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D E C I S I O N
of 29 September 2004

Case Number: T 0963/02 - 3.4.3

Application Number: 99301767.2

Publication Number: 0954027

IPC: H01L 23/532

Language of the proceedings: EN

Title of invention:

Copper interconnection structure incorporating a metal seed layer

Applicant:

International Business Machines Corporation

Opponent:

-

Headword:

Electromigration/IBM

Relevant legal provisions:

EPC Art. 56, 123(2), 84

EPC R. 33(2), 68(2)

Keyword:

"Inventive step (yes)"

"Abstract and claim in contradiction to the description in a prior art document"

Decisions cited:

T 0056/87, T 0450/89, T 0278/00, T 0897/03

Catchword:

General and ambiguous disclosure in the abstract and claim of a prior art document construed in the light of the specific embodiments described in the document.



Case Number: T 0963/02 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 29 September 2004

Appellant: International Business Machines Corporation
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Armonk, NY 10504 (US)

Representative: Moss, Robert Douglas
IBM United Kingdom Limited
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Decision under appeal: Decision of the Examining Division of the
European Patent Office posted 20 December 2001
refusing European application No. 99301767.2
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. 99 301 767.2 was refused by the examining division in a decision dispatched on 20 December 2001 for the reason that the objections raised in its preceding communications were not met.

In its first communication, the examining division raised objections of lack of unity of invention, lack of clarity, novelty and inventive step. After amendments were filed by the applicant in response to the first communication, the second communication only dealt with the objection of lack of inventive step, in particular with respect to the independent product claim 1 and the independent method claim 7. In reply to the second communication, the appellant deleted the product claims and maintained the independent method claim 7 as the new claim 1. In the third communication dated 17 August 2001, it was stated that since the new claim 1 was identical to previous claim 7, the reasoning given in the first two communications still applied. The third communication then further set out why the arguments given in the appellant's letter of reply to the second communication were not found convincing.

The following prior art documents were cited by the examining division in its communication dated 17 August 2001:

D1: EP-A-0 725 439; and

D2: EP-A-0 751 567.

II. Claim 1 filed with the letter dated 2 August 2001 and forming the basis of the communication dated 17 August 2001 and of the decision under appeal has the following wording:

"1. A method for forming an interconnection structure for providing electrical connection to an electronic device (65) comprising the steps of:

depositing a copper alloy seed layer (76) on an electronic device,

said copper alloy seed layer comprising copper and 0.25 to 1.5 atomic percent of either Sn or In, and

forming a copper or copper alloy conductor body (56) on said copper alloy seed layer in intimate contact therewith."

III. The appellant (applicant) lodged an appeal on 18 February 2002, paying the appeal fee the same day. A statement of the grounds of appeal was filed on 29 April 2002.

IV. In response to a communication of the Board, the appellant filed new requests with the letter dated 5 July 2004.

V. 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 9 according to the primary request filed with the letter dated 5 July 2004

Description:

pages 1, 2, 3 and 13 as originally filed
pages 4, 7 to 12 and 14 as filed with the letter dated 6 February 2001
pages 5 and 6 filed with the letter dated 2 August 2001

Drawings:

sheets 1/3 to 3/3 as originally filed.

First auxiliary request:

Claims:

1 to 8 according to the first auxiliary request filed with the letter dated 5 July 2004

Description and Drawings as for the main request

Second auxiliary request:

Claims:

1 to 8 according to the second auxiliary request filed with the letter dated 5 July 2004

Description and Drawings as for the main request

Furthermore, oral proceedings were requested in case the Board contemplated dismissing the appeal.

VI. The objections raised by the examining division can be summarized as follows:

- (a) Document D1 teaches to deposit In or Sn before the deposition of a further conductor layer in order to reduce electromigration, i.e. a seed layer of In or Sn is formed. Alternatively, these materials can also be added during deposition of the conductor layer.

Although the passage on page 5, lines 34 to 36 of document D1 only mentions the use of In or Sn for an Al electrode, this statement is only considered as an example. Both claim 13 and the abstract mention Sn and In as suitable for reducing electromigration in both Al and Cu electrodes.

- (b) Document D2 discloses that the addition of In or Sn to a Cu electrode improves the resistance to electromigration of Cu.

The skilled person starting from document D1 and using the teaching of document D2 would as a matter of course carry out routine experiments in order to optimize the concentration of In or Sn. Since the concentration range disclosed in document D2 is very similar to that specified in claim 1, the skilled person would arrive at the claimed method of claim 1 without involving an inventive step.

- (c) Claim 1 does not provide any indication as to the concentration of Sn or In in the conductor body. Therefore, a conductor body having a composition

similar to that of document D2 falls within the scope of claim 1. Nevertheless, according to document D2, the concentration in the bulk is irrelevant, since after diffusion the concentration of In or Sn at the grain boundaries saturates at a value corresponding to about 1 to 2 weight percent, whereas the additional Sn/In is merely a reservoir. Document D2 further suggests that the presence of Sn/In in the conductor body impairs its conductivity. Thus, the skilled person would recognize that the Sn/In concentration in the conductor body is not essential, and therefore, the Sn/In elements inside the conductor body could be dispensed with.

- (d) Document D1 discloses that the elements Sn or In could also be deposited during the deposition of the Cu electrode (cf. D1, page 6, lines 32 to 43), which indicates that the initial Cu-Sn/In alloy layer would function as a seed layer for the further deposition.

VII. In support of his requests, the appellant presented essentially the following arguments in support of the inventive step:

- (a) Document D1 only discloses a seed layer made of (pure) Sn or In for a conductor made of Al. Except for the abstract and claim 13 which specify a conductor made of Al or Cu and a seed layer made of, among others, Sn or In, there is no explicit suggestion in document D1 that Sn or In would be suitable for Cu or copper alloys. It is held in T 56/87 and T 450/89 that the technical disclosure

of a prior art document should be considered in its entirety.

- (b) It would not be obvious from reading document D2 to modify the method of document D1 changing the composition of the seed layer from e.g. Pb or Ti in pure form to a copper alloy seed layer having only a low concentration of Sn or In. In particular, the preferred overall concentrations of 0.5 to 2.0 weight percent Sn disclosed in document D2 could not be achieved with a seed layer alone.
- (c) The claimed method has the advantage that the electromigration resistance is enhanced without compromising the electrical resistivity of the overall conductor, whereas in the method of document D2, the high concentration of Sn/In in the bulk increases the electrical resistivity (see D2, column 6, lines 55 to 57).
- (d) The co-deposition referred to in document D1 (cf. item VI(d) above) does not suggest that the co-deposition is terminated to have a distinct alloy layer. Rather, the co-deposition appears to be a continuous process during formation of the complete conductor layer.

Reasons for the Decision

1. The appeal complies with Articles 106 to 108 and Rule 64 EPC and is therefore admissible.

2. *Formal matters*

Rule 68(2), first sentence, EPC, provides that decisions of the EPO which are open to appeal shall be reasoned. The decision must contain, in logical sequence, those arguments which justify the tenor. All facts, evidence and arguments which are essential to the decision must be discussed in detail (T 278/00, OJ EPO 2003, 546, see also T 897/03 of 16 March 2004). The absence of reasoning satisfying the criteria of Rule 68(1), first sentence, EPC amounts to a substantial procedural violation requiring the decision under appeal to be set aside and, in application of Article 111(1) EPC, remittal of the case to the first instance, at least to be considered (see T 897/03, point 7 of the reasons).

The decision of the examining division refusing the application-in-suit has only been reasoned by a reference to preceding communications, in particular to the communication dated 17 August 2001.

- 2.1 If a decision is merely reasoned by a reference to a preceding communication the requirement of Rule 68(2), first sentence, EPC is only met if the communication referred to fulfils itself the above defined conditions. The decisive reasons for refusal must be clear from the reference, for the party and for the board of appeal. This applies, in particular, if reference is made to more than one preceding communications, dealing with a number of issues, and possibly having as basis different sets of claims. The decision under appeal must not leave it to the board and the appellant to speculate as to which of the reasons given in preceding

communications might be essential to the decision to refuse the application (T 897/03, point 3 et seq. of the reasons).

- 2.2 In the present case, whereas the first communication of the examining division contained objections of lack of unity of invention, lack of clarity, lack of novelty and inventive step, the second and third communications only dealt with the objection of lack of inventive step (cf. item I above). In the third communication, the applicant was informed that the reasoning given in the previous two communications regarding inventive step still applied, since claim 1 was identical to the previous independent method claim. The communication further set out in detail why the arguments given in the appellant's letter of reply to the second communication were not found convincing.
- 2.3 In the Board's view the detailed reasoning on the objection of lack of inventive step given in particular in the third communication contains all the necessary elements to be expected from the reasons of a decision under Rule 68(1), first sentence EPC. It is also clear from the appellant's grounds of appeal that the appellant has understood the reference to the communications, and in particular the reference to the third communication, as meaning that the decision was based on the examiner's argumentation on inventive step. Furthermore, it appears from the statement of the grounds of appeal that the appellant has understood the substance of the objections raised. The Board is therefore satisfied that the requirements of Rule 68(1), first sentence, EPC are met in the present case.

3. *Amendments and Clarity*

- 3.1 Claim 1 according to the main request has the same wording as claim 1 which formed the basis of the decision under appeal.

With respect to independent method claim 8 as filed, claim 1 according to the main request further specifies that "the copper alloy seed layer comprises copper and 0.25 to 1.5 atomic percent of either Sn or In". This feature is disclosed on page 13, last paragraph of the application as filed. Since it is disclosed on page 12, first paragraph of the application as filed that the addition of Sn or In has the effect of improving the electromigration resistance relative to pure copper, the feature "such that electromigration resistance of said interconnection structure is improved" in claim 8 as filed has been omitted for clarity.

- 3.2 With respect to dependent claims 4 to 9 forming the basis of the decision under appeal, the dependent claims 4 to 9 of the present main request have been renumbered so that the previous dependent claim 4 corresponds to dependent claim 9, and the previous dependent claims 5 to 9 correspond to claims 4 to 8.

The Board is satisfied that the claims as amended comply with Articles 84 and 123(2) EPC.

4. *Main request*

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

4.1 Document D1 is a published European patent application and discloses methods of depositing Al or Cu interconnection structures in an integrated circuit device. In order to improve the crystalline properties of the Al or Cu electrode, and thereby improving the electromigration properties (cf. page 2, lines 34 to 35), it is suggested to use a seed layer made of In or Sn (among others) before depositing an electrode made of Al (cf. page 5, lines 34 to 35, page 6, lines 32 to 53; Examples 27, 29, and 30). Alternatively, In or Sn can be co-deposited with Al forming the electrode (cf. Examples 46, 48, and 55). For improving the electromigration properties of a Cu electrode, it is suggested to use at least one of Pb and Ti (cf. page 5, lines 35 to 36).

4.1.1 The abstract of document D1 contains the following passage reproducing the wording of claim 13:

"A method for manufacturing an electronic part, comprising the step of depositing a conductor layer which is mainly formed of one selected from Al and Cu on a substrate via an insulative layer, a barrier layer, a contact layer or an amorphous thin film layer wherein one element selected from Ga, In, Cd, Bi, Pb, Sn and Tl is supplied before or during the deposition of the conductor layer."

4.1.2 The examining division observed that the abstract and claim 13 of document D1 which is a published European patent application, can be construed as suggesting that Sn or In is supplied before or during the deposition of electrodes layer made of Cu or Al. The Board, however, observes that in the detailed description in document

D1 of the invention, there is no disclosure of the case of Sn or In in combination with Cu electrodes. In particular, from the 55 different Examples presented in document D1, Examples 1, 20, 26, 28, 34, 36, 42, 43, 44, 51 and 54 concern Cu or Cu-alloy wiring. None of these examples disclose seed layer containing In or Sn. In Examples 27, 29, and 30 and in Examples 46 to 48 and 55, In or Sn is supplied before or during the deposition of a conductive film, but the film is always an Al film.

4.1.3 As held in the decisions T 56/87 and T 450/89 cited by the appellant (cf. item VII(a) above), the technical teaching of a prior art document should be considered in its entirety (cf. T 56/87, headnote, reasons 3.1; T 450/89, reasons 3.11). In the present case, document D1 is an unexamined European patent application. Taking into account that the claims in a patent application should be supported by the description (Article 84 EPC), and the abstract should summarize the disclosure of the invention as contained in the description (Rule 33(2) EPC), it follows that general and ambiguous disclosure in the claims and the abstract has to be construed in the light of the specific embodiments described, which, in the present case, clearly does not disclose the use of In or Sn as a seed material for a Cu conductor.

4.1.4 Thus, document D1 does not disclose a method of forming an interconnection structure where a copper alloy layer comprising copper and either Sn or In is deposited, since document D1 teaches to use either Ti or Pb for this purpose.

4.2 Document D2 discloses a method of depositing a Cu interconnection structure having improved resistance against electromigration (cf. column 4, lines 49 to 56). This is achieved by co-depositing Cu and an alloying element, such as Sn and In. After a subsequent annealing step, In or Sn will concentrate at Cu grain boundaries and interfaces (cf. column 6, line 35 to column 7, line 5). The concentration of Sn/In is 0.01 to 10 weight percent, which corresponds to 0.05 to 5.4 atomic percent for Sn. The preferred range is 0.5 to 2 weight percent which corresponds to 0.27 to 1.07 atomic percent Sn and 0.28 to 1.11 atomic percent In (cf. column 5, lines 53 to 54; column 9, lines 47 to 53). It is also disclosed that a high concentration of In or Sn in the bulk lowers the conductivity of the electrode (cf. column 6, lines 52 to 57).

4.2.1 Thus, the method of claim 1 differs from that of document D2 in that a copper alloy seed layer comprising copper and Sn or In in the concentration specified in the claim is deposited before a copper or copper alloy conductor layer is formed, whereas in the method of document D2, Sn or In is co-deposited with Cu to form the Cu electrode.

4.3 It follows from the above that document D2 should be considered the closest prior art, since it discloses the addition of In or Sn in a Cu electrode with a view to improving the electromigration resistance. Document D1 which was cited by the examining division as closest prior art does not disclose the use of In or Sn for improving the electromigration properties of Cu electrodes, but instead uses Ti and Pb for this purpose.

- 4.4 The method of document D2 has the disadvantage that addition of In or Sn in the Cu electrode increases the electrical resistivity of the electrode (cf. column 9, Table 1). Therefore, the technical problem addressed by the application in suit relates to improving the electromigration resistance of a Cu electrode without compromising the resistivity of the overall electrode (cf. item VII(c) above).
- 4.5 The skilled person starting from document D2 would not arrive at the method according to claim 1 without exercising inventive skills, since there is no suggestion in the prior art documents suggesting a copper alloy seed layer containing In or Sn in the range as specified in claim 1. The combined teachings of documents D1 and D2 would instead suggest to the skilled person to use co-deposition of Cu and In or Sn, since this method is described in both the documents. As a second possibility, the skilled person would consider a method of depositing a seed layer made of pure In or Sn before the Cu electrode layer is deposited.
- 4.6 The examining division argued that since the problem of increased electrical resistivity was recognized in Document D2 to result from high concentration of In or Sn in the bulk of the Cu electrode, the skilled person would as a matter of routine seek to minimize the amount of In or Sn in the bulk, and would therefore as a matter of course seek to reduce the concentration of In or Sn in the seed layer (cf. item VI(c) above).

4.6.1 This argument, however, ignores the fact that document D2 teaches to distribute the solutes In or Sn evenly throughout the electrode, since according to document D2, an annealing step is considered important in order for the solute (Sn or In) to diffuse and concentrate at the Cu interfaces and the grain boundaries of Cu alloy grains throughout the electrode. In the case of Sn, the grain boundaries are saturated with Sn ions in Cu-Sn alloys containing about 1 to 2 weight percent Sn (cf. column 6, lines 35 to 47). Furthermore, Figure 11 shows the line resistance change as a function of electromigration stress time for different copper alloys. The sample having the best electromigration properties contains 1 weight percent of In. It also follows from Figure 11 that in case of Sn, it would be worthwhile to use a concentration significantly higher than 1 weight percent, in order to attain a high electromigration resistance.

4.6.2 Thus, document D2 teaches that at least 1 weight percent In and even more Sn should be added in a Cu electrode in order to attain high electromigration resistance. Translated into atomic percent, which is the unit used in claim 1, this corresponds to a lower limit of about 0.54 atomic percent *in the bulk of the electrode*. This value has to be compared to the claimed method which specifies 0.25 to 1.5 atomic percent *in the seed layer only*.

Therefore, judging from the Sn/In concentrations in the bulk disclosed in document D2, the skilled person would not consider using a seed layer with the low Sn/In concentration as claimed.

4.7 The examining division argued that a co-deposition of Sn or In with copper of the kind disclosed in documents D1 and D2 would mean that the initial Cu-Sn/In alloy layer would function as a seed layer for the further deposition (cf. item VI(d) above).

As the appellant convincingly argued, the co-deposition as disclosed in both of the document D1 and D2 is a continuous process during the formation of the complete conductor layer, in contrast to the method according to claim 1 in which a distinct alloy layer is formed before a separate step of forming the conductor body the seed layer is carried out. There is no teaching in documents D1 or D2 that would suggest otherwise.

4.8 For the above reasons, in the Board's judgement, the subject matter of claim 1 according to the main request involves an inventive step within the meaning of Article 56 EPC.

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 with the following documents:

Claims:

1 to 9 according to the primary request filed with the letter dated 5 July 2004

Description:

pages 1, 2, 3 and 13 as originally filed
pages 4, 7 to 12 and 14 as filed with the letter dated 6 February 2001
pages 5 and 6 filed with the letter dated 2 August 2001

Drawings:

sheets 1/3 to 3/3 as originally filed.

The Registrar:

The Chairman:

D. Meyfarth

R. K. Shukla