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D E C I S I O N
of 3 September 2002

Case Number: T 0488/99 - 3.4.3

Application Number: 94303200.3

Publication Number: 0638926

IPC: H01L 21/60

Language of the proceedings: EN

Title of invention:

Process of fabricating semiconductor unit employing bumps to bond two components

Applicant:

FUJITSU LIMITED

Opponent:

-

Headword:

Bump heights/FUJITSU

Relevant legal provisions:

EPC Art. 56
Guidelines C-III, 4,2

Keyword:

"Inventive step - main request(no) - auxiliary request(yes)"
"A narrower interpretation of a term in a claim than its normal meaning - not identified"

Decisions cited:

T 1129/97, T 0415/93

Catchword:

-



Case Number: T 0488/99 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 3 September 2002

Appellant:

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Decision under appeal:

**Decision of the Examining Division of the
European Patent Office posted 10 December 1998
refusing European patent application
No. 94 303 200.3 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: R. K. Shukla
Members: G. L. Eliasson
M. B. Günzel

Summary of Facts and Submissions

I. European patent application No. 94 303 200 3 was refused in a decision of the examining division dated 10 December 1998. The ground for the refusal was that the subject matter of claim 1 according to both a main request and an auxiliary request lacked inventive step having regard to the prior art document

D4: Patent Abstracts of Japan, vol. 6, No. 132 (E-119) 17 July 1982 & JP-A-57 056 937.

The following prior art documents were also cited in the examination procedure:

D2: US-A-5 125 560; and

D5: Patent Abstracts of Japan, vol. 17, No. 173 (E-1345) 2 April 1993 & JP-A-4 328 843 together with complete translation in English.

II. The appellant (applicant) lodged an appeal on 10 February 1999, paying the appeal fee the same day. A statement of the grounds of appeal was filed on 19 April 1999 together with two sets of claims forming a main and an auxiliary request, respectively.

III. In a communication accompanying summons for oral proceedings, the Board introduced a complete translation in English of document D4.

IV. At the oral proceedings held on 3 September 2002, the appellant requested that the decision under appeal be set aside and a patent be granted on the basis of one of the following requests:

Main request:

Claims: 1 to 5 according to the main request filed with the statement of the grounds of appeal dated 19 April 1999;

Description: pages 1 to 3 and 5 to 11 filed with the letter dated 11 February 1997, page 4 filed during the oral proceedings;

Drawings: Sheets 1/6 to 6/6 as originally filed.

Auxiliary request:

Claims: 1 to 4 according to the auxiliary request filed with the statement of the grounds of appeal;

Description and Drawings as for the main request.

V. Claim 1 according to the main request is the same as the auxiliary request under consideration in the decision under appeal and reads as follows:

"1. A semiconductor unit fabrication process, comprising:

forming a predetermined plurality of bumps (13) on at least one (11) of two components (11, 17);

measuring the respective heights (H) of all of the bumps (13);

connecting the two components (11,17) via the bumps (13) by bringing the two components (11,17) to within a distance L_1 of each other, the distance L_1 being determined using the results of the measuring and being equal to or less than the smallest measured bump height (H) so that all of the bumps (13) come into contact with the two components (11,17)."

VI. Claim 1 according to the auxiliary request reads as follows:

"1. A semiconductor unit fabrication process, comprising:

forming a predetermined plurality of bumps (13) on one (11) of two components (11, 17);

removing an oxide film (15) formed on the bumps;

measuring the respective heights (H) of all of the bumps (13);

connecting the two components (11,17) via the bumps (13) by bringing the two components (11,17) to within a distance L_1 of each other as a result of applying a predetermined pressure to the two components (11,17), the distance L_1 being determined using the result of the measuring and being equal to or less than the smallest measured bump height (H) so that all of the bumps (13) come into contact with the two components (11,17) and all of the bumps have the same height,

wherein the distance L_1 is determined for each

semiconductor unit fabricated."

Claims 2 to 4 are dependent claims.

VII. The appellant presented essentially the following arguments in support of patentability:

- (a) Since the expression "the distance L_1 being determined using the results of the measuring of the heights of the bumps" in claim 1 cannot be more narrowly defined without contravening Article 123(2) EPC, it should be interpreted in the light of the description as set out in Article 69 EPC and the Protocol on the interpretation of Article 69 EPC. It follows from a proper reading of the entire description that the term "determined" means that an *arbitrary value* of the distance L_1 between the two components can be selected by using the results of measuring the bump heights.

Although a step of carrying out measurements of the heights of the bumps is carried out in the method according to document D4, the distance between the two components is *not determined* using the results of the measuring of the heights of the bumps within the meaning of "determined" given above, since the distance between the two component can only be selected from a limited number of fixed values corresponding to the respective heights of the stepped electrodes. Since the stepped electrodes in the method of document D4 were formed before the heights of the bumps were measured, the distance between the two components cannot be freely selected.

- (b) Since the distance between the two components in the method of document D4 is restricted to the values of the heights of the stepped electrodes, only components having pair of bumps which are larger than the smallest of the stepped electrodes can be successfully connected. If one pair of bumps were smaller than the smallest electrode in the method of document D4, it would be impossible to select a distance between the two components which is smaller than the smallest pair of bumps.

In the claimed method, on the other hand, no lower limit for the distance between the two components is present which increases the yield.

- (c) In the method of document D4, each bump is contacting another bump in a so-called "double-bump" configuration, whereas in the claimed method, each connection is established by a single bump. Since document D4 only teaches how the heights of the stepped electrodes determined in terms of "variation of the heights of plural bumps", the skilled attempting to modify the teaching of document D4 to a "single-bump" configuration would not know how to adjust the heights of the stepped electrodes. As a consequence, the smallest of the stepped electrodes would be larger than some bumps, and therefore, not all the bumps will have established contact after completing the process of joining the two components.
- (d) Claim 1 according to the auxiliary request specifies that the predetermined distance L_1 is set as a result of applying a predetermined pressure.

There is no hint in document D4 that the distance is established or set on the basis of applied pressure, where stepped electrodes 11 - 14, 11' - 14' and an ammeter M for monitoring the distance between the components are required.

In the claimed method, on the other hand, it is possible to control the final height of the bumps by using a previously obtained relationship between the final height of the bumps as a function of applied pressure. Thus, it is not necessary to actually measure the distance between the two components at the time of the connection in order to control the distance between the two components.

Reasons for the Decision

1. The appeal meets the requirements of Articles 106 to 108 and Rule 64 EPC and is therefore admissible.

2. *Amendments*

Claim 1 according to the main request corresponds to claim 1 as filed. Claim 1 according to the auxiliary request contains the features of claims 1 and 4 as filed together the feature on page 4, lines 16 to 18 of the application as filed (step of removing oxide). Thus, the requirements of Article 123(2) EPC are met.

3. *Inventive step - Main Request*

The only issue in the present appeal is that of inventive step.

3.1 Document D4 was considered the closest prior art in the decision under appeal. It discloses a method of assembling two components where solder bumps on one component are brought in contact with corresponding solder bumps on the other component. In order to accurately control the distance between the two components to be assembled, a number of stepped electrodes 11 - 14, 11' - 14' with known heights are formed at the periphery of one of the two components. When the components are brought to a distance equal to the height of one of the stepped electrodes 11 - 14, 11' - 14', this electrode contacts the other component and a current can be detected through the electrode using an ammeter M, M' (cf. page 5, last paragraph to page 6, second paragraph). Thus, as the two components are brought closer together, successively shorter electrodes will establish contact with the other component.

In the assembling method of document D4, the heights of all the bumps are measured. Based on the measured solder bump heights, one of the stepped electrodes 11 - 14, 11' - 14' is chosen which has a height corresponding to a distance between the two components at which all the solder bumps are in contact with their respective counterparts (cf. translation, page 6, third paragraph). The two components are then pressed together until the chosen electrode is in contact with the counter metal pad 15, 15' and conducts current. The distance between the assembled components is at most equal to the height of the chosen electrode and is thus equal to or smaller than the size of the smallest pair of corresponding bumps.

3.2 In this connection the appellant argued firstly that in

the method of document D4, the distance between the two components is *not determined* using the results of the measuring of the heights of the bumps, since the heights of the stepped electrodes are fixed before the heights of the bumps are known, and therefore, the distance between the components cannot be chosen freely (cf. item VII(a) above). The expression in claim 1, "the distance L_1 being determined using the results of the measuring and being equal to or less than the smallest measured bump height (H)...", means that the distance L_1 is based directly on the measurement of the bump height so that an *arbitrary* value of the distance L_1 as defined in the claim, as against the preselected values of the heights of the stepped electrodes, can be chosen.

3.2.1 It is established practice in the EPO to give the words in a claim the meaning and scope which they normally have in the relevant art, unless the description gives the words a special meaning by explicit definition or otherwise (cf. e.g. Guidelines C-III, 4.2 and T 0415/93, reasons 4). Furthermore, in order to meet the requirements of Article 84 EPC, the claims should be clear in themselves without having to resort to the description for an interpretation (cf. T 1129/97, OJ EPO 2001, 273, reasons 2.1.3). An interpretation of the claims using the description and drawings, as provided for in Article 69(1) EPC, concerns the determination of the extent of protection whenever this is at issue and not the definition of the matter to be protected by a claim.

3.2.2 In the present case, the application in suit neither contains any special definition of the term "determine" nor any other disclosure which would justify a narrow

interpretation. Furthermore, the term "determined" was interchanged by the appellant in the appeal procedure with "selected", which suggests that a narrow interpretation of "determined" was not intended.

3.2.3 In the method of document D4, the distance between the two components is selected by selecting one of the stepped electrodes. Although the method of document D4 only allows the distance between the components to be chosen from a limited number of predetermined values, it does not change the fact that the results of the measurements of the bumps in the method of document D4 are used as input for determining which of the stepped electrodes has to be selected, which in turn determines the distance L_1 between the components. Thus, the distance L_1 in document D4 is determined using the results of measurement of the bump heights as in the method of claim 1.

3.3 The appellant further argued that the method according to document D4, in contrast to the claimed method, is restricted to components having pair of bumps which are larger than the smallest of the stepped electrodes. If one pair of bumps were smaller than the smallest electrode, it would be impossible to select a distance smaller than the smallest pair of bumps, and the components to be connected would have to be discarded (cf. item VII(b) above).

3.3.1 The Board, however, notes that the method according to claim 1 does not exclude a lower limit of acceptable bump sizes. Therefore, this argument cannot be accepted for this reason alone.

Furthermore, contrary to the contentions of the

appellant, the Board is satisfied that the method according to document D4 will work properly for most units, and therefore in most cases accomplishes the task of connecting the two components. According to document D4, the size of the largest of the stepped electrodes should be set larger than pairs of bumps, and the difference in height between the largest and the smallest of the stepped electrodes should be set so "that it exceeds the variation of the heights of plural bumps" (cf. translation, page 5, second paragraph, last sentence). Thus, it is ensured that for most units, there will be at least one of the stepped electrodes which has a height smaller than that of the smallest pair of bumps.

- 3.4 Document D5 discloses a method of measuring the height of a bump electrode using light incident at an oblique angle. The height is obtained from measuring the length of the shadow of the bump (cf. abstract). The method is described as being suitable for automation. Document D5, however, does not disclose that these measurements are used for bonding components together.
- 3.5 As apparent from the above discussion, document D4 is undisputably the closest prior art.

The method of claim 1 according to the main request differs from that of document D4 in that (i) the distance between the two components is set to be equal of smaller than the smallest measured bump height, whereas in document D4, due to the "double bump" configuration, the distance between the two components becomes less or equal to the smallest sum of the heights of the respective top and bottom bumps 3, 6.

3.6 The above difference is a direct consequence of the fact that both components 1, 2 in the unit of document D4 have bumps. Therefore, the technical problem relates to modifying the process of document D4 for a unit having solder bumps on only one of the two components to be connected.

3.7 At the priority date of the application in suit, it was commonly known in the art to employ flip-chip bonding techniques having solder bumps on only one of the two components to be bonded (cf. for example document D2). In the light of the simplified structure of such arrangement compared to the "double bump" configuration shown in document D4, it appears to be obvious to consider a "single bump" alternative whenever appropriate.

A skilled person faced with the task of applying the teaching of document D4 to a structure where only one of the components has solder bumps, would in accordance with the teaching of document D4 chose the distance between the components to be such that all the bumps are in contact with the two components. In other words, the distance is chosen to be equal to or less than the smallest measured bump height.

3.8 The appellant's argument that the skilled person would be unable to modify the teaching of document D4 to a "single-bump" configuration cannot be followed by the Board (cf. item VII(c) above), since, as mentioned under item 3.3.1 above, the teaching of document D4 regarding the heights of the stepped electrodes is sufficiently detailed so the skilled person is able to modify it for the case when only a single bump is used for each contact. The skilled person would therefore as

a matter of routine understand that the highest of the stepped electrodes should be higher than the highest bump, and that the difference between the highest and the lowest of the stepped electrodes is greater than the variation in heights of a *single bump*.

Therefore, in the Board's judgement, the subject matter of claim 1 according to the main request does not involve an inventive step within the meaning of Article 56 EPC.

4. *Inventive step - Auxiliary Request*

4.1 The method of claim 1 according to the auxiliary request specifies in addition to that of the main request that (ii) only one of the two components has bumps; (iii) oxide film is removed from the bumps; (iv) the distance L_1 between the components is the result of applying a predetermined pressure; and (v) the distance L_1 is determined for each unit fabricated.

Feature (v) is known from document D4. Thus, the method of claim 1 according to the auxiliary request differs from that of document D4 in the above features (i) to (iv) mentioned above (cf. also item 3.4 above for feature (i)).

4.2 As discussed in the application in suit (cf. application as published, column 1, line 55 to column 2, line 18), it is necessary that oxide on the solder bumps has to be removed either by etching or using flux in order to ensure proper bonding. For a process where no flux is used at the bonding operation, it is known in the art that the oxide film on the bumps must be removed prior to the bonding operation.

Feature (iv) (applying a predetermined pressure) has the advantage that after finding out the correspondence between the applied pressure and the resulting distance between the components, it is possible to carry out the assembly without having to resort to a complicated structure of stepped electrodes.

In view of the differences with respect to the method of document D4, the technical problems relate addressed by the claimed method relate to (a) providing a method of assembling a unit having solder bumps on only one of the two components, while (b) ensuring that the solder bonds are reliable without using flux at the bonding operation, and (c) simplifying the process so that the provision of stepped electrodes or the like on the components is not required.

- 4.3 Document D4 discloses that pressure has to be applied to the two components when the bumps are brought in contact with each other (cf. translation, page 6, second paragraph). It is however not suggested in document D4 that a predetermined value of the applied pressure selected in order to obtain the required distance between the components for contacting all the bumps. On the contrary, document D4 consistently discloses that it is necessary to provide a rather elaborate construction of stepped electrodes on one of the two components for monitoring the actual distance between the two components as the assembly operation is performed. The Board therefore agrees with the submissions of the appellant that the skilled person would not find any hint in document D4 to control the distance between the components as a function of applied pressure (cf. item VII(d) above).

Therefore, in the Board's judgement, the subject matter of claim 1 according to the auxiliary request involves an inventive step within the meaning of Article 56 EPC.

Order

For these reasons it is decided:

1. The decision under appeal is set aside.
2. The case is remitted to the examining division with the order to grant a patent with the following documents:

Claims: 1 to 4 of the auxiliary request filed with the statement of the grounds of appeal;

Description: pages 1 to 3, 5 to 11 filed with the letter dated 11 February 1997, page 4 filed during the oral proceedings;

Drawings: Sheets 1/6 to 6/6 as originally filed.

The Registrar:

The Chairman:

R. Schumacher

R. K. Shukla