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D E C I S I O N
of 4 July 2002

Case Number: T 0871/98 - 3.4.3

Application Number: 92304633.8

Publication Number: 0516344

IPC: H01L 21/90

Language of the proceedings: EN

Title of invention:
Method to fill a cavity in a substrate

Applicant:
Trikon Technologies Limited

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 54, 56

Keyword:
"Novelty (yes)"
"Inventive step (yes)"
"Inconsistent disclosure in prior art document"

Decisions cited:
T 0412/91

Catchword:
-

Case Number: T 0871/98 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 4 July 2002

Appellant: Trikon Technologies Limited
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 6 April 1998 refusing European patent application No. 92 304 633.8 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: R. K. Shukla
Members: V. L. P. Frank
M. B. Günzel

Summary of Facts and Submissions

I. The appeal lies against the decision of the Examining Division dated 6 April 1998 refusing the European patent application No. 92 304 633.8. The ground for the refusal was that the subject-matter of claim 1 was not new having regard to the disclosure of the prior art document:

D1: US-A-5 011 793

II. The appellant (applicant) lodged an appeal on 20 May 1998, paying the appeal fee on 29 May 1998. The statement setting out the grounds of appeal was filed on 24 July 1998.

III. At the oral proceedings before the Board held on 4 July 2002 the appellant submitted an amended request based on claims 1 to 5, replacing all the previous requests, and amended pages of the description.

IV. The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the following patent application documents:

Claims: 1 to 5 filed during the oral proceedings on 4 July 2002

Description: pages 1 to 18 filed during the oral proceedings on 4 July 2002

Drawings: Sheets 1/4 to 4/4 filed on 16 July 1992 with the letter dated 14 July 1992

The wording of the only independent claim is as follows (emphasis added by the Board to show the amendments introduced in the course of the appeal proceedings with respect to the independent claim on which the decision of the Examining Division was based):

"1. A method of processing a semiconductor wafer having a surface layer having an exposed surface and at least a part of said surface having a multiplicity of recesses therein, the method comprising:

depositing, **in a first chamber,** a further layer **of aluminum or aluminum alloy** on the exposed surface of at least said part of said surface layer without any melting of said further layer, the depositing of said further layer continuing at least until said further layer extends over all the recesses to close completely the mouths of all of said recesses in the exposed surface;

halting the depositing of said further layer;

placing the wafer in a high pressure chamber; and

subjecting said wafer and said further layer to elevated pressure **above 20×10^6 Pa** and an elevated temperature within the high pressure chamber sufficient to cause parts of said further layer to deform without melting, to fill respective recesses; wherein the elevated temperature to which said further layer is subjected is below the melting point of said further layer."

V. In the decision under appeal the Examining Division essentially argued as follows:

Document D1 discloses a method for filling recesses in a substrate comprising the steps of forming a layer on a substrate having at least one recess, depositing the layer so that a void is formed within the recess and applying pressure while the layer and the substrate are at a high temperature so that the layer is forced into the recess. The term "melted" as used in document D1 is clearly defined so as to include the conception of softening and fluidization, ie the layer is heated to a temperature at which the material is not necessarily molten, but reaches a state of plastic softening. In consequence, all the process steps of claim 1 are anticipated by the teaching provided by document D1.

The Examining Division further observed that an independent claim comprising the magnitude of the pressure utilised during the process would not involve an inventive step, since said value can be estimated by routine tests. Furthermore, the defined pressure magnitude does not result in an unexpected advantageous effect.

VI. The appellant argued essentially as follows in support of his request:

The interpretation of document D1 made by the Examining Division is erroneous and based on a retrospective reading of this document with the application in suit in mind. The Examining Division resolved any ambiguity in this document by forcing an interpretation such that the process in document D1 appears to be the same as the one claimed. However, both processes are

fundamentally different.

Document D1 discloses a pressurised reflow process in which the deposited metal is moved by heating it to flow into the recesses. This movement is assisted by the application of pressure. The amount of pressure that can be applied is determined by the vacuum chamber equipment used, ie about one atmosphere, because vacuum deposition chambers are not configured to withstand pressures which are significantly above atmospheric pressure. Moreover, the statement defining "melting" as merely applying heat for softening the metal layer does not make sense in the context of the prior art method mentioned in document D1. If the authors of this document would have realized that only simple heating was required, then it would be pointless to refer to melting or to put in any explanation of that term.

The method according to the application in suit consists essentially in applying a very high pressure to a layer maintained at a temperature below its melting point. This method thus corresponds to an "extrusion" type process in contrast to the "casting" type process disclosed in document D1.

Furthermore, it has to be noted that no suitable equipment for applying the high pressure disclosed in the application existed in the art (about 200 atmospheres) and had to be specially designed by the inventor. This demonstrates that the claimed method was in no way merely a result of routine tests.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

2.1 In the decision under appeal, there were no objections raised against the claims under Article 123(2) EPC, and the Board is also satisfied that the claims as amended during the examination proceedings complied with Article 123(2) EPC.

In the course of the appeal proceedings the independent claim has been amended to specify the material of the further layer which is deposited to fill the recesses, the magnitude of the applied pressure, and that after the deposition is halted the wafer is placed in a separate high pressure chamber (cf. column 3, lines 13 to 15 and column 8, lines 24 to 29 of the published application and point IV above).

The description has been amended to concord with the claims.

The Board is, therefore, satisfied that these amendments fulfill the requirement of Article 123(2) EPC.

2.2 In the appeal proceedings, the wording of claim 1 was amended (in relation to claim 1 which was refused by the Examining Division) as follows to comply with the requirement of clarity pursuant to Article 84 EPC:

- deletion of "significantly" from the expression "significantly below the melting point"; and

- deletion of "and is sufficient to decrease the yield strength of the material of said further layer to allow filling deformation".

Moreover, the description has been amended by deleting the sentence "If aluminum is used, temperatures in the range 350°C to 650°C and pressures in excess of 3,000 psi have been found suitable." on page 7, lines 26 to 28, to clarify the fact that the layer is not heated to a temperature as high as 650°C where aluminium melts.

3. *Novelty*

3.1 Document D1 discloses a method for filling recesses formed in a substrate without leaving voids within the recesses. The method comprises the following steps:

- forming a thin film on a substrate,

- heating the thin film while it is being formed on the substrate so that it is 'melted' and closes the entrance of the recesses by the melted material, but leaves a void within the recesses, and

- introducing a pressurizing gas into the same vacuum chamber in which the deposition was performed so that it pushes the 'melted' material into the recesses (cf. column 1, lines 57 to 68 and column 2, lines 62 to 65).

It is further specified in the introductory part of this document "that the wording 'melted' used herein is intended to include the conception of a softening or a fluidization" (cf. column 1, lines 26 to 28).

3.2 On the basis of the above definition of the word 'melted', the Examining Division argued that in the method of document D1, the thin film which was deposited on a substrate was heated to a temperature below its melting point, but high enough to soften the material to allow it to be deformed, and then pressed in this state into the recesses as in the method claimed in claim 1.

The appellant contested this interpretation arguing that the definition of 'melted' specified in document D1 contradicts the disclosure of this document taken as a whole.

Consequently, it needs to be considered whether the above definition of 'melted' is consistent with the remaining disclosure of document D1.

3.3 The introductory part of document D1 refers to a conventional, prior art method for filling recesses in which an aluminium alloy film, deposited on a substrate with recesses, is heated to a temperature *above approximately 500°C, so that it is melted*. The melted material is then *drifted* into the recesses, filling them (cf. column 1, lines 11 to 26). However, when the recesses have an aspect ratio above one, the melted material cannot be successfully *drifted* into the recesses and a void is left within them (cf. column 1, lines 29 to 35)

In the context of the above conventional process, which is known to rely on the reflow of aluminium, there is no doubt whatsoever that the aluminium film which is heated above 500°C is in the molten state. In this connection reference is made to a standard book, "ULSI

Technology", edited by C. Y. Chang and S. M. Sze, Mc Graw Hill Companies, Inc., 1996, page 140, section 8.4.3, where the above process is explained.

Moreover, the use of the term *drifted* means that the material has to be in a liquid state so that it fills up the recesses without the application of an external force to move it. A drifting of the layer's material cannot, however, be achieved if the layer is heated up so that it is merely softened.

For these reasons, the Board concludes that the definition of the word 'melted', as meaning merely a softening of the layer, cannot be applied to the prior art method described in document D1.

3.4 According to the pressurized reflow process described with reference to Figures 4 to 7 in document D1, an aluminium alloy layer is heated to a temperature *above approximately 500°C and is thus melted*. However, as the recesses to be filled have an aspect ratio above one, they are no longer filled by merely letting the melted material drift into the recesses, but an external pressure has to be applied to push the material into them. The statement defining the temperature at which the layer is heated in this situation is the same as the one used for describing the conventional reflow method, specifying that the temperature is sufficiently high to melt the material. In absence of any other indication in the document to the contrary, the heating temperature has to be interpreted as in the case of the conventional reflow method.

3.5 Having regard to the present circumstances, the Board concludes that the definition of the word 'melted' as

comprising a softening of the layer is inconsistent with both the conventional reflow method and the pressurized reflow method described in document D1. As stated in decision T 412/91, the disclosure of a prior art document is governed not merely by the words actually used, but by what the publication reveals to the skilled reader as a matter of technical reality (cf. point 4.6 of the reasons).

The Board, therefore, concludes that the method disclosed in document D1 does not comprise a step in which the further layer deposited on top of the recesses, closing their mouths, is subjected to an elevated temperature below the melting point of this layer, but discloses a method in which pressure is applied onto a layer of melted material.

3.6 The method according to claim 1 of the application in suit differs, therefore, from the method disclosed in document D1 in that:

(i) the wafer is placed in a separate, high pressure chamber after the further layer has been deposited;

(ii) the wafer and the further layer are subjected to an elevated pressure above 20 x 10^6 Pa to cause parts of the further layer to deform; and

(iii) the elevated temperature applied during the deformation step of the further layer is below the melting point of this layer.

Consequently, the method according to claim 1 is new with respect to the disclosure of document D1.

4. *Inventive step*

4.1 The problem addressed by the application in suit is to provide a method for completely filling up recesses having an high aspect ratio that can be carried out at lower temperatures than the ones used in the prior art, ie temperatures above 500°C as disclosed in document D1. The use of lower process temperatures is important for avoiding unwanted side effects.

The Board is satisfied that this is achieved by the application of a high pressure above 20 x 10^6 Pa (ie about 200 atmospheres), since under these circumstances processing temperatures significantly below the melting point of the layer can be used. In particular, temperatures as low as 350 to 400°C have been successfully used at this pressure for filling the recess with aluminium (cf. column 6, lines 25 to 29 of the published application).

4.2 The Examining Division has argued in their decision that it would have been a matter of routine experimentation to find out the required pressure allowing the deformation of the layer at a temperature below its melting point.

The Board, however, cannot concur with this line of reasoning, since, as convincingly argued by the appellant, document D1 discloses that the pressurizing gas was introduced into the same vacuum chamber in which the deposition was done (cf. column 2, lines 62 to 65). A vacuum deposition equipment, however, is normally designed to withstand pressure differentials of a few atmospheres at the most, since under normal working conditions it supports an underpressure of one

atmosphere, and it would have been severely damaged if subjected to a pressure above 20 x 10^6 Pa (ie about 200 atmospheres). Moreover, thermal treatment chambers withstanding such high overpressures were not routinely used in the art of semiconductor device manufacturing, and, for this reason, an adequate equipment, fulfilling the conditions required in this field, had to be specially designed by the appellant.

Admittedly, a person skilled in the art would have routinely experimented with pressure values in the vicinity of one atmospheric pressure in the prior art process. However, the application of a pressure of a magnitude which is about two orders higher than the one which is normally employed, cannot be regarded as a value arrived at by routine experimentation especially when such a high pressure results in a considerable reduction in the temperature (350°C to 400°C as compared to above 500°C) at which the recesses can be filled by physical deformation of the aluminium alloy film. Moreover, the application of such a high pressure results in a process which relies on physical deformation of the solid film material to fill the recess rather than on the flow of the melted material.

5. The Board therefore comes to the conclusion that claim 1 involves an inventive step within the meaning of Article 56 EPC.

The dependent claims 2 to 5 concern further particular embodiments of the invention which are patentable for the same reasons.

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 the first instance with the order to grant a patent on the basis of the following documents:

Claims:	1 to 5 filed during the oral proceedings on 4 July 2002
Description:	pages 1 to 18 filed during the oral proceedings on 4 July 2002
Drawings:	Sheets 1/4 to 4/4 filed on 16 July 1992 with the letter dated 14 July 1992

The Registrar: The Chairman:

D. Spigarelli R. K. Shukla