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Case Number: T 1108/09 - 3.4.03

Application Number: 04009746.1

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Language of the proceedings: EN

Title of invention:
Method of mounting an electronic part on a mounting board

Applicant:
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Sony Corporation
Kabushiki Kaisha Toshiba
NEC Corporation
Fujitsu Semiconductor Limited
Panasonic Corporation
Rohm Co., Ltd.
Renesas Technology Corp.

Headword:

Relevant legal provisions:
EPC 1973 Art. 56

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

Keyword:
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Decisions cited:

Catchword:

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Case Number: T 1108/09 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 6 February 2014

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Decision under appeal:

Decision of the Examining Division of the European Patent Office posted on 11 November 2008 refusing European patent application No. 04009746.1 pursuant to Article 97(2) EPC.

Composition of the Board:

Chairman: G. Eliasson
Members: T. M. Häusser
P. Mühlens

Summary of Facts and Submissions

I. The appeal concerns the decision of the examining division refusing the European patent application No. 04009746 for lack of inventive step (Article 56 EPC 1973) in view of the following document:

D1: Suga T. et al., Surface Activated Bonding and its Applications on Micro-Bonding at Room Temperature, 9th European Hybrid Microelectronic Conference Proceedings, 1993, France, p. 314-321.

II. Reference is made to the following further documents:

D2: JP 2002-064266 A,
D2a: US 2003/70164394 A1 (family member of D2),
D3: Hosoda N., Suga T., The Effect of Surface Roughness on Room Temperature Bonding, J. of Welding Society, Vol. 69, No. 2, 2000, p. 54-57,
D4: Suga T. et al., Direct Bonding of Ceramics and Metals by Means of a Surface Activation Method in Ultrahigh Vacuum, MRS Int'l Mtg. on Advanced Materials, Vol. 8, 1989, p. 257-262,
D5: Suga T., Miyazawa K., Metal/Metal- and Metal/ Ceramic Interfaces Produced by Means of a Surface Activation Method at Room Temperature, Acta-Scripta Met. Proc. Ser. Vol. 4, 1990, p. 189-195,
D7: DE 100 18 358 A1.

III. At the oral proceeding before the board the appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of claim 1

filed with the statement of the grounds of appeal dated 12 March 2009.

IV. The wording of claim 1 according to the sole request is as follows (board's labelling "(i)" and "(ii)"):

"1. A method of mounting an electronic part (11) on a board (15), comprising:
- placing the electronic part and board in a vacuum or inert atmosphere,
- activating bonding surfaces of bonding members (13, 17) of the electronic part and board,
- bringing the bonding members of the electronic part and board into contact with each other at a temperature lower than a melting point of the materials of the bonding members to thereby mount the electronic part on the board, wherein the bonding members of at least one of the electronic part and board are formed of a solder material, characterized in that
(i) the solder material is one that requires at the bonding temperature a vertical load of not greater than 100 grams to change the height of a spherical bump, having a diameter in a direction parallel to a body of the electronic part of 130 μm, by 8 μm, and that
(ii) the bonding members of the electronic part and board are brought into contact with each other without preprocessing the bonding surfaces of the bonding members with regard to roughness and height."

V. The appellant argued essentially as follows:

Document D1 did not disclose the claimed deformability criterion for selecting the solder material in combination with the omission of preprocessing the bonding members with regard to roughness and height. Consequently, the method of claim 1 differed from the

teaching of document D1 in comprising features (i) and (ii). The distinguishing features allowed the bonding of all of the plurality of bonding members of the electronic part. Furthermore, formulating the objective technical problem as to improve the process of D1 regarding processing time and effectiveness contained a pointer to the solution. The objective technical problem was thus to establish contacts at all bonding members as the number of bonding members per electronic part increased and electronic parts became more susceptible for mounting forces and heat during the bonding process and to make the method of mounting simpler and more effective.

The reference in document D1 on page 314, last paragraph, to "[t]he surface activated bonding (SAB) [1-3,6]" meant that the teaching in documents 1-3 and 6 concerning the surface activated bonding method was in fact disclosed by reference in document D1. In particular, document D4 was document "1" referred to in document D1. It related to bonding experiments for aluminum and ceramics and disclosed that before bonding the surface of a metal was lapped and electrochemically polished so as to have a hemispherical form while a ceramic part was polished so that a uniform contact between the two parts was ensured (D4, page 259, "EXPERIMENTAL PROCEDURE"). Furthermore, document D5 was document "2" referred to in document D1. It also related to surface actuated bonding of aluminum and ceramics and disclosed mechanical and electrochemical polishing in order to ensure good contact between the parts to be bonded; it was further stated that the maximum surface roughness was about 0.1 µm (D5, paragraph bridging pages 189 and 190). Preprocessing the bonding surfaces of the bonding members was therefore to be regarded as disclosed in document D1.

Moreover, in document D3 it was stated that "a surface roughness is needed to be controlled in nanometer scale in order to provide complete adhesion between two members". From documents D3 to D5 in combination with D1 it was clear that the notion in the art was that in order to perform surface activated bonding successfully, preprocessing of the bonding surfaces had to be performed for realizing a certain surface roughness on the order of 100 nm or lower. The presence of a prejudice in the art in this respect was further confirmed by documents D2 and D7. In document D2 it was stated that in case the surface regularity was small, pressing for bonding became unnecessary (see D2a, paragraph [0005]). In document D7, a German patent application with several different very large corporations as applicants, it was stated that it was indispensable for surface bonding to smoothen and activate the surfaces (D7, column 9, lines 1-10).

Document D1 only referred to "local plastic deformation" and was merely concerned with increasing the bond strength between a single pair of bonding members. D1 could therefore not provide an incentive for selecting a solder material adapted for overcoming the height variations between a plurality of bonding members. Furthermore, table 1 of D1 showed that Al-Pb and Al-PbSn bonds had low tensile strength. In addition, Figure 9 revealed that after annealing, which was needed to improve tensile strength, the contact resistance for a Cu-PbSn bond was very high. The skilled person was therefore discouraged from using these combinations of materials.

Moreover, in document D2 it was stated that a *fine gap* could be removed by a final bonding step; this could

not render the claimed method obvious since only that method closed large gaps due to height variations among different bonding members on the order of 8 µm as specified in claim 1.

Reasons for the Decision

1. The appeal is admissible

2. Inventive step

2.1 Closest state of the art

In the appealed decision the examining division considered document D1 as the closest state of the art, an opinion shared by the appellant. Indeed, document D1 is conceived for the same purpose as the invention, namely to provide a method of mounting an electronic part on a board, and has the most relevant technical features in common with it. Document D1 is therefore regarded as the closest state of the art.

2.2 Distinguishing features

2.2.1 Document D1 relates to surface activated bonding (SAB) methods and devices and discloses (see page 314, last paragraph - page 316, first paragraph and Figure 1; page 320, line 4 - page 321, line 2 and Figure 11) that specimens to be bonded are introduced into a bonding chamber. After evacuation of the chamber, the surfaces of the specimens are sputter-cleaned by Ar fast-atom-beam bombardment. Immediately after the bombardment, the specimens are brought into contact under contact pressure. Various examples are mentioned for the first and second bonded parts: the first bonded part is Cu in

a lead form at the end of which a Cu bump is electroplated or one of Cu, Al, Pb, Sn, Pb-5%Sn, and Sn-3%Ag in a cylindrical shape with a hemispherical end; the other part is a Cu plate, Al plate, Cu film on a polyimide substrate or an Al sputtered thin film on a silicon wafer. Furthermore, in Figure 11 is shown an LSI flip chip with PbSn solder bumps which are bonded to a Cu electrode on a silicon wafer by means of the SAB method at room temperature.

2.2.2 Using the wording of claim 1 document D1 discloses therefore, in particular in relation to the example of Figure 11, a method of mounting an electronic part (LSI flip chip) on a board (silicon wafer), comprising:
- placing the electronic part and board in a vacuum or inert atmosphere (in the evacuated chamber),
- activating bonding surfaces of bonding members of the electronic part and board (by means of sputter-cleaning of the surfaces using Ar fast-atom-beam bombardment),
- bringing the bonding members of the electronic part and board into contact with each other (at a contact pressure) at a temperature (namely room temperature) lower than a melting point of the materials of the bonding members to thereby mount the electronic part on the board, wherein the bonding members of at least one of the electronic part and board are formed of a solder material (PbSn solder).

This has not been contested by the appellant.

2.2.3 The appellant argued that document D1 did not disclose disclose feature (i). In the appealed decision it was pointed out in this respect that the solder "Pb-5%Sn" disclosed in document D1 was also described in the application as filed as one of the specific examples of a solder material which could be used according to the

present invention. Indeed, this is relevant because feature (i) defines an intrinsic property of the claimed solder material, namely its *deformability* in terms of a certain height change (8 µm) of a spherical bump of the solder material having a specified diameter (130 µm) in a direction parallel to a body of the electronic part when a certain vertical load (100 g or less) is applied. From Figures 3 to 5 and the corresponding description it emerges that the solder material Sn-95Pb easily exhibits the claimed deformability. From Figure 5 it can be seen that this material is in fact much more deformable than what is required to fulfill the deformability criterion of feature (i).

The example of Figure 11 of document D1 comprises lead/ tin solder and it is evident from the last paragraph on page 315 of D1 that its composition is 5% tin and 95% lead, i.e. the same as the lead/tin solder material described in the application. Therefore, the solder material used in that example of document D1 fulfills the deformability criterion of feature (i).

2.2.4 Concerning feature (ii) it is stated in the appealed decision that D1 was silent about any preprocessing of the bonding surfaces of the bonding members with regard to roughness and height. The bonding procedure is indeed described only briefly in document D1, essentially in one paragraph comprising ten lines (see page 315, the paragraph with the heading "2.1 Bonding Procedure"). Therefore, the absence of the description of any preprocessing cannot be taken as a disclosure that no such preprocessing is to be carried out.

On the other hand, the appellant argued that the reference in document D1 to documents D4 and D5 when

referring to "surface activated bonding" meant that preprocessing the bonding surfaces of the bonding members was to be regarded as disclosed in document D1, since such preprocessing was used in the methods of D4 and D5. Documents D4 and D5 relate to surface activated bonding of metal/metal and metal/ceramic interfaces. In particular, the bonding of aluminum to aluminum, silicon nitride, sapphire and aluminum nitride is described in both documents; in addition, the bonding of aluminum to silicon and diamond and the bonding of copper to copper is described in D4. In documents D4 and D5 it is indeed described that the metals and ceramics are polished (D4, page 259, second paragraph; D5, paragraph bridging pages 189 and 190). However, all the materials described in documents D4 and D5, especially the ceramics, have higher hardness values than several of the materials described in document D1. In particular, the materials Pb, Sn, Pb-5%Sn and Sn-3%Ag mentioned in D1 are known to have very low hardness values. In view of these differences, any polishing or other preprocessing of the bonding surfaces of the bonding members cannot be regarded as disclosed in document D1.

In summary, neither the absence nor the presence of the step of preprocessing the bonding surfaces of the bonding members with regard to roughness and height can be regarded as disclosed in document D1.

2.3 In view of the above the board comes to the conclusion that the subject-matter of claim 1 differs from the method of D1 in comprising feature (ii).

2.4 Objective technical problem

The appellant argued that it was an objective technical problem of the invention to establish contacts at all bonding members. This is considered to be an effect of feature (i) concerning the deformability of the solder material, as it allows to compensate differences in height between the bonding members. Feature (i) is however already known from the closest prior art document D1 and does not distinguishing the invention from D1. It is the effects of the distinguishing features which have to be considered when formulating the objective technical problem. In the present case, the effect of the distinguishing feature (ii) is to leave out the step of preprocessing the bonding surfaces of the bonding members with regard to roughness and height in the mounting method thereby simplifying that method. Furthermore, in the description of the application it is mentioned that the step of preprocessing the bonding surfaces increases the burden on the chip (page 2, lines 2-13). Leaving out that step reduces therefore the burden on the chip.

It is therefore regarded to be the objective technical problem to simplify the mounting method while reducing the burden on the electronic part.

2.5 Obviousness

2.5.1 The skilled person, an electrical engineer working in the field of surface activated bonding, is aware that, when the parts to be bonded are brought into contact under a contact pressure, there is some plastic deformation of the surfaces in contact. The deformation will be more or less pronounced depending on the hardness of the materials involved. The skilled person is aware of such deformation from his common general knowledge, in particular his knowledge of the physical

properties of the relevant materials. However, there is also an explicit disclosure in this respect in document D1: in the paragraph bridging pages 316 and 317 it is mentioned that there is always some open area between the surfaces to be bonded; at room temperature it could be reduced by local plastic deformation of the surfaces in contact.

The appellant argued that D1 was merely concerned with *local* deformation and increasing the bond strength between a single pair of bonding members. The skilled person would however understand that, when the parts are brought into contact under a contact pressure, the plastic deformation also leads to a change in height of the bonding members.

Moreover, the skilled person is also aware of closing gaps by means of pressure, which necessarily involves plastic deformation of the bonding members, from the disclosure in document D2 (see paragraph [0050] in D2a, a family member of D2). The fact that in that document it is merely mentioned to remove *fine gaps* in this way, as pointed out by the appellant, does not matter since there is no definition in claim 1 as to the size of the gaps that can be removed by means of the preprocessing.

In the method according to the closest state of the art a lead/tin solder is used, which is known to be a soft material, as mentioned above. When starting from that method and attempting to simplify it while reducing the burden on the electronic part, the skilled person would therefore be led to perform no preprocessing of the bonding surfaces with regard to roughness and height, as he would rely on the plastic deformation of the lead/tin solder to compensate any surface roughness and variations in height of the bonding members.

2.5.2 The appellant argued that there existed a prejudice in the art regarding the necessity of performing preprocessing of the bonding surfaces in order to achieve surface activated bonding successfully. He pointed in particular to the teaching of documents D4 and D5 mentioned above under point 2.2.4 and to documents D2 and D7.

In the jurisprudence of the Boards of Appeal (see *Case Law of the Boards of Appeal of the European Patent Office*, 7th edition 2013, section I.D.10.2) a technical prejudice in a particular field relates to an opinion or preconceived idea widely or universally held by experts in that field. The existence of a technical prejudice is normally demonstrated by reference to the literature or encyclopedias published before the priority date. A high standard of proof is applied when assessing whether a prejudice existed or not.

In the present case, a relatively small number (five) of journal articles (D3, D4 and D5) or patent applications (D2 and D7) were cited by the appellant in support of the allegation of the existence of a technical prejudice. Furthermore, the name of one expert (Tadatomo Sugo) appears either in the list of inventors (in case of the patent applications D2 and D7) or in the list of authors (in case of the journal articles D3, D4 and D5) in all of these references. Therefore, the teaching in these documents cannot be regarded to demonstrate any widely held opinion, but might well merely represent the personal view of that expert. The appellant pointed out that several large corporations were the applicants of the German patent application D7. This is however regarded to be of no relevance in the present context, as it is the view of

the technical experts, i.e. the inventors of D7, which is significant for assessing whether a technical prejudice exists.

Moreover, in documents D3 to D5 it is merely mentioned that the parts to be bonded are polished without stressing that this step was indispensable. Furthermore, as pointed out above the polishing was only mentioned in the context of certain materials to be bonded. In document D2 it is not even described that any preprocessing was in fact performed, but only stated that in case of small surface irregularities, pressing for bonding became unnecessary. Finally, in document D7 it is stated that it was indispensable for surface bonding to smoothen and activate the surfaces (D7, column 9, lines 1-10). However, this statement is in the context of the bonding of semiconductor substrates. The only example of the material of the substrate mentioned is silicon, which is a very hard material. The necessity to polish may therefore well be linked to the specific circumstances in that document. Therefore, the content of these documents does not suggest the existence of the alleged prejudice, either.

2.5.3 In view of the above, the board is of the opinion that it would be obvious to solve the posed objective technical problem by means of feature (ii).

Therefore, the subject-matter of claim 1 does not involve an inventive step (Article 52(1) EPC and Article 56 EPC 1973).

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

S. Sánchez Chiquero G. Eliasson

Decision electronically authenticated