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Datasheet for the decision of 21 October 2014

Case Number:	T 2469/09 - 3.4.03
Application Number:	03758353.1
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Language of the proceedings:	EN

Title of invention:
FORMATION OF CONTACTS ON SEMICONDUCTOR SUBSTRATES

Applicant:
Siemens Aktiengesellschaft

Headword:

Relevant legal provisions:
EPC 1973 Art. 56
EPC Art. 123(2)

Keyword:
Inventive step - (yes)

Decisions cited:

Catchword:

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Case Number: T 2469/09 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 21 October 2014

Appellant: (Applicant)	Siemens Aktiengesellschaft Wittelsbacherplatz 2 80333 München (DE)
Representative:	McCann, Heather Alison EIP Fairfax House 15 Fulwood Place London WC1V 6HU (GB)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 9 July 2009 refusing European patent application No. 03758353.1 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	G. Eliasson
Members:	S. Ward
	T. Bokor

Summary of Facts and Submissions

I. The appeal is against the decision of the Examining Division refusing European patent application No. 03 758 353 for "lacking inventive activity in the sense of Art. 56 EPC."

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

D1: JP 09 083008 A (including a certified English translation provided by the appellant);

D5: Development of a bump bonding interconnect technology for GaAs pixel detectors; Breibach J et al; Nuclear Instruments & Methods in Physics Research, Section A; Volume 470; pages 576-582; 2001;

D9: GB 2 307 785 A.

III. At the end of the oral proceedings held before the Board the appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of:

Description, pages 1,2,2a,3-6,6a,7-13 as filed during the oral proceedings before the Board;

Claims 1-5 filed during the oral proceedings before the Board;

Drawings: Sheets 1/7-7/7 as published.

IV. Claim 1 of the sole request reads as follows (the numbering (1-9) used by the appellant in the statement of grounds of appeal to label the corresponding features of claim 1 then on file has been included in square brackets):

"1. A method of manufacturing a radiation detector having a plurality of conductive contacts (12) on a surface of a cadmium-based semiconductor substrate (1), in which each of the conductive contacts is located at a respective contact position and is suitable for joining with a bump bond, the method including the steps of:

[1] *forming a layer of photoresistive material (4) on said substrate surface;*

[2] *removing said photoresistive material (4) from areas corresponding to said contact positions to expose said semiconductor substrate surface;*

[3] *forming a plurality of contiguous layers (8,9; 36, 38;45...48) of conductive material on remaining photoresistive material and on said exposed semiconductor substrate (1) surface, each of the plurality of contiguous layers comprising one of platinum, nickel, gold, indium, titanium, tungsten, a nickel/gold alloy and a titanium/tungsten alloy, the plurality of layers including first and second layers, wherein the first layer is formed adjacent to the substrate, and the second layer comprises gold;*

[4] *removing conductive material overlying said remaining photoresistive material by removing said remaining photoresistive material so as to form, from remaining conductive material, said conductive contacts*

(12) on the substrate surface, the conductive contacts (12) defining one or more radiation detector cells in the semiconductor substrate (1);

[5] *applying a layer of aluminium nitride passivation material (14) on said second, gold, layer of the conductive contacts (12) and the regions between said contacts (12);*

[6] *forming a further layer (16) of photoresistive material over said passivation layer;*

[7] *removing portions of the further photoresistive layer (16) to expose portions (18) of the passivation material (14) overlying said conductive contacts (12);*

[8] *removing, using a passivation etchant, portions of said passivation material (14) overlying the conductive contacts to expose the conductive contacts (12), such that passivation material remains in the regions between said contacts, wherein the portions of passivation material are removed from areas smaller in size than the size of said conductive contacts (12) such that the remaining passivation material overlaps the second, gold, layer of the conductive contacts (12); and*

[9] *removing remaining further photoresistive material."*

V. The appellant argued essentially as follows:

Document D1 relating to semiconductor radiation detection elements did not describe either a method of forming a pattern of detector pixels ("process a") or any information relating to the formation of the protective layer ("process b") except that it was formed on each multilayer electrode "apart from its central portion" and in the regions between the electrodes.

There was no reason for regarding the steps of process a as being "totally standard" as alleged by the Examining Division, and it was disputed that process b is "what is done" in D1.

Document D5 disclosed a procedure, described in relation to Figure 8, which appeared to describe steps similar to those of process b. However, D5 did not describe the steps of process a, and furthermore, document D5 related exclusively to GaAs pixel detectors whereas claim 1 of the main request specified a cadmium-based semiconductor substrate.

Moreover, claim 1 specified that the passivation layer was an aluminium nitride layer and that it was applied on a conductive contact layer comprising gold, i.e. the layer furthest from the substrate surface was gold. D1 did not describe that the corresponding layer (top layer 13) comprised gold, and indeed gold "is considered unsuitable for this purpose".

D5 discussed the use of gold as the outermost layer, however, the method used for forming the gold layer, and indeed the end product resulting therefrom, was different to that of claim 1. In Figure 8 of D5, the interface between the passivation layer and the contacts was formed of nickel, not gold; the gold layer being evaporated after the formation of the passivation layer.

Document D9 disclosed that aluminium nitride is advantageous as the passivation layer for cadmium based semiconductor radiation detectors because it can be processed at lower temperatures. This might prompt the skilled person to use it in place of silicon dioxide in the method of figure 8 of document D5. However, there is no teaching in document D9 that aluminium nitride displays better adhesion to gold than silicon dioxide, and hence the skilled person would not consider applying the layer of aluminium nitride passivation material on an upper gold layer of the conductive contacts as claimed.

Unlike the SiO_2 passivation layer of D5, the AlN passivation layer formed an effective combination with the gold layer, so there was no need for the complicated structure formed by the process of D5; instead the gold layer formed both the wetting agent for the bump and the interface with the passivation layer. This also allowed the omission of the additional step in D5 of forming the gold layer after forming the gaps in the passivation layer, simplifying the manufacturing procedure.

Reasons for the Decision

1. The appeal is admissible.

2. Article 123(2) EPC

2.1 Claim 1 of the main request may be seen as being based on claims 1, 4-7 and 22 as originally filed; figures

1A-2B and 6; and features disclosed in the following passages of the original description: page 3, lines 5-15; page 3, line 24 - page 4, line 12; page 5, lines 20-30; page 7, line 14 - page 8, line 23 (i.e. Steps B-J) and page 8, line 31 - page 10, line 2 (i.e. Examples 1-4).

In claim 1 the upper (second) layer is gold (see features [5] and [8]); the basis for this is seen as follows: In the description as filed, although a wide variety of combinations of materials for the underlying layers is disclosed, with a single exception (the first entry in the list of "other examples" on page 10, lines 6-7), the topmost layer is invariably gold.

Specifically, the upper layer is gold in the embodiments set out as "EXAMPLE 1" (referring to figures 1A-1J, and disclosing platinum/gold), "EXAMPLE 2" (referring to figure 2A and disclosing platinum/gold/nickel/gold), "EXAMPLE 3" (referring to figure 2A and disclosing platinum/gold/indium/gold) and "EXAMPLE 4" (referring to figure 2B and disclosing nickel/gold). This is also the case in four of the five "other examples" in the list mentioned above (platinum/gold; indium/gold; chrome/copper/gold and platinum/titanium-tungsten alloy/gold) and the example on page 5, lines 9-30 (platinum/gold/nickel/gold). In the light of this and originally-filed claims 19 and 21, the Board considers that a skilled person would unambiguously infer from the application as filed the general teaching of an upper layer of gold.

Hence, claim 1 is satisfactorily based on the content of the application as filed. Dependent claims 2-5 also comply with the requirements of Article 123(2) EPC.

3. *Inventive Step*

3.1 Document D1 is considered by the Board to be the closest prior art. This was also the view of the Examining Division, and the appellant has not disputed that this document represents a suitable starting point for the discussion of inventive step.

Although document D1 is mainly concerned with the details of a device *per se*, it is uncontested that it discloses at least some aspects of a method of manufacturing a radiation detector having a plurality of conductive contacts (see figure 2 and associated text) on a surface of a cadmium-based semiconductor substrate (CdTe), in which each of the conductive contacts is located at a respective contact position and is suitable for joining with a bump bond (figure 2).

3.2 In broad terms, the subject-matter of claim 1 differs from document D1 in defining:

a) a process (steps [1]-[4], as defined above) for forming a pattern of conductive contacts defining radiation detector cells in the semiconductor substrate; and

b) a process (steps [5]-[9], as defined above) for fabricating a passivation layer between and overlapping the contacts.

Document D1 does not disclose any process for patterning the conductive contacts or for fabricating a passivation layer.

3.3 More specifically, in relation to the second process the subject-matter of claim 1 differs from document D1 in that the passivation layer is formed by the **sequence of steps** set out in features [5]-[9], including the choice that the material of the upper layer of the conductive contacts is **gold** (implicit in features [5] and [8]) and that the material of the passivation layer is **aluminium nitride** (feature [5]).

3.4 The sequence of steps [5]-[9] can be seen as solving the general problem of finding a suitable method for fabricating a passivation layer; using gold as the upper layer of the conductive contacts can be seen as solving the problem of providing suitable wetting properties for a subsequent bump-bonding procedure (alluded to on page 4, lines 19-23 of the present application), and the use of aluminium nitride can be seen as solving the problem of finding a passivation material better adapted to processes employing cadmium-based substrates (see page 5, lines 24-30 of the present application). Whether more specific advantages of the distinguishing features referred to either in the description or by the appellant can be plausibly invoked in support of inventive step will be discussed in the following.

3.5 Combining documents D1 and D9

3.5.1 Starting from the cadmium telluride detector described in document D1 and seeking a solution to the problems outlined above, the skilled person would naturally look to other prior art disclosures dealing with cadmium-based radiation detectors. One such document is D9, which discloses that aluminium nitride is particularly effective as a passivation material because it can be applied at low temperatures (page 5, lines 20-25; page

6, line 23 - page 7, line 1). Although the benefit of low-temperature processing is particularly stressed in relation to CdZnTe, the skilled person would be aware that CdTe is also physically and chemically unstable, and hence that high-temperature processing should be avoided (see D1, paragraph [0003]).

It is therefore plausible that, on the basis of the information contained in document D9, a skilled person would use aluminium nitride in place of the materials disclosed in document D1 for the passivation layer.

3.5.2 Document D9 also discloses two (somewhat similar) methods for applying the aluminium nitride passivation layer (page 9, line 19 - page 11, line 29, and figures 2A-3L). These methods are completely different from that of the present invention. For example, the aluminium nitride passivation layer 11 is the first upper layer deposited on the substrate surface (figures 2B, 3B), and is formed well before the deposition of the conductive contact material 16 (figures 2G, 3H). This is in marked contrast to step [5] of the method of claim 1 of the present application. Moreover, in the final product of document D9 (figures 2K, 3L) the passivation layer does not not overlap portions of the conductive contacts as defined in step [8] of present claim 1.

Clearly, the sequence of steps for forming the passivation layer set out in features [5]-[9] of claim 1 of the present application would not be obvious on the basis of the combination of documents D1 and D9.

3.5.3 Furthermore, the conductive contact of document D9 is formed of a single layer, preferably of gold, which provides "good contact" with the substrate (page 12, lines 11-15). The advantage of using gold for the layer in contact with the substrate would already be known to the skilled person from document D1 (see paragraphs [0007], [0009] and [0013]). There is, however, no mention in document D9 of any advantage associated with the upper surface of the contact being gold, and hence document D9 would not incite the skilled person to select gold in place of the materials disclosed in document D1 as being preferred for the top layer (Ni, Ti, Cr, W or Mo).

3.5.4 The Board concludes, therefore, that the subject-matter of claim 1 is not obvious on the basis of a combination of documents D1 and D9.

3.6 Combining documents D1 and D5

3.6.1 Although document D5 deals exclusively with detectors based on gallium arsenide rather than cadmium, it is at least arguable that a skilled person, faced with the problem of finding a method for fabricating a suitable passivation layer, would look to this document which describes various methods for forming passivation layers of silicon dioxide or polyimide.

In particular, the skilled person would find in figure 8 a method for depositing a silicon dioxide passivation layer including all of the steps (but not the materials) defined in features [5]-[9] of claim 1.

The skilled person would also find in document D5 a clear statement (page 580, left-hand column, lines 4-7) of the advantage of using gold as the upper layer of the conductive contacts as a result of its "excellent wetting properties".

However, the problem of "extremely poor adhesion" between a silicon dioxide passivation layer and a gold surface of a contact is acknowledged in document D5 (page 577, right-hand column, lines 4-7), and the skilled person would also be aware of this issue from document D1 (paragraph [0004]). A strategy is therefore adopted in the method depicted in figure 8 of document D5 whereby the silicon dioxide passivation layer is applied on an upper nickel layer of the conductive contacts, and a subsequent layer of gold providing the required wetting properties is deposited after the structuring of the passivation layer.

Hence, document D5 discloses a method which explicitly avoids applying a passivation layer on an upper gold layer of conductive contacts as required by claim 1 of the present application. Moreover, there is no suggestion of using aluminium nitride as the passivation material in either document D1 or D5.

The subject-matter of claim 1 cannot, therefore, be said to be obvious on the basis of a combination of documents D1 and D5.

3.7 *Combining documents D1, D5 and D9*

3.7.1 It appears to the Board that an argument that the claimed subject-matter is obvious based on a combination of documents D1, D5 and D9 would inevitably require an element of "cherry-picking" from the three documents, with the skilled person selecting just those features that are needed to arrive at a method within the ambit of claim 1 while omitting those features which would shift the method outside the ambit of claim 1, an approach which clearly relies on inadmissible hindsight of the claimed invention.

For example, starting from D1, it is certainly plausible that a skilled person would choose aluminium nitride as a passivation material to allow processing at lower temperatures as taught in document D9. The obvious way of fabricating the aluminium nitride layer disclosed in document D9 would be to use a method based on the detailed sequence of manufacturing steps set out in document D9 itself. An argument that the skilled person would take from document D9 only the passivation material, and would look elsewhere for a manufacturing method, in particular to a document dealing with the deposition of a silicon dioxide passivation layer on a gallium arsenide substrate, would lack plausibility and would, in the opinion of the Board, be based on an *ex post facto* analysis.

3.7.2 Moreover, such a combination of documents would not, in the absence of further modifications, lead to the features of claim 1. Using the aluminium nitride in place of silicon dioxide in the method of figure 8 of D5 would result in aluminium nitride being deposited on a nickel layer, with an upper gold layer being deposited subsequently. This is not what is defined in step [5] of present claim 1.

3.8 Inventive Step: Conclusion

3.8.1 The Board does not see a plausible route by which a skilled person would be led in an obvious manner from the available prior art to the features of claim 1.

3.8.2 Moreover, the Board can accept that the combination of claimed features plausibly provides advantages over the prior art.

The appellant's arguments in this regard were mainly based on the contention that aluminium nitride has a better adhesion to gold than silicon dioxide. Even if this statement is true, the Board is reluctant to base an assessment of inventive step on a technical effect which does not appear to be mentioned anywhere in the application.

Nor is there any need to do so, as other advantages which *are* mentioned in the application can plausibly be invoked.

For example, for the reasons given above, the Board considers that it would be obvious for a skilled person to employ aluminium nitride deposited according to the method disclosed in document D9 as the passivation layer. This method involves first forming a passivation layer, and then forming the contacts (21, 31) on regions of the substrate from which portions of the passivation layer have been removed (figures 2F, 3F). By contrast, according to the present invention the conductive contacts are first formed on the substrate, and the passivation layer is subsequently applied on the conductive contacts and in the regions between the contacts. The advantages of the approach of the present invention in this respect are plausibly set out in the passage from page 2, line 29 to page 3, line 4.

3.8.3 Since the Board concludes that features [5]-[9] define a method which would not be obvious in the light of the prior art, it is not necessary to decide on the question of obviousness in relation to the remaining differences over the closest prior art (features [1]-[4]).

3.8.4 For the reasons given above, the Board judges that the method of claim 1 involves an inventive step within the meaning of Article 56 EPC 1973.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance with the order to grant a patent with the following documents:

   Description, pages 1,2,2a,3-6,6a,7-13 as filed during the oral proceedings before the Board

   Claims 1-5 filed during the oral proceedings before the Board

   Drawings: Sheets 1/7-7/7 as published.

The Registrar: The Chairman:

S. Sánchez Chiquero G. Eliasson

Decision electronically authenticated