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**Datasheet for the decision  
of 4 September 2025**

**Case Number:** T 2610/22 - 3.4.03

**Application Number:** 16182474.3

**Publication Number:** 3133650

**IPC:** H01L31/078, H01L31/18

**Language of the proceedings:** EN

**Title of invention:**

FOUR JUNCTION SOLAR CELL FOR SPACE APPLICATIONS

**Patent Proprietor:**

SolAero Technologies Corp.

**Opponent:**

AZUR SPACE Solar Power GmbH

**Relevant legal provisions:**

RPBA 2020 Art. 12(4), 12(6), 13(2)  
EPC Art. 56

**Keyword:**

Amendment to case - objection admissibly raised and maintained during first instance proceedings (no)

Late-filed evidence - should have been submitted in first-instance proceedings (yes) - circumstances of appeal case justify admittance (no)

Inventive step - (yes) - ex post facto analysis - non-obvious modification

**Decisions cited:**

T 2730/16



**Beschwerdekammern**

**Boards of Appeal**

**Chambres de recours**

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**Case Number: T 2610/22 - 3.4.03**

**D E C I S I O N**  
**of Technical Board of Appeal 3.4.03**  
**of 4 September 2025**

**Appellant:** AZUR SPACE Solar Power GmbH  
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**Representative:** Koch Müller  
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**Respondent:** SolAero Technologies Corp.  
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**Representative:** Rummler, Felix  
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**Decision under appeal:** Interlocutory decision of the Opposition  
Division of the European Patent Office posted on  
15 December 2022 concerning maintenance of the  
European Patent No. 3133650 in amended form.

**Composition of the Board:**

**Chairman** T. Häusser  
**Members:** J. Thomas  
E. Mille

## **Summary of Facts and Submissions**

- I. This is an appeal by the appellant - opponent (hereinafter, "the opponent") against the interlocutory decision of the opposition division that the European patent EP 3 133 650 B1 and the invention to which it related met the requirements of the EPC taking into account the amendments made by the patent proprietor during the opposition proceedings according to the then first auxiliary request.
- II. Grounds for the opposition were lack of novelty and lack of inventive step (Articles 100(a), 52(1), 54 and 56 EPC).
- III. At the end of the oral proceedings before the board the opponent requested that the decision under appeal be set aside and that the European patent be revoked.
- IV. The respondent - patent proprietor (hereinafter "the patent proprietor") requested at the end of the oral proceedings before the board that the appeal be dismissed (main request), i.e. that the patent be maintained in accordance with the impugned decision, or alternatively that the impugned decision be set aside and the case be remitted to the opposition division with the order to maintain the patent in amended form based on the set of claims of one of the first or second auxiliary requests filed with the reply to the statement setting out the grounds of appeal and corresponding respectively to the second auxiliary request and to the third auxiliary request filed with letter dated 18 August 2022 during the opposition proceedings.

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

D1: "*High efficiency four junction lattice matched solar cells for space applications: analysis of radiation hardness against 1 MeV electrons*", Campesato R. et al., 29th European Photovoltaic Solar Energy Conference and Exhibition, 22 to 26 September 2014, Amsterdam, Netherlands

D8: "*Investigations on  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  Solar Cells Grown by MOVPE*", Heckelmann S. et al., IEEE Journal of Photovoltaics, Vol. 5, No. 1, January 2015, pages 446 to 453

D17: US 6,660,928 B1

Reference 1: "*Chapter 7 - Gallium Indium Arsenide Phosphide ( $\text{Ga}_x\text{In}_{1-x}\text{As}_y\text{P}_{1-y}$ )*", Y. A. Goldberg and N. M. Shmidt, Handbook Series on Semiconductor Parameters (Vol. 2), World Scientific, Singapore, New Jersey, London, Hong Kong, 1996

Reference 2: "*Ortsaufgelöste Charakterisierung von Entmischungsphänomenen in  $\text{Ga}_x\text{In}_{1-x}\text{As}_y\text{P}_{1-y}$ -Halbleiter-Heteroschichten im Raster-Transmissionselektronenmikroskop*", C. Mendorf, Dissertation, Fachbereich Elektrotechnik der Gerhard-Mercator-Universität, Gesamthochschule Duisburg, 7. Dezember 2001

Reference 3: "*Strained  $\text{In}_{1-x}\text{Ga}_x\text{As}_y\text{P}_{1-y}/\text{InP}$  quantum well heterostructures grown by low-pressure metalorganic vapor phase epitaxy*", W. de Carvalho Jr et al., Materials Research, Vol. 2, No. 2, 49-57, 1999

VI. Claim 1 of the patent proprietor's main request has the following wording:

"A four junction solar cell comprising:  
an upper first solar subcell composed of indium gallium  
aluminum phosphide and having a first band gap;  
a second subcell adjacent to said first solar subcell  
including an emitter layer composed of indium  
gallium phosphide or aluminum gallium arsenide,  
and a base layer composed of aluminum gallium  
arsenide and having a second band gap smaller  
than the first band gap and being lattice matched  
with the upper first solar subcell;  
a third solar subcell adjacent to said second solar  
subcell and composed of indium gallium arsenide  
and having a third band gap smaller than the  
second band gap and being lattice matched with  
the second solar subcell; and  
a fourth solar subcell adjacent to said third solar  
subcell and composed of germanium and having a  
fourth band gap smaller than the third band gap,  
wherein the fourth subcell has a band gap of  
approximately 0.67 eV, and the second subcell has  
a band gap in the range of 1.65 to 1.8 eV,  
**characterized in that** the upper first subcell  
has a band gap in the range of 2.0 to 2.15 eV and  
the third subcell has a band gap of  
approximately 1.41 eV, wherein the average band  
gap of all four subcells, namely the sum of the  
four band gaps of each subcell divided by four is  
greater than 1.44 eV."

VII. The opponent's arguments, insofar as they are relevant to the present decision, are summarised as follows:

Documents "reference 1", "reference 2" and "reference 3" should be admitted into the proceedings since they substantiate that quaternary substances were difficult to produce in solar cell. The search to find

these documents was time-consuming and cumbersome, which was the reason why these documents were not submitted earlier in the proceedings. The objections of lack of inventive step with document D1 as starting point and with document D17 as starting point in combination with document D1 should be admitted into the proceedings, since document D1 was part of the proceedings from the very beginning of the opposition proceedings.

Concerning the objection of lack of inventive step starting from document D17 in combination with document D8, the problem should be formulated differently in view of the differentiating features. The combination of documents D17 with D8 led the skilled person in an obvious manner to the subject-matter of claim 1.

VIII. The patent proprietor's arguments, insofar as they are relevant to the present decision, are summarised as follows:

Documents "*reference 1*", "*reference 2*" and "*reference 3*" were an amendment to the case according to Article 13(2) RPBA and should not be admitted into the proceedings as no exceptional circumstances were indicated. The objections of lack of inventive step starting with document D1 and starting with document D17 in combination with document D1 should not be admitted into the proceedings under Article 12(4) and (6) RPBA since they were not part of the impugned decision and therefore represented an amendment to the case. Also for these lines of arguments the opponent did not provide any justification for the late filing. With regard to the objection of lack of inventive step based on documents D17 and D8, no new technical problem needed to be formulated. Moreover, when starting from document D17, there was no indication which parameter

should be modified and the selection to modify the substances of the base layer and the emitter layer of the second subcell was based on hindsight. The combination of the teachings of documents D17 and D8 was not obvious and did not lead the skilled person to the claimed subject-matter.

### **Reasons for the Decision**

1. Admittance of documents "reference 1", "reference 2" and "reference 3"
- 1.1 Documents "reference 1", "reference 2" and "reference 3" were filed with the opponent's letter dated 28 July 2025, i.e. more than five months after the communication under Article 15(1) RPBA had been issued and about one month prior to the oral proceedings before the board.
- 1.2 According to Article 13(2) RPBA, *"[a]ny amendment to a party's appeal case made after ... notification of a communication under Article 15, paragraph 1, shall, in principle, not be taken into account unless there are exceptional circumstances, which have been justified with cogent reasons by the party concerned"*.
- 1.3 Documents "reference 1" to "reference 3" therefore constitute an amendment to the opponent's appeal case.
- 1.4 In the opponent's view, these documents demonstrated that the skilled person was aware that ternary substances were easier to produce and more stable than quaternary substances. This made replacing the quaternary substance in the second subcell with a ternary substance obvious to the skilled person.



- 1.5 The board is not convinced that these documents demonstrate the skilled person's common general knowledge or that they merely support arguments already put forward by the opponent which could not be provided earlier.
- 1.5.1 The opponent had already put forward this line of argument of exchanging the quaternary substance by a ternary substance during the first instance proceedings (see Reasons for the decision, point 3.3.4 and the minutes of the oral proceedings before the opposition division, point 20), but did not provide any written proof of this allegation at that time. Therefore, the allegation relating to the replacement of the quaternary substance by a ternary substance was already discussed during the opposition proceedings. However, written evidence proving allegations should be submitted as early as possible. Therefore, the search for documents "reference 1" to "reference 3" could and should have been carried out at the latest shortly after the oral proceedings before the opposition division, hence prior to the appeal proceedings. The three documents could and should then have been submitted with the statement setting out the grounds of appeal.
- 1.5.2 These documents cannot be regarded as evidence of the skilled person's common general knowledge, either. They go far beyond to what is normally considered to be part of the common general knowledge (*Case Law of the Boards of Appeal of the EPO*, 11th edition 2025, section I.C.2.8.3). In the board's view "reference 1" relates to a handbook compiling a plurality of scientific articles. The selection of a specific article dealing with a substance defined in claim 1 cannot be regarded

as common general knowledge but is rather based on hindsight. Similarly, the dissertation "*reference 2*" dealing with the particular substance is a technical teaching going far beyond the common general knowledge. Dissertations are normally focused on new research and should, at least in the case at hand, not be used for indicating common general knowledge since they report on a rather specific technical development. Finally, the research article "*reference 3*" relates to a very specific technical teaching which should not be considered to represent the common general knowledge of the skilled person.

Moreover, it cannot convincingly be said - as argued by the opponent - that the skilled person in the present case is represented by a highly informed technical specialist working in MOVPE (metal-organic vapour phase epitaxy) with more than five years of detailed research experience and having as its active knowledge all technical research articles carried out in the very specialised field of MOVPE. In the board's view, in the case at hand, the technically skilled person is the expert in the field of solar cells and their production but not the high-end specialist with long-term experience of the very narrow field of MOVPE.

Finally, as an aside, the board is of the opinion that the fact that the search to find these documents was so time-consuming and cumbersome as alleged by the opponent, is already a strong indication that the outcome of the search is not representative of the skilled person's common general knowledge, which should in general not be difficult to be proven.

- 1.5.3 Therefore, the documents "*reference 1*" to "*reference 3*" go far beyond the common general knowledge and could

and should have been provided during the first-instance proceedings or at the latest with the statement setting out the grounds of appeal. They are an amendment to the case and their admission requires exceptional circumstances. However, no exceptional circumstances were presented, and the board cannot see any, either.

- 1.6 Therefore, according to Article 13(2) RPBA, the documents "*reference 1*", "*reference 2*" and "*reference 3*" are not admitted into the proceedings.
2. Admittance of the line of argument of lack of inventive step with document D1 as starting point
  - 2.1 In its statement setting out the grounds of appeal, the opponent argued lack of inventive step with document D1 as starting point, a line of argument which was not dealt with in the decision underlying the appeal. Also, according to the minutes, this line of argument was not discussed during the oral proceedings before the opposition division.
  - 2.2 Document D1 was part of the proceedings from the beginning of the examination proceedings. It was mentioned in the European Search Report as a document particularly relevant if taken alone and was discussed in detail during the examination phase. In the notice of opposition, the opponent presented the differences between the subject-matter of the impugned patent and document D1 (notice of opposition, page 15, second paragraph to page 19, fourth paragraph).
  - 2.3 During the oral proceedings before the opposition division, no objection of lack of inventive step starting from document D1 was argued by the opponent although the chairman of the opposition division asked

the parties repeatedly if they had "*something to add*" (see Minutes, points 24, 35 and 39).

- 2.4 Not discussing this line of argument during the oral proceedings before the opposition division although it was previously discussed in writing is considered as an abandonment of this line of argument. Hence, the opponent did not maintain this objection during the oral proceedings before the opposition division by at least referring to the written proceedings with document D1 as starting point for the inventive step attack. Similar to T2730/16, point 4.2, the board considers that the appellant's silence as to the objection of lack of inventive step starting from document D1 during the oral proceedings before the opposition division must be regarded as a deliberate abandonment of this objection. Therefore, this line of argument (lack of inventive step with document D1 as starting point) has not been "*admissibly raised and maintained in the proceedings leading to the decision under appeal*" (see Article 12(4) RPBA; underlining by the board).
- 2.5 According to Article 12(6) RPBA, "*objections ... which were no longer maintained, in the proceedings leading to the decision under appeal, [shall not be admitted] unless the circumstances of the appeal case justify their admittance*".
- 2.5.1 The opponent argued that one reason for not pursuing this line of argument in the oral proceedings before the opposition division was the uncomfortable format of the oral proceedings in opposition, namely the videoconference, which rendered the interaction with the opposition division cumbersome. In the opponent's

view, further objections are sometimes overseen in a videoconference, as it was the case here.

2.5.2 In addition, the opponent argued that this line of argument was brought forward again during appeal due to the fact that the board indicated in the communication under Article 15(1) RPBA a different interpretation of the term "*approximately*". Based thereon, the differences of the band gaps between the subject-matter of claim 1 and document D1 were considered differently by the board than by the opposition division, so that document D1 became again more relevant. Therefore, the appellant considered that the subject-matter of claim 1 might now even be considered not new over document D1.

2.5.3 The board cannot accept the appellant's reasoning as indicating circumstances which could justify the reintroduction of the abandoned line of argument into the proceedings for the following reasons.

Firstly, whether a videoconference is comparable or not with in-person oral proceedings might be disputable, but this format certainly does not hinder a party to present all attacks it wishes to be considered by the opposition division (or the board). There is no convincing reason linked to the format of the oral proceedings which could have hindered the opponent to present all attacks of inventive step it considered convincing, the attack of lack of inventive step with document D1 as starting point included.

Secondly, the opponent alone must decide which attacks it considers promising or whether and when it will drop an objection it has raised previously in the proceedings. The abandonment of the objection of lack of inventive step with document D1 as starting point

during the oral proceedings before the opposition division and its reintroduction in the appeal proceedings cannot be justified by a slightly different interpretation of the term "*approximately*" by the board in it's communication under Article 15(1) RPBA, point 8.2.3 compared to the opposition division's view. This is particularly true given that this issue had already been discussed during the first instance proceedings in relation to the different band gap values (e.g. communication from the examining division of 14 June 2018, in particular page 2, paragraph 2). Therefore, in the present case, a slightly different interpretation of terms or situations by the board compared to the opposition division cannot open the door for the reintroduction of an abandoned line of argument. The decision on which line of argument might be successful and should therefore be presented lies exclusively within the opponent's control and should not be influenced by the different viewpoints of the various panels (examining division, opposition division and board of appeal).

- 2.6 Therefore, the line of argument of lack of inventive step using document D1 as starting point is not admitted into the proceedings (Article 12(4) and (6) RPBA).
- 3. Admittance of the line of argument of lack of inventive step with document D17 as starting point in combination with document D1
  - 3.1 The opponent argued in the statement setting out the grounds of appeal lack of inventive step starting from document D17 in combination with document D1. This line of argument was, according to the minutes, not discussed during the oral proceedings before the

opposition division and was also not dealt with in the opposition division's decision.

3.2 The opponent reasoned with the same arguments as for the line of argument with document D1 as starting point for arguing inventive step (see points 2.5.1 and 2.5.2 above).

3.3 Hence, *mutatis mutandis* this line of argument was not part of the impugned decision and therefore constitutes an amendment to the appeal case (Article 12(4) RPBA). It was not "*admissibly raised and maintained*" during the first-instance proceedings although both documents D17 and D1 were known. Therefore, the board cannot see any circumstances which could justify the admission of this new line of argument into the proceedings only at appeal.

3.4 For the same reasons as the ones considered under point 2. with sub-points above, the line of argument of lack of inventive step starting from document D17 in combination with document D1 is not admitted into the proceedings (Article 12(4) and (6) RPBA).

4. Main request - inventive step based on document D17 in combination with document D8

4.1 Closest prior art

4.1.1 Document D17 is a suitable closest prior art, because it discloses a multi-junction photovoltaic solar cell, including a four-junction photoelectric cell. This is undisputed.

4.1.2 In the wording of claim 1 (in the following paragraph the references in parentheses refer to document D17;

struck-through features are not disclosed in document D17; numbers with prefix "M" are added by the board and concern the feature numbering, other numbers refer to reference signs of document D17), document D17 discloses

- (M1.1) a four junction solar cell (column 3, lines 44 to 49; column 7, lines 25 to 26; Figure 2) comprising:
- (M1.2) an upper first solar subcell (90) composed of indium gallium aluminum phosphide (93) and having a first band gap;
- (M1.3) a second subcell (80) adjacent to said first solar subcell including an emitter layer ~~composed of indium gallium phosphide or aluminum gallium arsenide~~, and a base layer ~~composed of aluminum gallium arsenide~~ and having a second band gap smaller than the first band gap (column 7, lines 42 to 52) and being lattice matched with the upper first solar subcell (column 7, line 27 to 31);
- (M1.4) a third solar subcell (70) adjacent to said second solar subcell and composed of indium gallium arsenide (72, 73) and having a third band gap smaller than the second band gap (column 7, line 37 to 47) and being lattice matched with the second solar subcell (column 7, line 27 to 31); and
- (M1.5) a fourth solar subcell (60) adjacent to said third solar subcell and composed of germanium (61, 62) and having a fourth band gap smaller than the third band gap (column 7, line 32 to 42), wherein
- (M1.6) the fourth subcell has a band gap of approximately 0.67 eV (column 7, line 32 to 36), and



(M1.7) the second subcell has a band gap in the range of 1.65 to 1.8 eV (column 7, line 42 to 46), characterized in that

(M1.8) the upper first subcell has a band gap in the range of 2.0 to 2.15 eV (column 7, line 48 to 52) and

(M1.9) the third subcell has a band gap of approximately 1.41 eV (column 7, line 37 to 41), wherein

(M1.10) the average band gap of all four subcells, namely the sum of the four band gaps of each subcell divided by four is greater than 1.44 eV (taking the sum of all higher end values of the four indicated gap ranges divided by four, a value of 1,55 eV is obtained).

4.1.3 The patent proprietor was of the opinion that document D17 did not disclose the band gaps of the first to fourth subcells as defined in claim 1. However, the board is of the opinion that they are disclosed as indicated above.

## 4.2 Differentiating features

4.2.1 The substances used for the base layer and the emitter layer of the second subcell represent differentiating features.

4.2.2 According to claim 1, the "*base layer [is] composed of aluminum gallium arsenide*" and the "*emitter layer [is] composed of indium gallium phosphide or aluminum gallium arsenide*", whereas in document D17 the corresponding second subcell 80 (named "top-middle subcell" in D17) discloses an emitter layer 83 and base layer 82, both of which consist of "*indium gallium*

*arsenide phosphide*" (InGaAsP) (Figure 2 and column 8, line 58 to 61).

- 4.2.3 It is undisputed that these features are not disclosed in D17.
- 4.3 Objective technical problem to be solved
  - 4.3.1 In the statement setting out the grounds of appeal, page 5, first line, the opponent formulated the objective technical problem solved by the differentiating features as an "*increase in efficiency*". This is in agreement with the technical problem formulated in the impugned decision. During the oral proceedings before the board, the opponent argued without further proof that the differentiating features did not solve this problem since they did not lead to an increase in efficiency. In its view, the real problem was the mass-production manufacturability of the solar cell. The solar cell described in document D17 was allegedly not suitable for mass production due to the use of quaternary substances in the second subcell. Hence, the opponent redefined the technical problem as providing a four-junction solar cell made from substances suitable for mass production.
  - 4.3.2 The patent proprietor argued that the objective technical problem discussed in the impugned patent was the producibility and increased efficiency of the solar cell of claim 1. In its view, the opponent had not convincingly demonstrated why the objective technical problem had to be reformulated. The technical problem solved by the differentiating features was correctly formulated as an increase in efficiency of the solar cell of claim 1 (see impugned patent, column 8, line 20

to column 9, line 10 and paragraphs [0008] to [0010]) as already indicated in the impugned patent.

4.3.3 The board agrees with the patent proprietor that the opponent had not convincingly demonstrated that the efficiency of the solar cell of claim 1 has not been increased, contrary to the disclosure of the impugned patent. Therefore, the board cannot see any reason to reformulate the objective technical problem as discussed in the impugned patent and also considered by the opposition division. Therefore, the objective technical problem solved by the differentiating features is the increase in efficiency of the solar cell of claim 1.

#### 4.4 Non-obviousness

4.4.1 The skilled person wishing to improve the efficiency of the solar cell known from document D17, Figure 2, could alter many parameters. Document D17 does not provide any indication as to which parameter in which subcell to modify. There is no obvious indication that the substances in the second subcell might cause manufacturing difficulties or that changing it might increase efficiency. This question was explicitly discussed in the impugned decision and the opponent did not provide any convincing argument why it should be obvious for the skilled person to replace precisely the (quaternary) substance of the second subcell rather than to change any other parameter or substance of the solar cell known from document D17 apart from the skilled person's alleged preference for ternary substances over quaternary substances.

The board is not convinced that the skilled person would necessarily avoid the use of quaternary

substances. For example, in document D8 a four- and five-junction solar cell including a quaternary substance is proposed (D8, page 446, right-hand column, lines 8 to 11) and document D17 does not discuss any difficulty in relation with the producibility due to the quaternary substance.

Therefore, the opponent has not convincingly demonstrated why modifying the quaternary substances of the second subcell should be obvious to the skilled person, which is considered not obvious and any argumentation in this regard is based on hindsight.

Therefore, already at this point it can be concluded that the subject-matter defined in claim 1 is inventive when starting from document D17 since the choice of modifying the (quaternary) substances of the base layer and the emitter of the second subcell is inventive.

- 4.4.2 Even if the skilled person were to decide to replace the quaternary substance of the second subcell it would not arrive at the subject-matter of claim 1 in an obvious and straightforward manner when considering the combination of documents D17 and D8 for the following reasons.

Document D8 discusses the suitability of AsGaAs in general as an emitter and base layer in solar cells. This rather general teaching of using AsGaAs in a solar cell is however not a clear hint to replace the substances of precisely the second subcell of the four-junction heterojunction solar cell of document D17 by AsGaAs. Moreover, a four-junction space solar cell is, in document D8, mentioned for AsGaInAs (D8, page 446, right-hand column, lines 8 to 11). Therefore, document

D8 does not contain any hint to replace the substances of the second subcell of document D17 by AsGaAs.

- 4.5 Thus, the subject-matter of claim 1, the only independent claim of this request, involves an inventive step when starting from document D17 and combining it with the teaching of document D8.

Since this is the only objection raised in an admissible manner with regard to inventive step, the requirements of the EPC, in particular of Articles 52(1) and 56 EPC, are fulfilled.

5. Conclusion

The board concludes that the patent proprietor's main request fulfils the requirements of the EPC. The appeal must therefore fail.

## Order

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

The appeal is dismissed.

The Registrar:

The Chairman:



S. Sánchez Chiquero

T. Häusser

Decision electronically authenticated