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**Datasheet for the decision
of 4 September 2018**

Case Number: T 1554/13 - 3.4.03

Application Number: 03816807.6

Publication Number: 1606843

IPC: H01L27/146, G01D18/00, H01L21/28

Language of the proceedings: EN

Title of invention:
CONDUCTIVE ADHESIVE BONDED SEMICONDUCTOR SUBSTRATES FOR RADIATION IMAGING DEVICES

Applicant:
Oy AJAT Ltd.

Headword:

Relevant legal provisions:
EPC Art. 52(1), 56

Keyword:
Inventive step - all requests (no)

Decisions cited:

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It can be changed at any time and without notice.

Catchword:

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

Beschwerdekammern

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Case Number: T 1554/13 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 4 September 2018

Appellant: (Applicant)
Oy AJAT Ltd.
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02150 Espoo (FI)

Representative:
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Decision under appeal:
Decision of the Examining Division of the European Patent Office posted on 29 January 2013 refusing European patent application No. 03816807.6 pursuant to Article 97(2) EPC.

Composition of the Board:

Chairman G. Eliasson
Members: M. Papastefanou
C. Heath

Summary of Facts and Submissions

I. The appeal is against the decision of the Examining Division refusing European patent application 03 816 807.6 (published as WO 2004/097938 A1) on the grounds that neither the Main request nor the Auxiliary requests 1 to 5 before it involved an inventive step within the meaning of Article 56 EPC. In addition, the Main request and Auxiliary requests 2 to 5 did not meet the requirements of Article 123(2) EPC.

II. Reference is made to the following documents, cited in the decision under appeal:

D1: US 6 344 370 B1;
D3: EP 1 207 559 A2;
D10: US 6 323 475 B1;
D11: US 5 886 353 A.

III. In a preliminary opinion annexed to the summons to oral proceedings, the Board indicated that neither the Main request nor any of the Auxiliary requests 1-11 appeard to involve any inventive step.

IV. At the end of the oral proceedings before the Board, the Appellant's request was that the decision under appeal be set aside and that a patent be granted according to the Main request or one of Auxiliary requests 1-12. The Main request and Auxiliary requests 1-11 were filed with the grounds of appeal. Auxiliary request 12 was filed during the oral proceedings before the Board.

V. Claim 1 of the **Main request** is worded as follows:

An x-ray and gamma-ray radiation energy imaging device

(11) comprising:

a detector substrate (20; 32), the detector substrate (20; 32) having an electrode surface and a pixel surface, and suitable for converting said radiation energy impinging on the electrode surface to electrical charges, and with the pixel surface having a plurality of pixels and associated pixel contacts (22) thereon with the pixels for collecting the electrical charges and the pixel contacts (22) disposed in a pixel contact pattern;

a readout substrate (21), which is a semiconductor substrate, the readout substrate (21) having a readout surface disposed opposite the pixel surface of the detector substrate (20; 32), a plurality of CMOS pixel signal circuits (36) disposed on the readout surface and the signal circuits (36) each having a signal contact (37) processed on the readout surface in a signal contact pattern, the signal contacts being inputs to the signal circuits (36) of the readout substrate (21); and

a plurality of electrically conductive bonds each discretely connecting a pixel contact (22) in the pixel pattern to a signal contact (37) in the signal contact pattern,

***characterized** in that the electrically conductive bonds comprise an electrically conductive adhesive (27; 28; 38), which bonds the detector substrate (20; 32) to the readout substrate (21)* (emphasis in the original).

VI. Claim 1 of **Auxiliary request 1** differs from claim 1 of the Main request by the following specification regarding the readout substrate:

"a readout substrate (21), which is a ~~semiconductor substrate~~ CMOS chip diced from a wafer, ..."

VII. Claim 1 of **Auxiliary request 2** differs from claim 1 of the Main request in that its characterising part is worded as follows (additions underlined, deletions in ~~strike through~~):

characterized *in that the electrically conductive bonds ~~comprise~~ consisting* [sic] *of an electrically conductive adhesive (27; 38) discretely and directly applied on at least one of the pixel contact (22), the signal contact (37), a bump (25) on the pixel contact (22) or a bump (25) on the signal contact (37), wherein the electrically conductive adhesive (27; 38) is isotropically conductive adhesive and ~~which~~ bonds the detector substrate (20; 32) to the readout substrate (21).*

VIII. With respect to claim 1 of the Main request, claim 1 of **Auxiliary request 3** comprises the additional features of both claim 1 of Auxiliary request 1 as well as those of claim 1 of Auxiliary request 2.

IX. Compared to claim 1 of the Main request, claim 1 of **Auxiliary request 4** comprises the additional features of claim 1 of Auxiliary request 2 as well as the specification that the detector substrate is

"a CdTe or CdZnTe detector substrate (20; 32)...".

X. Compared to claim 1 of the Main request, claim 1 of **Auxiliary request 5** comprises all the additional features of claim 1 of Auxiliary requests 1, 2 and 4.

XI. With respect to claim 1 of the Main request, claim 1 of **Auxiliary request 6** comprises the specification that the detector substrate is

"*a CdTe or CdZnTe detector substrate (20; 32) ...*" while its characterising part is worded as follows:

*" **characterized** in that the electrically conductive bonds ~~comprise~~ consisting* [sic] *of an electrically conductive adhesive ~~which bonds the detector substrate (20;32) to the readout substrate (21)~~ between the signal contacts (37) or bumps on the signal contacts (37) and the pixel contacts (22) or bumps on the pixel contacts (22), the electrically conductive adhesive comprising an adhesive matrix filled with metal coated polymer particles."*

XII. Compared to claim 1 of the Main request, claim 1 of **Auxiliary request 7** comprises the additional features of claim 1 of Auxiliary request 1 and Auxiliary request 6.

XIII. Claim 1 of **Auxiliary request 8** has the same wording as claim 1 of the Main request except that the term "comprise" in the characterising feature (*"characterized in that the electrically conductive bonds comprise and electrically conductive adhesive..."*) has been replaced with the term "consisting of".

XIV. Claim 1 of **Auxiliary request 9** has the same wording as claim 1 of Auxiliary request 1 except that the term "comprise" in the characterising feature (*"characterized in that the electrically conductive bonds comprise and electrically conductive adhesive..."*) has been replaced with the term

"consisting of".

XV. Compared with claim 1 of the Main request, claim 1 of **Auxiliary request 10** comprises the additional features that the detector substrate is "*a CdTe or CdZnTe detector substrate (20; 32)*" and that the readout substrate is *"a CMOS chip diced from a wafer",* while the characterising part reads as follows:

*"**characterized** in that the electrically conductive bonds consisting* [sic] *of an isotropically electrically conductive adhesive (27; 38)".*

XVI. Compared with claim 1 of the Main request, claim 1 of **Auxiliary request 11** comprises the additional features that the detector substrate is "*a CdTe or CdZnTe detector substrate (20; 32)*", that the readout substrate is *"a CMOS chip diced from a wafer"* while the characterising part reads as follows:

*"**characterized** in that the electrically conductive bonds consisting* [sic] *of an electrically conductive adhesive (27; 38) comprising an adhesive matrix filled with metal coated polymer particles".*

XVII. Compared with claim 1 of the Main request, claim 1 of **Auxiliary request 12** comprises the additional features that the detector substrate is "*a CdTe or CdZnTe detector substrate (20; 32)*", that the readout substrate is *"a CMOS chip diced from a wafer"* while the characterising part reads as follows:

*"**characterized** in that the electrically conductive bonds consisting* [sic] *of an electrically conductive adhesive between bumps on the signal contacts (37) and*

the pixel contacts (22)".

XVIII. The Appellant argued mainly that the selection of D1 as closest prior art by the Examining Division was not correct because the imaging device described in D1 was of a different technology from the imaging device of the claimed invention. D10 was a more suitable choice as closest prior art and the skilled person starting from D10 would not have considered the disclosure of D1 as a suitable combination unless hindsight was involved.

Reasons for the Decision

1. The appeal is admissible.

2. The claimed invention

The claimed invention relates to an x-ray and gamma-ray radiation energy imaging device. The device consists of two parts, two substrates joined/connected to each other. One part is the detector substrate, which receives the x-rays or the gamma rays and creates electrical charge that are collected by corresponding pixel contacts arranged in a pixel pattern. The other part is the readout substrate to which the charges from the pixel contacts of the detector substrate are led, through corresponding signal contacts, and which, through a grid of pixel circuits consisting of CMOS chips, controls an active matrix array to display images corresponding to the received charges.

The application addresses the problem of how to provide an electric connection between the two substrates that

is electrically and mechanically reliable. The proposed solution consists in using an electrically conductive adhesive to connect the pixel contacts of the detector substrate to corresponding signal contacts of the readout substrate.

3. Main request

3.1 Closest prior art

3.1.1 In the decision under appeal, the Examining Division considered either of the documents D1 or D3 to be representing the closest prior art to the claimed subject matter. This selection of the closest prior art was supported by the argument that D1 described an x-ray and gamma-ray imaging device, consisting of a detector substrate and a readout substrate - like the device in the claimed invention - and that it was addressing the same problem as the claimed invention, i.e. how to provide an electrically and mechanically reliable connection between the two substrates. The feature distinguishing the claimed device from the one in D1 was that its readout substrate comprised CMOS chips instead of thin film transistors (TFTs) on a glass substrate as in the readout substrate of the device of D1.

3.1.2 The Appellant argued that this selection of the closest prior art was based on hindsight. Documents D10 and D11 described x-ray and gamma-ray imaging devices with two substrates of the same type with the device of the claimed invention, i.e. the readout substrate comprised CMOS chips as well.

It was well known that CMOS-based readout substrates were of smaller size than TFT-based readout substrates

and this difference was also reflected in the corresponding imaging devices. Hence, an x-ray imaging device with a CMOS-based readout substrate would be of smaller size than an x-ray imaging device using TFT-based readout substrate. This would lead to the former being used mainly in applications like dental x-ray imaging devices and the latter in x-ray imaging devices for lager parts of the body, like the chest of a person, for example. Since the claimed imaging device had a CMOS-based readout substrate, the logical starting point for the skilled person would have to be an imaging device of the same type, like the one in D10 or D11. The selection of D1 as closest prior art was based on hindsight because D1 disclosed the use of the electrically conductive adhesive.

3.1.3 The Board, without taking a decision on which document is more suitable as closest prior art, decided to follow the Appellant's argument in this matter because selecting D10 as closest prior art did not lead to a conclusion different from its preliminary opinion or the decision under appeal, as it will be detailed in the following paragraphs. The question of which document best represents the closest prior art can therefore be left open.

3.1.4 It is common ground that D10 discloses the preamble of claim 1 (see also grounds of appeal, bottom of page 1).

D10 describes an x-ray and gamma-ray radiation imaging device comprising a detector substrate and a readout substrate (column 4, lines 28-54). The detector substrate (44) has an electrode surface and a pixel surface suitable for converting said radiation energy impinging on the electrode surface to charges. On the pixel surface a plurality of pixels and associated

pixel contacts disposed in a pixel contact pattern are formed for collecting the electrical charges (see column 4, line 63 - column 5, line 7; column 5, lines 12-40 and Figures 1 and 4). The imaging device comprises further a readout substrate (42), which has a readout surface disposed opposite the pixel surface of the detector substrate (see Figures 2 and 4) and a plurality of CMOS pixel signal circuits disposed on the readout surface (column 7, lines 28-29 and 35-38) and the signal circuits each having a signal contact processed on the readout surface in a signal contact pattern, the signal contacts being inputs to the signal circuits of the readout substrate (column 8, lines 47-52, Figure 5). The device further comprises a plurality of electrically conductive bonds each discretely connecting a pixel contact in the pixel pattern to a signal contact in the signal contact pattern (see for example column 4, lines 54-62 or column 8, lines 59-64).

3.2 Difference and technical problem

3.2.1 The difference between the claimed imaging device and the one in D10 lies in the way the connection of the two substrates is made. In the claimed device, the electrically conductive bonds between the detector substrate and the readout substrate comprise an electrically conductive adhesive. In D10, the two substrates are mainly connected by bump-bonding (see column 3, lines 24-25 or column 8, lines 62-63), which are soldered metallic bonds that correspond to the state of the art described in the present application (see page 2 of the description).

3.2.2 These metallic bonds require high temperature and pressure in order to render the soldering of the

contacts via the metallic bump possible. This can affect the materials of the substrates, especially the detector substrate, and can cause damage. Another known issue in soldered contacts are the so called "cold solder joints", i.e. contacts that are defective and not electrically conductive.

The use of an electrically conductive adhesive for connecting the two substrates does not require higher temperature or pressure and the risk of damaging the substrates is considerably lower. At the same time, the created bond is more reliable both mechanically and electrically.

3.2.3 Starting from D10, the skilled person is, thus, faced with the technical problem of how to obtain electrically conductive bonds between the two substrates that are mechanically and electrically reliable and at the same time easier to manufacture without risking any damage to the substrates.

3.3 Solution and obviousness

3.3.1 As discussed already (see point 3.1.1), document D1 describes an x-ray and gamma-ray radiation imaging device, which consists of two substrates, a detector substrate and a readout substrate, connected to each other. The readout substrate in the device of D1 comprises TFT signal circuits instead of the CMOS-based signal circuits of the claimed invention (see for example column 8, lines 1-22 and Figure 1).

In D1, the same problem of improving the connection and conductivity between the two substrates is addressed. One of the proposed solutions is the use of a conductive adhesive to bond the two substrates (column

5, lines 29-36 and column 6, lines 47-52).

3.3.2 The skilled person starting from D10 and seeking to solve the identified technical problem, would consider D1 and apply its teaching in the device of D10 in an obvious and straightforward way, without exercising any inventive skill. He would, arrive, thus at the subject matter of claim 1.

3.3.3 The Appellant argued that the skilled person starting from D10 would not consider D1 unless he had knowledge of the claimed invention (hindsight). Following its arguments regarding the selection of the closest prior art, the Appellant argued that TFT-based imaging devices belonged to a different technological field than the CMOS-based imaging device. This was also evident from the sizes of the devices described in D10 and D1 respectively. The skilled person looking to solve a technical problem related to a CMOS-based imaging device like the one in D10 would never consider prior art related to TFT-based imaging devices, like D1. He would look for solutions within the known CMOS-based imaging devices and, since the prior art documents did not disclose or suggest the solution of the claimed invention, claim 1 was inventive.

3.3.4 The Board does not share the Appellant's opinion on this matter. The problem of providing a reliable and easy to manufacture, electrically conductive bond between the two substrates is not related to the type of the readout substrate or the possible application/ use of the imaging device. Neither the application nor the prior art documents show or suggest any relation between the type of the readout substrate and the way the two substrates are bonded.

It is also to be considered that the pixel array in the readout substrate of the imaging device consists of several individual signal circuits and, therefore, the size of the array depends on the particular intended use and not on the type of the signal circuit itself. The size of the image detector mentioned in D1 (which uses TFT-based signal circuits, see column 8, lines 7-9), which was referred to by the Appellant, refers to the size of the whole device and not of the signal circuit itself. As it is specified in the same passage, the pixels in this detector are arranged in a matrix at pitches of 150 µm. The image detector in D10, which uses CMOS-based signal circuits has a pixel pitch between 35 µm - 140 µm (column 9, lines 56-61), which is not that different from the one in D1. In addition, the invention in D10 foresees putting several readout substrates (i.e. CMOS-based signal circuits) together to form a semiconductor imaging device of a larger size (see column 2, lines 34-39, column 2, line 48 - column 3, line 24, column 7 lines 1-12, 28-55 and Figure 4). Hence, in both cases, the size of the pixel circuit itself does not directly affect the overall size of the imaging device.

Moreover, since the pixel pitch is similar in both devices, the resolution of the pixel arrays of both devices are also similar. This indicates that the sizes of the signal and pixel contacts to be bonded together are also similar, suggesting that, in both the device of D1 and the one of D10, the technical constraints and considerations to be taken into account when bonding the two substrates are similar.

3.3.5 The Board concludes, thus, that the skilled person starting from D10 and seeking to solve the identified technical problem would consider D1 and apply its

teaching in the device of D10 in an obvious way and without using any inventive skill or hindsight.

Therefore, the subject matter of claim 1 of the Main request does not involve an inventive step within the meaning of Article 56 EPC.

4. Auxiliary Requests 1-11

4.1 The Appellant did not present any arguments in response to the Board's preliminary opinion regarding these requests. The Board, considering the discussion regarding the Main request, does not see any reason to deviate from its preliminary opinion regarding Auxiliary requests 1-11.

4.2 Comparing claim 1 of each of the Auxiliary requests 1-11 to claim 1 of the Main request, the following features have been added, in various combinations in each of these claims (numbering by the Board):

(i) the readout substrate (21) is specified as a *CMOS chip diced from a wafer* (Auxiliary requests 1, 3, 5, 7, 9, 10 and 11);

(ii) the electrically conductive bonds are specified as consisting of an electrically conductive adhesive (22), *discretely and directly applied on at least one of the pixel contact (22), the signal contact (37), a bump (25) on the pixel contact (22) or a bump on the signal contact (37)* (Auxiliary requests 2, 3, 4, 5, 6 and 7);

(iii) the electrically conductive adhesive is further specified as being *an isotropically conductive adhesive and bonds the detector substrate (20;32) to the readout substrate*

(21) (Auxiliary requests 2, 3, 4, 5 and 10);

(iv) the detector substrate (20;32) is specified as a *CdTe or CdZnTe detector substrate* (Auxiliary requests 4, 5, 6, 7, 10 and 11);

(v) the electrically conductive adhesive is specified as *comprising an adhesive matric filled with metal coated polymer particles* (Auxiliary requests 6, 7 and 11).

4.3 Regarding feature i), the Board considers that the provision of CMOS chips by dicing a wafer is a standard way of manufacturing CMOS chips and semiconductor chips in general. It would, thus, be within the common knowledge of the skilled person to provide CMOS chips in such a way.

Regarding feature ii), the Board notes that the electrically conductive adhesive in D1 is discretely and directly applied on at least one of the pixel contact or the signal contact, as it can be seen in Figure 2 of D1 (conductive connection material 6, see also column 10, lines 13-18 and column 3, lines 12-16). This feature is, thus, disclosed in D1.

As to feature iii), the conductive connection material in D1 is a resin material that is a photoconductive resin with a conductive pigment dispersed therein (column 10, lines 19-20). There is also mention of using both isotropically and anisotropically conductive adhesives in D1 (see column 3, lines 11-18). The Board considers that the advantages and disadvantages of the two types of conduction in such adhesives were known to the skilled person by the priority date of the application, as it is also indicated in the present application (page 4, lines 16-21). Hence, the selection

of an isotropically conductive adhesive when applying the teaching of D1 would be an obvious step for the skilled person.

Feature iv) is disclosed both in D10 (see for example column 7, lines 17-24) as well as in D1 (see column 9, lines 37-45).

Feature v) is disclosed in D1, column 3, lines 26-27.

4.4 Hence, none of these features can be combined with the remaining features of the corresponding claim(s) and lead to a feature combination involving an inventive step. Taking also into account the findings regarding the Main request, the Board concludes that the subject matter of claim 1 in Auxiliary requests 1-11 does not involve an inventive step, either.

5. Auxiliary request 12

5.1 This request was filed during the oral proceedings before the Board. It was uncontested that it was a late filed request, amending the Appellant's case. The Board, exercising it discretion under Articles 13(1) and 13(3) of the Rules of Procedure of the Boards of Appeal, decided to admit this request into the proceedings.

5.2 Claim 1 of Auxiliary request 12 comprises features i) and iv) (see points XVII and 4.2). As already concluded before (point 4.3), neither of these features can support the presence of an inventive step.

According to the characterising feature of claim 1 of Auxiliary request 12, the electrically conductive bonds between the two substrates consist of an electrically

conductive adhesive between the pixel contacts (of the detector substrate) and bumps on the signal contacts (of the readout substrate).

5.3 According to the Appellant, the provision of bumps improves the quality/reliability of the electrical connection between the two contacts. In addition, the required layer of the adhesive becomes thinner, reducing the pressure necessary to achieve the bonding, reducing, thus, further the risk of damaging the substrates.

In D1 there was no mention of bumps when adhesive was used. The teaching of the combination of D10 with D1 was that using bumps and using adhesive were two alternative ways of bonding the two substrates and there was no hint for the skilled person to combine the two.

5.4 Regarding document D3 - which describes an imaging device similar to the one in D1; see abstract for example - the Appellant pointed out that, although the use of both bumps and adhesive in bonding the two substrates was disclosed, the bump was on the pixel contacts (i.e. on the detector substrate) and not on the signal contacts (on the readout substrate) as in the claimed invention (see Figure 1 and paragraph [0022] in D3). The Appellant argued that the bumping process (creating the bump on the contact) involved high temperature and pressure and this would damage the fragile material of the detector substrate (CdTe or CdZnTe in both cases - see paragraph [0016] in D3 and second line of claim 1 of Auxiliary request 12).

By having the bump on the signal contact (i.e. on the readout substrate), the claimed invention provided the

technical effect of improved bonding (using bump and adhesive), while at the same time protecting the fragile material of the detector substrate. In D3 there was an additional embodiment where bumps were provided at both contacts (Figure 11 and paragraph [0056]) but there was no hint for providing a bump only on the signal contact of the readout substrate.

Claim 1 of Auxiliary request 12 involved, thus, an inventive step.

5.5 The Board does not agree with this argument of the Appellant. There is no indication in the application as originally filed, nor in the documents of the state of the art that the process of creating the bumps on the pixel contacts would damage or risk to damage the detector substrate. On the contrary, as D3 shows, it was known to create bumps on both substrates. The Appellant's allegation is also contradicted by the application itself, which states *"Although shown in Fig. 2B as being disposed [on] the CMOS readout substrate 21, the bump 25 alternatively may be disposed on the pixel contact 22 of the detector substrate 20 or on the contacts 22 & 37 of both substrates 20 & 21."* (page 12, lines 17-20 of the application as published). It is, thus, to be concluded that the selection of which contact (substrate) the bump will be disposed on is not dictated by any particular technical constraints.

5.6 The skilled person, hence, who is starting with the device of D10 and seeks to obtain the identified technical effect (see point 5.3 above) would find the solution in D3 and apply it to the device of D10 in an obvious and straightforward manner. The selection of which particular contact (substrate) the bump will be

placed on is considered as an arbitrary choice, which cannot provide any basis for the support of an inventive step.

5.7 The Board concludes, therefore, that the subject matter of claim 1 of Auxiliary request 12 does not involve an inventive step.

6. Summarizing, the Board's conclusion is that the subject matter of claim 1 of the Main request and Auxiliary requests 1-11 does not involve an inventive step in view of the combination of D10 with D1 and the subject matter of claim 1 of Auxiliary request 12 is obvious in light of the combination of D10 and D3. Since none of the requests on file is allowable, the appeal must fail.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

S. Sánchez Chiquero G. Eliasson

Decision electronically authenticated