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Case Number: T 1638/10 - 3.4.03

Application Number: 00103474.3

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Language of the proceedings: EN

Title of invention:
Thin film photoelectric conversion module and method of manufacturing the same

Applicant:
Kaneka Corporation

Headword:

Relevant legal provisions:
EPC 1973 Art. 56

Keyword:
Inventive step (no)

Decisions cited:

Catchword:

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European Patent Office
D-80298 MUNICH
GERMANY
Tel. +49 (0) 89 2399-0
Fax +49 (0) 89 2399-4465

Case Number: T 1638/10 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 17 June 2014

Appellant: (Applicant)	Kaneka Corporation 2-3-18, Nakanoshima, Kita-ku, Osaka (JP)
Representative:	Vossius & Partner Siebertstrasse 4 81675 München (DE)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 4 March 2010 refusing European patent application No. 00103474.3 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	G. Eliasson
Members:	R. Bekkering
	T. Bokor

Summary of Facts and Submissions

I. The appeal is against the refusal of application no. 00 103 474 for lack of an inventive step, Article 56 EPC.

II. At oral proceedings before the board, the appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the following:

Claims 1 to 11 according to the sole request filed with the statement setting out the grounds of appeal.

III. Reference is made to the following document:

D2: Charles Gonzalez and Ronald G. Ross Jr.: "*Response of Amorphous Silicon Cells to Reverse Biasing*", Proc. International Conference on Stability of Amorphous Silicon Alloy Materials and Devices, Palo Alto, California, January 28-30 1987, pages 342 to 349,

IV. Claim 1 reads as follows:

"*A thin film photoelectric conversion module (1), characterized by comprising:*
a substrate (2);
a plurality of series-connected arrays (11) each including a plurality of thin film photoelectric conversion cells (10) formed on said substrate (2) and said plurality of thin film photoelectric conversion cells (10) being connected to each other in series; and
a pair of common electrodes (12, 12a, 12b) for connecting said plural series-connected arrays in parallel,

wherein the short-circuit current of said module (1) is not lower than 1A under conditions that a xenon lamp is used as a light source, irradiance is 100 mW/cm^2, air mass is 1.5, and temperature is 25°C, and the short-circuit current of each of said plural series-connected arrays (11) is not higher than 600 mA under the conditions."

V. The appellant submitted in substance the following arguments:

Document D2 was related to the issue of finding a hot-spot qualification test for amorphous silicon modules. The document mentioned to limit the cell size and thus the current for amorphous silicon modules by scribing a module into two or more parallel strings of smaller cells in some cases. However, according to D2 some considerations had to be made concerning the use of bypass diodes, smaller cell size and lateral heat transfer if testing the quality of such modules. Moreover, D2 referred to plots shown in figure 6 as being useful as guidelines for determining maximum cell size to limit hot-spot temperature to a given level, but this figure, as well as figure 5, failed to give any clear guidance in this respect. Accordingly, D2 did not provide any teaching how to manufacture an advantageous module and/or any characteristic features such a module may have.

Furthermore, even if the skilled person were to follow D2 in this respect, he would immediately know that laser scribing was difficult to perform without making short-circuit defects in the module and such scribing unfavourably reduced the light-receiving area of the solar cell.

Moreover, since document D2 was old, the skilled person would not have consulted it.

Accordingly, the subject-matter of claim 1 involved an inventive step.

Reasons for the Decision

1. The appeal is admissible.

2. *Novelty*

2.1 Document D2 (cited by the appellant) is concerned with the hot-spot susceptibility of photovoltaic modules.

According to D2, "*Since the degree of hot—spot heating is a function of the series—parallel configuration of the circuit in which the cell is located, there are circuit—design techniques that can be used, both in a module and in an array, to ameliorate the effects of the heating. In the past, the primary technique for crystalline silicon modules was the use of bypass diodes which limit the reverse-bias voltage. A more important technique for amorphous—silicon modules is that of limiting current by limiting cell size*" and "*Because hot-spot heating can also be controlled by reducing the available current, a promising approach to controlling hot-spot in an a-Si modules consists of limiting the cell size (and thus the current) by scribing a module into two or more parallel strings of smaller cells. Plots such as Figure 6 are useful as guidelines for determining maximum cell size to limit hot-spot temperature to a given level*" (cf page 342, fifth paragraph and page 348, first paragraph).

Accordingly, document D2 discloses, using the terminology of claim 1, a thin film photoelectric conversion module comprising a substrate, a plurality of ("*series-connected*") arrays ("*strings*") each including a plurality of thin film photoelectric conversion cells formed on said substrate and said plurality of thin film photoelectric conversion cells being connected to each other in series; and a pair of common electrodes for connecting said plural ("*series-connected*") arrays in parallel.

In particular, it is noted that the substrate and common electrodes are necessary for providing a functioning module and are therefore implicit for a skilled person from D2.

Claim 1 further defines that

- the short-circuit current of said module (1) is not lower than 1A under conditions that a xenon lamp is used as a light source, irradiance is 100 mW/cm^2, air mass is 1.5, and temperature is 25°C, and

- the short-circuit current of each of said plural series-connected arrays (11) is not higher than 600 mA under the conditions.

The above features are not known from document D2.

Accordingly, the subject-matter of claim 1 is new over document D2, Article 54(1) EPC 1973.

2.2 The subject-matter of claim 1 is also new over the remaining available, more remote prior art.

3. Inventive step

3.1 As noted above, a first distinguishing feature over document D2 is that the short-circuit current of the module is not lower than 1 A under conditions that a xenon lamp is used as a light source, irradiance is 100 mW/cm^2, air mass is 1.5, and temperature is 25 ^{o}C.

The light conditions claimed correspond to the common standard for simulated sunlight illumination.

As far as the current is concerned, according to the application, "*The above-noted effect produced by the second embodiment of the present invention is rendered particularly prominent under the conditions that the module 1 is heated to a high temperature when the hot spot phenomenon has taken place, i.e., in the case where the short-circuit current of the module 1 is large. It follows that the second embodiment is effective in the case where the short-circuit current of the module 1 under the conditions given above is not smaller than 1 A, particularly, not smaller than 1.2 A*" (page 20, lines 6 to 15).

The effect of the claimed minimum current value, thus, is that the module is one in which the current is such that hot-spot heating may occur.

Claim 1, moreover, defines that the short-circuit current of each of the arrays is not higher than 600 mA under the same standard sunlight illumination conditions above.

According to the application, "*In this case, the module 1 is not heated so much as to melt the metal back surface electrode layer 5 of the cell 10 even if the photoelectromotive force of any of the cells 10 is*

lowered to zero. Thus, the cell 10 is prevented from being broken" and *"It is desirable for the short-circuit current of the series-connected array 11 under the conditions given above to be not larger than 300 mA, preferably not larger than 200 mA. With decrease in the short-circuit current of the series-connected array 11, the cell 10 can be prevented from being broken more effectively*" (page 19, line 30 to page 20, line 5).

The maximum value for the short-circuit current of each array of 600 mA is, thus, selected based on a consideration of when a breakdown due to hot-spot heating may be expected.

Accordingly, the objective problem to be solved relative to document D2 may be formulated as finding suitable current values for the module and for each of the arrays in order to control hot-spots.

3.2 As noted above, the light conditions claimed correspond to the common standard for simulated sunlight illumination (also commonly referred to as Standard Test Conditions (STC) in the technical field of photovoltaic modules). The selection of these conditions would thus be obvious to a person skilled in the art, working in the field of photovoltaic modules at issue.

As far as the minimum current value is concerned, the selection of a suitable value would be straightforward for a person skilled in the art, as it can be easily verified whether the current is such that hot-spot heating may occur.

Also the selection of the maximum value for the short-circuit current of each array would be straightforward

for a person skilled in the art. Document D2, already points out that hot-spot heating may be prevented by limiting the current through the cells. Accordingly, the person skilled in the art would determine a suitable maximum value for this current with some straightforward experimentation, thereby arriving at the claimed value without the exercise of inventive skills.

3.3 The appellant argued that document D2 was related to the issue of finding a hot-spot qualification test for amorphous silicon modules. Document D2 mentioned to limit the cell size and thus the current for amorphous silicon modules by scribing a module into two or more parallel strings of smaller cells in some cases. However, D2 indicated that some considerations had to be made concerning the use of bypass diodes, smaller cell size and lateral heat transfer if testing the quality of such modules. Moreover, D2 referred to plots shown in figure 6 as being useful as guidelines for determining maximum cell size to limit hot-spot temperature to a given level, but this figure, as well as figure 5, failed to give any clear guidance in this respect. Accordingly, D2 did not provide any teaching how to manufacture an advantageous module and/or any characteristic features such a module may have.

Furthermore, even if the skilled person were to follow D2 in this respect, he would immediately know that laser scribing was difficult to perform without making short-circuit defects in the module and unfavourably reduced the light-receiving area of the solar cell.

Moreover, since document D2 was published about 12 years before the priority date of the application, it would not have been consulted by the skilled person.

3.4 In the board's opinion, however, it is clear that document D2, while being concerned with developing a hot-spot qualification test for amorphous silicon modules, is also concerned with providing guidelines for reducing module hot-spot susceptibility. In fact, according to D2 "*Recommendations are made on ways of reducing module hot-spot susceptibility including the traditional method of using bypass diodes and a method unique to thin-film cells, limiting the string current by limiting the cell areal size*" (cf page 342, "*Abstract*"). These recommendations are in fact provided in the chapter "*Recommendations and Conclusions*" (cf pages 347 and 348).

Contrary to what is argued by the appellant, these recommendations apply to how the modules should be built and not to how they should be tested. Clearly, all three approaches to reduce hot-spot susceptibility suggested in D2, the use of bypass diodes, limiting cells size and thus the current, and improve lateral heat transfer, are measures which are implemented when manufacturing the module.

According to D2, the use of diodes, indicated to be difficult to integrate into the monolithic structure of a-Si module circuits, should be traded off against reducing cell size to lower the current and also against improved lateral heat transfer to reduce the hot-spot temperature (cf page 348, first and third paragraph).

In the board's view, a person skilled in the art would however have no difficulty in dealing with such a trade-off, and depending on circumstances, decide for limiting cell size and current as suggested, where

appropriate. Moreover, contrary to what is argued by the appellant, plots such as figure 6 are considered to provide guidance to a person skilled in the art how to limit the cells size and current in order to reduce hot-spot susceptibility. Figure 6 is a plot of cell back-bias current versus hot-spot temperature for a number of modules from different manufacturers. Such a plot provides, for a given maximum acceptable cell temperature increase, guidance as to what the maximum current should be. Evidently, different plots result for different manufacturers of the modules, as different modules may heat differently. This is indeed also apparent from figure 5, also referred to by the appellant. Obviously, as would be readily understood by the skilled person from D2, such a plot would have to be produced for the module under consideration in order to determine the maximum current and thereby the maximum cell size so as to limit the hot-spot temperature to a given acceptable limit. As noted above, this is considered to be well within the abilities of the person skilled in the art.

Regarding the appellant's argument that the alleged known disadvantages of scribing would have kept the skilled person from applying the teaching of D2 to scribe the module into two or more parallel strings of smaller cells, it is noted that such scribing is in fact used in the application to form the series connected arrays (cf original application, paragraph bridging pages 35 and 36). Where the prior art suggests a particular measure, it cannot be convincingly argued that, since the skilled person would know that this measure has disadvantages, applying the measure would be inventive, if all the application does is applying this very measure. In this case, the underlying consideration merely is to accept any known

disadvantages, which does not involve inventive skills.

As to the question whether the skilled person would have consulted D2 at all, the board sees no reasons why a time span of just over ten years would have kept the skilled person from studying D2, as it specifically deals with recommendations on ways of reducing module hot-spot susceptibility and thus is clearly highly relevant.

3.5 Accordingly, the subject-matter of claim 1, having regard to the state of the art, is obvious to a person skilled in the art and, thus, lacks an inventive step in the sense of 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