains having fewer boundaries, while in accordance with the present invention more effort is put on the grains having a columnar structure - ideally a hexagonal structure - avoiding boundaries et the ends of the columns, which form very narrow blade-type spaces as shown in item 6 or item 7, see Figure 1 in each document. These narrow spaces lower the minority carrier diffusion length limiting the efficiency of the sheet. In this context the appellant referred also to item 4, page 952, left-hand column, last sentence, to item 6, "Discussion" at page 1013, and to item 7, page 942, left-hand column, section "Growth Ambient", last sentence, all confirming the existence of a bias among experts towards larger grain sizes. Therefore the problem solved over D2 is related to the optimisation of crystal morphology and throughput.

2.2.3 From the analysis of the documents D1 to D5 made in connection with novelty above, it follows that there is no straightforward combination of D2 with any of

documents D1 and D3 to D5 leading a skilled person facing the mentioned problem to the subject-matter of present claim 1 in an obvious manner. Therefore this subject-matter involves an inventive step within the meaning of Article 56 EPC 1973.

2.3 Dependent claims

The dependent claims 2 to 5 are related to embodiments of the invention as defined in claim 1 and as such also meet the requirements of the EPC 1973.

2.4 Description

The description has been adapted to claim 1 as amended. Moreover, documents D1 to D3 are cited now in the introductory part of the description. Therefore the requirements of the EPC 1973 are met with respect to the description.

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 in the following version:

Description: Pages 1-3, 6-12, and 14-16 filed on 14 March 2008;
Pages 4, 5 and 13 filed during the oral proceedings on 9 July 2008;

Claims: Nos. 1-5 filed on 4 July 2008;

Drawings: 1 sheet as originally filed.

The Registrar: The Chairman:

M. Kiehl A. G. Klein