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Datasheet for the decision of 2 July 2026

Case Number: T 0991/24 - 3.4.03

Application Number: 17772017.4

Publication Number: 3685450

IPC: H01L21/02, H01L33/12, H01L29/205

Language of the proceedings: EN

Title of invention:
SEMICONDUCTOR MULTILAYER STRUCTURE

Applicant:
Tampere University Foundation sr

Headword:

Relevant legal provisions:
EPC Art. 56, 123(2)

Keyword:
Inventive step - main request and auxiliary requests 1 -3 (no)
Amendments - extension beyond the content of the application as filed - auxiliary requests 4-5 (yes)

Decisions cited:

This datasheet is not part of the Decision
It can be changed at any time and without notice

Catchword:

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Case Number: T 0991/24 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 2 July 2026

Appellant: (Applicant)	Tampere University Foundation sr c/o Tampere University Kalevantie 4 33100 Tampere (FI)
Representative:	WSL Patentanwälte Partnerschaft mbB Kaiser-Friedrich-Ring 98 65185 Wiesbaden (DE)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted/electronically transmitted on 20 March 2024 refusing European patent application No. 17772017.4 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chair	T. Bokor
Members:	M. Papastefanou
	M. Ley

Summary of Facts and Submissions

I. The appeal is against the decision of the examining division refusing European patent application No. 17 772 017 (published as international application WO 2019/052672 A1).

II. In the decision under appeal, the examining division came to the conclusion that the main request and auxiliary requests 2 and 4 contained added subject-matter, while auxiliary requests 1 and 3 did not involve an inventive step. Auxiliary request 4bis, filed during the oral proceedings, was not admitted into the proceedings because it *prima facie* lacked clarity.

III. Reference is made to document

D2: US 2017/0033261 A1.

IV. At the end of the oral proceedings before the board the appellant's main request was that the decision under appeal be set aside and a patent be granted according to the main request. As an auxiliary measure, the appellant requested that a patent be granted on the basis of one of auxiliary requests 1, 4bis, 2, 3, 4 or 5 in that order. All the requests were filed with the statement of grounds of appeal and correspond to the respective requests underlying the impugned decision. It is noted that the examining division had considered that auxiliary request 5 met the requirements of the EPC and had issued a communication under Rule 71(3) EPC with an intention to grant a patent on that basis. The appellant (then applicant), however, did not accept it

and maintained its higher ranking requests.

V. Claim 1 of the main request has the following wording (emphasis in bold by the board):

Semiconductor device (1, 10, 20, 30, 40, 50, 60) comprising
a substrate (5, 7, 17) including a layer (2, 24) made of Ge and
a semiconductor multilayer structure (3, 4, 9, 11, 19, 23) including
at least one first layer, and
at least one second layer consisting of a material chosen from a group consisting of GaInAsNSb, GaInAsN, AlGaInAsNSb, AlGaInAsN, GaAs, GaInAs, GaInAsSb, GaInNSb, GaInP, GaInPNSb, GaInPSb, GaInPN, AlInP, AlInPNSb, AlInPN, AlInPSb, AlGaInP, AlGaInPNSb, AlGaInPN, AlGaInPSb, GaInAsP, GaInAsPNSb, GaInAsPN, GaInAsPSb, GaAsP, GaAsPNSb, GaAsPN, GaAsPSb AlGaInAs and AlGaAs, wherein for any material a sum of the contents of all group-III elements equals 1 and a sum of the contents of all group-V elements equals 1,
wherein the semiconductor multilayer structure (3, 4, 9, 11) is grown on the Ge layer (2, 24) of the substrate (5, 7, 17),
characterized in that
the at least one first layer consists of a material selected from a group consisting of
$Al_xGa_{1-x}As$, wherein x is approximately 0.6,
$Al_xGa_{1-x-y}In_yAs$, wherein $0<x\leq0.6$ and $0<y\leq0.02$,
$Al_xGa_{1-x-y}In_yAs_{1-z}P_z$, $Al_xGa_{1-x-y}In_yAs_{1-z}N_z$, and $Al_xGa_{1-x-y}In_yAs_{1-z-c}N_zP_c$, wherein $0<x\leq1$, $0<y\leq1$, $0<z\leq0.3$, and $0<c\leq1$,
$Al_xGa_{1-x-y}In_yAs_{1-z-c}N_zSb_c$, wherein $0<x\leq1$, $0<y\leq1$, $0<z\leq0.3$, and $0<c\leq0.7$, and

$Al_xGa_{1-x-y}In_yAs_{1-z-c}P_zSb_c$, wherein $0<x\leq1$, $0<y\leq1$, $0<z\leq1$, and $0<c\leq0.3$,
wherein for any material a sum of the contents of all group-III elements equals 1 and a sum of the contents of all group-V elements equals 1
wherein one or more of the at least one first layer of the semiconductor multilayer structure (3, 4, 9, 11, 19, 23) has a lattice constant, which differs from the lattice constant of the Ge layer (2, 24) of the substrate (5, 7, 17) by less than the difference between the lattice constant of GaAs and the lattice constant of Ge.

VI. Claim 1 of each of **auxiliary requests 1, 2 and 3** differs from claim 1 of the main request in that the material choices for the first layer are more limited with respect to claim 1 of the main request. However, the choice of $Al_xGa_{1-x-y}In_yAs$, wherein $0<x\leq0.6$ and $0<y\leq0.02$ (**bold** in claim 1 of the main request above) is still included among the available choices.

VII. Claim 1 of **auxiliary request 4bis** defines the same choices for the material of first layer(s) as claim 1 of the main request.

VIII. Claim 1 of **auxiliary requests 4 and 5** differs from claim 1 of the main request in that the selection of the material for the first layer has been limited to $Al_xGa_{1-x-y}In_yAs_{1-z-c}N_zP_c$, wherein $0.6\leq x$, $0<y\leq0.002$, $0\leq z\leq0.3$, and $0\leq c\leq1$.

IX. The appellant argued essentially that the addition of indium in the AlGaAs layer was a purposive choice and not arbitrary. Indium improved the lattice matching of the first layer to the Ge substrate. Starting from D2

the addition of indium in the first layer was not obvious for the skilled person.

Reasons for the Decision

The claimed invention

1. The application relates to a semiconductor multilayer structure comprising a substrate, at least one inactive layer and at least one active layer. It is known that such structures with inactive layers of a GaAs-based material are advantageous for the fabrication of optoelectronic devices and fast transistors (see page 1, lines 26 to 32).

2. When such structures with inactive layers based on an AlGaAs material are fabricated on GaAs substrates, the AlGaAs layers are not lattice-matched to the GaAs substrate and build up strain in the structure. The strain increases with increasing layer thicknesses. This strain has a negative effect on the lifetime of the optoelectronic components, which is dependent on the total strain in the structure (see page 1, line 34 to page 2, line 5).

3. The invention aims at reducing or completely avoiding such a strain by reducing the lattice mismatch between the layers. For this purpose a Ge, Si or SiGe substrate is used and for the inactive and active layers specific (groups of) materials are selected (see page 2, line 31 to page 3, line 6). Moreover, the inactive layers are selected such that at least one inactive layer has a lattice constant, which differs from the lattice constant of the Ge layer of the substrate by less than the difference between the lattice constant of GaAs and

the lattice constant of Ge (page 4, lines 7 to 10).

4. It is noted that the claims define "first" and "second" layers, without specifying active and inactive layers.

Main request, inventive step (Articles 52(1) and 56 EPC)

5. In its preliminary opinion the board did not share the examining division's conclusion regarding added subject-matter in claim 1 of the main request. Consequently, inventive step was the main issue to be discussed. The examining division had discussed inventive step in the context of claim 1 auxiliary request 1, which includes the same alternative selections for the materials of the first layer(s).

6. It is common ground that D2 discloses all the features of claim 1 except the materials for the first layer(s), which correspond to the inactive layer(s) of D2.

7. D2 discloses two examples of materials for the inactive layer, namely $Al_{0.2}Ga_{0.8}As$ and $Al_{0.1}Ga_{0.9}As$ (see paragraphs [0023] and [0029]).

8. According to the definitions in claim 1 of the main request, the first layers consist of AlGaAs when x is approximately 0,6 (see first choice in the corresponding list in point V. above). When x=0,1 or x=0,2 (as in the examples of D2), the first layers consist of materials comprising additional elements. The first layer composition closest to the disclosure of D2 is AlGaInAs (see second choice in the list in point V., marked in bold by the board).

9. Consequently, the first layers consisting of $Al_xGa_{1-x-y}In_yAs$ (with $0<x\leq 0.6$ and $0<y\leq 0.02$) according to

claim 1 of the main request differ from those of D2 only in that they also contain In (indium). This was undisputed by the appellant.

10. The contested points related to the questions of what technical effect indium achieved and whether or not adding indium in the inactive layer of D2 consisting of AlGaAs would be inventive in the context of the present application.

11. The appellant argued that indium had two relevant technical effects in the present context.

- Firstly, it increased the critical thickness of the AlGaInAs layer by enhancing the layer's ability to tolerate a greater degree of strain before misfit dislocations or other crystal defects occurred. As the appellant explained, the critical thickness of the first layer referred to the maximum thickness the first layer could achieve before significant dislocation or defect formation occurred due to lattice mismatch.

- Secondly, it reduced the lattice mismatch itself, and so reducing the strain caused by that lattice mismatch. This reduction of the lattice mismatch also contributed to an increase of the critical thickness of the layer. This was the primary mechanism contributing to the increase of the critical thickness of the alloy.

The technical contribution of indium was, therefore, not limited to improving the layer's tolerance to an already existing mismatch. Rather, indium acted at two levels: it primarily reduced the origin of the strain by improving the lattice match to the Ge layer, and

secondly, it improved the ability of the first layer to accommodate any remaining residual strain without defect formation, such as disclocations.

12. According to the appellant, starting from D2, the skilled person would have faced the technical problem of how to improve the lattice matching between the Ge substrate and the first (inactive) layer(s). Since D2 did not provide any hints or suggestions about adding indium to the AlGaAs layer to improve the lattice matching, the subject-matter of claim 1 of the main request involved an inventive step.

13. The board does not accept the appellant's argument.

14. The board does not dispute that adding indium would improve the lattice matching of an AlGaAs-based layer to a Ge substrate. However, the board notes that there is no relevant disclosure or suggestion in the application explaining this effect of adding indium. There is only one example in the application mentioning reducing the lattice constant of the AlGaAs-based material of the first (inactive) layer. This relates to a layer consisting of AlGaInAsNP, where the quantities of N and P are adjusted to reach the desired lattice constant which is smaller than the one of Ge and larger than that of the strain compensation layer 8 (see page 8, lines 22 to 26). There is no mention of any specific role that indium might play in this example.

15. In addition, the board notes that the application is not only completely silent about the role of indium in the lattice matching, but could also be understood to imply that the presence of indium is not even necessary. There are several instances in the application where $Al_xGa_{1-x-y}In_yAs$ is defined as the

material for the first layer when x is between 0 and 0.6 (as in claim 1 of the main request). In six of them the value of y is set within the range $0 \leq y \leq 0.02$ (i.e. the value y=0 is also included, meaning that indium is not indispensable); see page 1, lines 11 and 12, page 2, line 33, page 3, lines 33 and 34, page 7, lines 6 and 7, and original claims 1 and 3. At the same time, there are two instances, where the value y=0 is excluded (i.e. $0 < y \leq 0.02$; indicating that the presence of indium is necessary), see page 3, line 25 and page 3, last line going to page 4. There is no indication or suggestion in the application as to what might be the conditions that might require the presence of indium in the $Al_xGa_{1-x-y}In_yAs$ layer or what difference its presence or absence might make. The board, therefore, agrees with the examining division that the application does not differentiate between cases where y can take the value of 0 (i.e. there is no indium) and those where some indium is required in the $Al_xGa_{1-x-y}In_yAs$ layer (see also impugned decision, point 2.1.5 of the Reasons).

16. Regarding the technical effects of indium put forward by the appellant, the board does not question them. However, as mentioned earlier (see point 14. above), such technical effects are not mentioned or suggested in the application. The appellant argued that the application's teaching was to use AlGaAs-based layers to reduce the strain caused by the lattice mismatch to the Ge substrate. Even if the application made no explicit mention of an AlGaInAs-based (i.e. including In) first layer in that context, the skilled person would derive such a layer from the general teaching using common general knowledge (see appellant's letter dated 1 June 2026, page 3, first paragraph). The board notes, however, that first (inactive) AlGaAs layer(s)

on Ge substrates are disclosed in D2. Accordingly, this cannot be considered as the teaching of the claimed invention over the prior art. The difference from D2 relates only to the addition of indium in the AlGaAs layer.

17. In the board's opinion, the specific technical effects of indium mentioned by the appellant (see point 11. above) are to be considered to be part of the common general knowledge of the skilled person, since they are neither disclosed nor suggested in the application.

18. Accepting the appellant's formulated objective technical problem and applying the so-called "problem-solution approach", the skilled person starting from D2 and wishing to improve the lattice matching and/or reduce the strain between the Ge substrate and the first layer(s) would consider it obvious to add indium based only on common general knowledge. Consequently, no inventive step within the meaning of Article 56 EPC can be based on those technical effects.

19. In an alternative reasoning, the technical effects of indium put forward by the appellant have to be ignored, since they are neither disclosed nor suggested in the application. In that case, the skilled person reading the application as a whole, would arrive at the conclusion that the claimed range of $0<y\leq 0.02$ for the indium is an arbitrary limitation of the (infinitesimally) broader range $0\leq y\leq 0.02$ (i.e. including the value y=0 and the possibility that there is no indium in the layer, as in D2) and no particular technical effect is obtained by such a limitation.

20. Consequently, since there is no particular technical effect achieved by the presence of indium in the first

layer(s), there is also no technical problem to be solved. Whether indium is present in the first layer(s) or not is considered an arbitrary choice and as such it is obvious for the skilled person (see also "Case Law of the Boards of Appeal of the EPO", 11th ed., I.D.9.21.9a)). The board's conclusion is, therefore, that claim 1 of the main request does not involve an inventive step within the meaning of Article 56 EPC.

Auxiliary requests 1, 2, 3 and 4bis

21. In claim 1 of each of auxiliary requests 1 to 3 and 4bis, the material choices for the first layer are limited with respect to claim 1 of the main request. In claim 1 of each of them, however, the choice of $Al_xGa_{1-x-y}In_yAs$, wherein $0<y\leq0.02$, when $0<x\leq0.6$, is still included. This choice remains the one closest to the disclosure of D2, so that the same reasoning as for the main request applies to these requests, as well. The appellant did not present any further arguments for these auxiliary requests.

22. Consequently, the board holds that the subject-matter of claim 1 of auxiliary requests 1, 2, 3 and 4bis also lacks an inventive step.

23. In view of this conclusion, the question of admittance of auxiliary request 4bis into the appeal proceedings can be left open.

Auxiliary requests 4 and 5, added subject-matter (Article 123(2) EPC)

24. In the application, there are three disclosures of $Al_xGa_{1-x-y}In_yAs_{1-z-c}N_zP_c$ where the ranges for y, z and c correspond to those defined in claim 1 of auxiliary

requests 4 and 5.

- On page 3, lines 33 and 34 it is defined that x>0.6 (i.e. without including the value x=0.6 in the range). Here, for the value x=0.6, different materials are defined, namely $Al_xGa_{1-x-y}In_yAs$ ("once 0≤x≤0.6"; see line 32) or $Al_xGa_{1-x}As$ ("once x is approximately 0.6"; see lines 31 and 32).

- Similarly, on page 4, lines 1 and 2, x is also defined as being (only) greater than 0.6 (x>0.6). In the same way, for the value x=0.6, different materials are defined, the same as in the previous point.

- The same definition is given in claim 3 as filed.

It follows that there is no disclosure in the application as filed of the claimed combination of materials and value ranges ($Al_xGa_{1-x-y}In_yAs_{1-z-c}N_zP_c$, *wherein* $\mathbf{0.6 \leq x}$, $0<y\leq 0.002$, $0\leq z\leq 0.3$, *and* $0\leq c\leq 1$, see point VIII. above; bold by the board). Therefore, claim 1 of auxiliary requests 4 and 5 contains added subject-matter.

25. In relation to Figures 1 to 3, two specific embodiments of first layer material are disclosed in the application, namely $Al_{0.6}Ga_{0.39}In_{0.01}As_{0.998}N_{0.001}P_{0.001}$ and $Al_{0.6}Ga_{0.39}In_{0.01}As_{0.949}N_{0.001}P_{0.005}$ (see page 8, lines 12 and 24). In these examples, x=0.6 (i.e. within the range 0.6≤x of claim 1 of auxiliary requests 4 and 5) and the values for y, z and c also fall within the claimed ranges. However, in these examples this specific first layer material (AlGaInAsNP) is combined with a specific second layer material, namely

GaInAsNSb. Moreover, this part of the description refers to Figure 3, where an additional layer of AlInP is grown onto the Ge layer, so that the semiconductor multilayer structure (including the first and second layers) is not grown (directly) on the Ge layer, as claim 1 defines, but on the AlInP layer (see page 8, lines 1 to 26). Therefore, these examples do not fall under claim 1 of auxiliary requests 4 and 5.

26. This objection was raised by the board in its preliminary opinion issued in a communication under Article 15(1) RPBA. The appellant did not provide any arguments or amendments either in writing or during the oral proceedings in relation to this objection. The board, therefore, sees no reason to deviate from its preliminary opinion.

27. Accordingly, the board concludes that claim 1 of auxiliary requests 4 and 5 contains subject-matter extending beyond the content of the application as filed, contrary to the requirements of Article 123(2) EPC.

28. Since none of the appellant's requests is allowable, the appeal cannot succeed.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chair:

B. Atienza Vivancos T. Bokor

Decision electronically authenticated