Case Number: T 0766/92 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 14 May 1996

Appellant: SIEMENS SOLAR INDUSTRIES L.P.
4650 Adohr Lane
P.O. Box 6032
Camarillo, California 93010 (US)

Representative: Heckel, Dieter
Postfach 22 13 17
D-80503 München (DE)

Decision under appeal: **Decision of the Examining Division of the European Patent Office dated 11 March 1992 refusing European patent application No. 86 304 252.9 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: G. D. Paterson
Members: U. G. O. Himmler
Y. J. F. van Henden

Summary of Facts and Submissions

I. European patent application No. 86 304 252.9 was refused by a decision of the Examining Division on the ground that the claimed subject matter did not fulfil the requirement of inventive step according to Articles 52 and 56 EPC in view of the following prior art documents:

D1: Thin Solid Films, vol. 102, April 1983, no. 1, pages 1 to 46

D2: Thin Solid Films, vol. 111, January 1984, no. 2, pages 167 to 174

II. Independent claim 1, which formed the basis of the above decision, reads as follows:

"A device for generating an electric current on exposure to light, comprising a semiconductive layer capable of generating an electrical potential upon exposure to light and front and back contacts, characterised in that at least that the back contact comprises a transparent conductive layer comprising zinc oxide."

III. In its decision the Examining Division held essentially that both documents D1 and D2 suggest the use of zinc oxide (ZnO) as a transparent contact coating for solar cells, and that the claimed subject matter differs from the disclosure of document D1 or D2 only in that it is specified that **the back contact** comprises a ZnO layer. The Examining Division held that this difference did not imply any inventive

selection among the three possible contact locations: front contact, back contact or both front and back contact. Furthermore, the Examining Division considered that no inventive step could be seen in the corresponding independent method claim or in the dependent claims.

IV. The Appellant lodged an appeal against the decision and requested the grant of a patent based on an amended set of claims. Claim 1 had been amended to specify that both the contact layers were transparent, wherein at least one of said layers comprised ZnO having a resistivity of about 10^{-4} to 10^{-2} Ohm cm.

V. In a communication annexed to a summons to oral proceedings, the Rapporteur of the Board informed the Appellant that according to the Rapporteur's preliminary opinion the claimed subject matter did not involve any inventive step in view of documents D1 and D2 and the following additional documents:

D3: Applied Physics letters, vol. 41, no. 10, 1982, pages 958 to 960;

D4: US-A-3 507 706

D5: "Technik der Solarzelle" by G. Diaz-Santanilla, Franzis-Verlag München, 1984, pages 92 to 97;

D6: "Fundamentals of Solar Cells" by A.L. Fahrenbruch et al., Academic Press 1983, Chapter 9, pages 330 to 339.

The Rapporteur suggested essentially that document D2 constituted the closest prior art and disclosed a photovoltaic device with at least one transparent conductive contact comprising zinc oxide with a resistivity in the range of about 10^{-4} to 10^{-2} Ohm cm. Furthermore, it was pointed out that thin film semiconductors are common in the field of photovoltaic devices as disclosed by documents D5 and D6, and, moreover, that document D4 disclosed that it is known in the field to use transparent conductors on both sides of the semiconductor layer.

VI. During the oral proceedings which were held on 14 May 1996, the Appellant submitted two amended claims as main and auxiliary requests.

The claim of the main request reads:

"1. A device for generating an electrical current on exposure to light, comprising a thinfilm semiconductive layer capable of generating an electrical potential on exposure to light and front and back contacts, characterised in that both contacts comprise zinc oxide as a transparent conductive layer, having a resistivity in the range of about 10^{-4} to 10^{-2} Ohm cm and that the semiconductive layer comprises a thinfilm silicon layer."

The claim of the Auxiliary request reads:

"1. A device for generating an electrical current on exposure to light, comprising an amorphous thinfilm semiconductive layer capable of generating an electrical potential on exposure to light and front and back contacts,

characterised in that both contacts comprise zinc oxide as a transparent conductive layer, having a resistivity in the range of about 10^{-4} to 10^{-2} Ohm cm, further characterised in that the semiconductive layer comprises a thinfilm silicon layer, and further characterised in that the device is a solar cell having an efficiency of 7% or higher."

VII. In support of his requests, the Appellant argued essentially as follows:

(a) Document D2 does not describe any particular device in combination with zinc oxide contact layers. From document D2 can only be derived a comparison of the properties between zinc oxide and indium tin oxide. The result of such comparison would deter the skilled person from using zinc oxide as a contact layer due to its unstable properties with changing temperatures. There is no indication given in document D2 to use zinc oxide as a contact of a semiconductor device.

(b) Contrary to the present invention which refers to a photovoltaic device comprising an amorphous thin film semiconductor layer with transparent ZnO electrodes on the front and the backside, it is suggested in document D2 that ZnO may be used on **single crystal** silicon and because the production of electrode layers on a single crystal layer is always the last step in the production process, there is no further deteriorating influence on the stability of the contact layers, i.e. the zinc oxide layers.

(c) Document D2 also explains that ZnO may be disadvantageous as a transparent electrode, since its resistivity increases at high temperatures. Furthermore, in document D2 it is stated that ZnO may have less stable electrical properties than indium tin oxide (ITO). The skilled person would therefore be discouraged from using ZnO as a transparent electrode on a thin film semiconductor.

(d) Moreover, the applicant has found that it is advantageous to use ZnO both as a front and back contact because of its high light scattering effect, and there is no hint in any of the cited documents that ZnO can be used for both the front and back contacts. Additionally, it is surprising that the solar cell of the present invention shows an efficiency of 7% or higher.

In response to a question by the Board concerning the disclosure of a 7% efficiency of the particular device specified in claim 1 of the auxiliary request, the Appellant asserted that support for the feature of an efficiency of at least 7% in the auxiliary request can be found in the second paragraph on the originally filed page 10.

VIII. At the conclusion of the oral proceedings the decision was announced that the appeal is dismissed.

Reasons for the Decision

1. Admissibility of the amendments in Claim 1 of the main request:

The device according to claim 1 is based on the originally filed claim 1; it further incorporates the following additional features:

(a) it comprises a thin film semiconductive layer comprising silicon;

(b) both, the front **and** back contacts of the device, comprise zinc oxide as a transparent conductive layer.

The feature under point (a) has been disclosed in the originally filed description on page 3, line 26 and on page 4, line 32. The feature under (b) can be derived from the originally filed claim 10.

2. The only issue in the appeal proceedings is that of inventive step.

2.1 The subject-matter of claim 1 starts from document D2 as the closest prior art which discloses:

A device for generating an electric current on exposure to light, comprising a layer capable of generating an electrical potential upon exposure to light and front and back contacts (such a device is generally called a "photovoltaic device" as mentioned on page 167, paragraph "1.Introduction", line 2 of document D2), the device having a (at least one) contact which comprises a transparent

conductive layer comprising zinc oxide having a resistivity in the range of about 10^{-4} to 10^{-2} Ohm-cm; cf. page 167 the abstract of the article as well as the first paragraph "1.Introduction" of document D2.

Consequently, the subject-matter of Claim 1 differs from the prior art described in document D2 by the following features

(a) the layer capable of generating an electrical potential upon exposure to light comprises a "thin film **silicon semiconductor**"; and

(b) it is not explicitly said in document D2 that **"both"** contacts of the device may comprise zinc oxide as a transparent conductive layer.

2.2 According to the originally filed description (cf. page 2, lines 4 to 5 and page 3, lines 5 to 8) the above mentioned features are intended for solving the problem of creating an **inexpensive** photovoltaic device in comparison with known photoconductive and photovoltaic devices.

That in combination with photovoltaic devices the distinguishing features as set out under 2.1 are particularly useful for achieving the object of an inexpensive device had been known for feature (a) (cf. document D5, page 93, par. 4.5.2.1, last eight lines) as well as for the use of zinc oxide contacts as an inexpensive transparent conductive layer (cf. document D2, page 167, para. "1.INTRODUCTION", line 3).

Consequently, it was obvious for the skilled person to take into consideration materials like "thin film silicon semiconductor" or "transparent conductive contacts comprising zinc oxide" when trying to build a cheap photovoltaic device.

Moreover, the use of silicon thin film semiconductors in order to build a photovoltaic device had been described in textbooks like document D5 (cf. chapter 4.5.2, pages 92 to 97) or document D6 (cf. chapter 9, in particular Figure 9.4 and Table 9.1 on pages 334 to 339) at the time of the claimed priority.

Additionally it was known from document D4 that thin film photovoltaic cells can advantageously be contacted on **both** sides by a transparent conductive electrode; cf. column 3, lines 1 to 10 and 42 to 68.

Consequently, these distinguishing features have already been employed for the same purpose in a similar device, and therefore in the Board's judgment, it was obvious to a person skilled in the art, with the same result to be achieved, to apply these features with corresponding effect to the device known from document D2 and thus to arrive at the subject-matter according to claim 1.

2.3 The Board was not convinced by the arguments put forward by the Appellant:

(i) Even if there is not given a detailed description of the structure of a thin film semiconductive photovoltaic device in document D2, on which device

zinc oxide contacts are attached, it is clear from the whole article of D2 that zinc oxide contacts are suitable and useful as highly transparent inexpensive electrodes on such photovoltaic devices; cf. page 167, the first paragraph "1.Introduction" of document D2. As the structure of the semiconductive body of such a photovoltaic device formed part of the basic knowledge of a person skilled in the field of semiconductor devices, an invention cannot be seen in the semiconductive structure.

The Board agrees with the Appellant that a comparison can be derived from document D2 between zinc oxide and indium tin oxide. On the basis of this rather complete comparison of properties of each of both materials the skilled person is able to make his choice taking into account the advantages and disadvantages of both materials and balancing one against the other.

In the Board's view, the skilled person would not be deterred from using ZnO electrodes as a consequence of the instability at higher temperatures. In the present application it is disclosed that the ZnO may be sputtered at a temperature of about 25EC to 250EC and that ZnO(H) may be deposited at a temperature of 25EC to 90EC (paragraph bridging page 8 to 9), while the semiconductive layer is said to be applied at a temperature in the range of 150EC to 300EC. In document D2 it is explained (page 169, first paragraph, lines 6 and 7) that heat treatment of the ZnO layer up to about 250EC did not result in any

significant changes in the room temperature resistivity.

For these reasons the Board cannot follow the Appellant's arguments that the skilled person would be deterred from using zinc oxide as he knows in advance the advantages (high transparency, low resistivity, inexpensive) as well as the disadvantages (unstable resistance after heat treatment over about 250EC).

(ii) Also the advantages (of a high scattering effect of the zinc oxide layers and of the efficiency of the device of 7% or higher) put forward by the Appellant in support of the inventiveness of the subject-matter of the independent claims cannot be taken into account in favour of the decision on the merits of the case.

These advantages had originally not been disclosed in connection with the particular features of the device now claimed. As set out in decision **T 192/82** (OJ 1984, 415) the skilled person has to be free to employ the best means available for his purposes. In the present case the object of the invention originally had been to create an **inexpensive** device. For the achievement of this object there was a clear predetermined solution suggested by the state of the art as set out under 2.2. Therefore, the skilled person had not a choice from a multiplicity of possibilities but was in a "**one-way-street**" situation leading to the predictable advantage of low costs. At the same time this "one-way" solution included the

advantage of high scattering. This additional effect achieved inevitably by the skilled person on the basis of the obvious use of zinc oxide layers has to be considered as a "bonus" effect which cannot prove inventive step.

The above situation is different from the situation mentioned in the Guidelines for Examination, part C, chapter VI, no. 5.7a, last sentence, because the originally disclosed means to which the newly filed effect of high scattering is related do not involve an inventive step.

Further, any test results from comparative experiments have never been filed to support this argument.

3.5 For these reasons, in the Board's view, the subject matter of claim 1 according to the main request does not involve an inventive step within the meaning of Article 56 EPC.

4. *Auxiliary request:*

Claim 1 of the auxiliary request in comparison to claim 1 of the main request includes the additional features that the device has

- an **efficiency of 7% or higher** and that
- its thin film semiconductive silicon layer is **amorphous**.

4.1 The figure of 7% efficiency is only mentioned on page 10 in the originally filed application. It is there stated that due to the low resistance of the ZnO layers, the overall efficiency of the device is enhanced. The following sentence reads:

"For instance, solar cells having an efficiency of 7 percent or higher have been produced using the zinc oxide transparent conductive layers of this invention."

As the description of the application includes several alternatives of how to produce the photovoltaic device, including different materials, different thicknesses of the layers and different deposition temperatures, it cannot be derived from the originally filed documents that the 7% efficiency is obtained by a device with the specific features now claimed in claim 1 of the auxiliary request. The feature concerning the efficiency of at least 7% is therefore, in the Board's view, not originally disclosed in the context of the entirety of the features of the claim.

The amended claim therefore contains subject-matter extending beyond the content of the application as filed, and Article 123(2) EPC is therefore contravened.

4.2 Even if the unallowable feature of at least 7% efficiency had been cancelled, the claim would, in the Board's view, not have involved an inventive step.

Such an amended claim would have differed from claim 1 of the main request in that

(i) the device is a solar cell
(ii) the thin film layer is specified as being amorphous.

(i) The first item that the device is a solar cell is in principle not a particular feature of the device because any photovoltaic device generally can be used as a solar cell. In the context of the claim the technical function of this term is to give a reference to which spectral distribution of the incoming light the efficiency of 7% is related.

Therefore, the indication of this possible use of the claimed device is not per se a distinguishing feature over the state of the art.

(ii) The other feature that the thin film silicon layer is amorphous, was part of the general knowledge of a person skilled in the art at the priority date as it could be explicitly found in textbooks like document D5 (cf. page 93, chapter 4.5.2.1) or document D6 (cf. page 332, paragraph 1, lines 1 to 3 and paragraph 3, lines 1 to 5).

Therefore it would have been obvious to a person skilled in the art to use amorphous silicon in order to produce an inexpensive thin film photoconductive layer in a solar cell. Consequently, an admissibly amended claim 1 of the auxiliary request would not have involved an inventive step.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

M. Beer G. D. Paterson