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D E C I S I O N
of 6 April 2005

Case Number: T 0509/03 - 3.4.3

Application Number: 97308454.4

Publication Number: 0838848

IPC: H01L 21/321

Language of the proceedings: EN

Title of invention:
Plasma etching of a metal layer comprising copper

Applicant:
Texas Instruments Incorporated

Opponent:
-

Headword:
Plasma etching/Texas Instruments

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no)"

Decisions cited:
-

Catchword:
-

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0509/03 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 6 April 2005

Appellant: Texas Instruments Incorporated
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Representative: Holt, Michael
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 2 December 2002 refusing European application No. 97308454.4 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: V. L. P. Frank
Members: G. L. Eliasson
P. Mühlens

Summary of Facts and Submissions

I. European patent application No. 97 308 454.4 was refused in a decision of the examining division dated 2 December 2002 on the ground that the requirement of inventive step was not met having regard to the documents

D1: US-A-4 919 750; and
D2: JP-A-06 177 084 together with a translation in English.

II. The appellant (applicant) lodged an appeal on 31 January 2003, paying the appeal fee the same day. A statement of the grounds of appeal was filed on 2 April 2003.

III. At the oral proceedings held on 6 April 2005, the appellant filed amended claims and description pages. The appellant requested that the decision under appeal be set aside and a patent be granted on the basis of the following documents:

Claims 1 and 2 filed during the oral proceedings,

Description pages 1 to 5 filed during the oral proceedings,

Drawings sheet 1/1 as originally filed

IV. Independent claims 1 and 2 according to the appellant's request read as follows:

"1. A method of fabricating an electrical device comprising the steps of:

forming a metal layer over a substrate, said metal layer comprising copper-doped aluminum comprising 1 to 4% by weight copper; and

etching said metal layer by subjecting it to a combination of plasma, a gaseous etchant comprising Cl_2, and a gaseous aluminum source selected from trimethylaminealane, dimethylethyl-aminealane, and dimethylethylaminedimethylalane."

"2. A method of etching a conductive structure comprised of copper-doped aluminum comprising 1 to 4% by weight copper and overlying a semiconductor substrate, said method comprising the step of:

subjecting said conductive structure to a combination of plasma, a gaseous etchant comprising Cl_2, and a gaseous aluminum source selected from trimethylaminealane, dimethylethyl-aminealane, and dimethylethylaminedimethylalane."

V. The appellant's arguments in support of his request can be summarized as follows:

(a) The application in suit relates to a method of plasma etching copper-doped aluminium having 1 to 4% by weight copper. Document D1, on the other hand, is concerned with plasma etching of "Cu-

rich" aluminium, that is more than 4% Cu, including pure copper (cf. D1, column 2, lines 8 to 13; paragraph bridging columns 2 and 3). Since document D1 lacks any indication that the method disclosed therein would be useful also for copper-doped aluminium having less than 4% Cu, the skilled person would not consider document D1 as a valid starting point for etching copper-doped aluminium.

(b) Document D1 consistently teaches to introduce a solid source of aluminium into the reaction chamber. Document D2 on the other hand discloses a gaseous aluminium source but only in the context of etching a metal where copper is the *main* ingredient. Therefore, only with hindsight can the teachings of the documents D1 and D2 be combined with the purpose of finding a method of etching copper-doped aluminium.

(c) Even if documents D1 and D2 were combined, such a combination would fail to arrive at the claimed invention, since the use of one of trimethylamine-alane, dimethylethylaminealane, and dimethylethyl-aminedimethylalane as a gaseous source of aluminium is not disclosed in any of the cited documents. The aluminium compounds specified in the claimed methods are chosen for their chemical properties, in particular their degree of chemical stability and ability to act as scavenger of chlorides. Therefore the compounds specified in independent claims 1 and 2 improve the etching of copper-doped aluminium over other aluminium source in a non-obvious manner.

Reasons for the Decision

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

2. *Amendments and Clarity*

Claim 1 corresponds to a combination of claims 1 to 3, 5, and 6 as filed, where the gaseous aluminium source has been restricted to the group consisting of trimethylaminealane, dimethylethylaminealane, and dimethylethylaminedimethylalane. Claim 2 corresponds to a combination of claims 7 to 9 and 11 to 13 as filed, with the same restricted group of possible gaseous aluminium sources as in claim 1. Claims 1 and 2 are furthermore clear.

The requirements of Articles 84 and 123(2) EPC are therefore met.

3. *Inventive step*

3.1 Document D1 discloses plasma etching of Cu-rich Al/Cu alloys having more than 4% Cu copper-doped aluminium using chlorine as etchant (cf. column 1, lines 61 to 66; column 2, lines 8 to 12). A source of aluminium in form of a powdered Al electrode or an Al wire is introduced in the reaction chamber to allow volatile Al-Cu-Cl compounds to form (cf. column 3, lines 18 to 22). As an example, a layer of pure copper is etched in a plasma formed of $BCl_3/Cl_2/CHCl_3/N_2$ in the presence of an aluminium wire (cf. D1, column 2, line 61 to column 3,

line 5), and in a second example, layers made of Al/3% Cu/2% Si are etched under the same conditions as for pure copper (cf. column 3, lines 6 to 17). It was also observed that the presence of an aluminium wire in the reaction chamber increases the etch rate of the 3% Cu-Si-Al alloy by about 50%. Residue build-up on the Al wire which eventually impaired the etching rate could be reduced to a certain degree by applying a bias voltage to the aluminium wire (cf. column 3, line 50 to column 4, line 12).

As an alternative to using an aluminium wire, it is suggested in document D1 to etch an Al layer in a Cl-based plasma in a second chamber, such that the reactive products from the second chamber could be controllably introduced into the chamber where the Cu/Al alloy is being etched (cf. column 4, lines 25 to 30).

3.2 The method according to claim 1 differs from that of document D1 in that a gaseous aluminium source selected from trimethylamineala ne, dimethylethylamineala ne, and dimethylethylaminedimethylala ne is introduced at the step of etching the copper-doped aluminium layer, whereas in document D1 an aluminium wire in the reaction chamber is employed as a source of aluminium.

3.3 Document D2 discloses plasma-etching of copper or a metal layer having copper as its main constituent using Cl as etchant (cf. paragraph 0001). The etching step is carried out by subjecting the metal layer to a combination of plasma, $SiCl_4$ as etchant, and a gaseous source of aluminium, such as trimethylaluminium or dimethylaluminiumhydride (cf. paragraphs 0010 and 0012).

The source of aluminium has the function of forming a Cu-Al-Cl compound which is volatile also at low temperatures (cf. paragraph 0008). As an alternative source of aluminium, a solid source, such as a ring, is also mentioned (cf. paragraph 0013).

3.4 The method according to claim 1 differs from that of document D2 in that a gaseous aluminium source selected from trimethylamineala ne, dimethylethylamineala ne, and dimethylethylaminedimethylala ne is introduced at the step of etching the copper-doped aluminium layer, whereas in document D2 a gaseous aluminium source such as trimethylaluminium or dimethylaluminiumhydride is used. Furthermore, the claimed method is for etching copper-doped aluminium having 1 to 4% Cu, whereas document D2 addresses etching of a metal having Cu as its main ingredient.

3.5 The appellant argued that document D1 would be an inappropriate starting point for assessing inventive step (cf. item V(a) above). The Board is unable to share this view, since document D1 relates to the same kind of etching (reactive plasma etching using chlorine as etchant) for etching the same type of materials (aluminium with copper added). In particular, document D1 discloses the etching of a layer made of an Al/Cu/Si alloy having 3% Cu (cf. D1, column 3, lines 6 to 8), a layer having a composition within the claimed range.

3.6 The method of document D1 has the disadvantage that the aluminium wire eventually gets coated with Al-Cl residual products impairing the etching process (cf. D1, column 3, lines 12 to 17). Although a bias voltage applied to the aluminium wire relieves this problem, it

appears that the use of a bias voltage does not completely prevent the process of passivating the aluminium wire but only slows it down. As a result, the aluminium wire eventually has to be replenished or replaced, even when a bias voltage is applied to the aluminium wire (cf. column 3, lines 15 to 17; column 3, line 50 to column 4, line 31). The different measures suggested in document D1 in addition to a bias voltage (use of a second reaction chamber or a spool of Al wire in a separate housing) have other drawbacks, such as being bulky and complicated.

3.7 Having regard to document D1, the objective technical problem addressed by the application in suit therefore relates to finding an alternative to the solid source of aluminium which does not have the above-mentioned drawbacks.

3.8 Since document D1 discloses that the method disclosed therein works for etching 3% Cu aluminium alloys as well as pure copper, the skilled person would in the Board's view take the teaching of document D2 into account when seeking an improved method of etching copper-doped aluminium. It is also noted that in document D2, a biased solid source of aluminium is disclosed as an alternative to gaseous organic aluminium compounds, i.e. essentially the same process as that of document D1 (paragraph 0013; Figure 1).

Therefore, contrary to the appellant's arguments (cf. item V(b) above), the Board finds that the skilled person would have strong reasons to expect that gaseous organic aluminium compounds would be useful as a source of aluminium not only for etching pure copper but also

copper-doped aluminium layers having a copper content of less than 4%.

3.9 As acknowledged in the application in suit, at least trimethylamineala ne and dimethylethylamineala ne are used in the field of semiconductor technology as aluminium precursor in MOCVD processes, and therefore, their chemical and physical properties are known in the art (cf. column 2, lines 54 to 57). Furthermore, since document D2 discloses the use of gaseous organic aluminium compounds, such as dimethylaluminiumhydride, as suitable aluminium source (cf. paragraph 0012), the skilled person would consider other organic aluminium compounds as an aluminium source in the etching process of document D1, such as the aluminium compounds specified in claim 1, in particular those compounds which are used in other types of plasma processes (e.g. MOCVD) in the field of semiconductor technology.

3.10 The appellant alleged that the group of trimethylamineala ne, dimethylethylamineala ne, and dimethylethylaminedimethylala ne as specified in claim 1 had particularly favourable properties over other aluminium compounds for the etching process (cf. item V(c) above). These arguments cannot be accepted, since the application as filed does not contain any indication that the above three compounds are better choices than the other aluminium compounds (dimethylaluminium hydride, trimethylaluminium, dimethylala ne, and $AlCl_3$) mentioned in the application as filed (cf. application as published, column 2, lines 52 to 58). Although the application as filed discloses a high etching rate (7500 Å/min) for etching copper-doped aluminium, it is not disclosed which

aluminium source was used for attaining this etching rate (cf. column 3, lines 6 to 12). Therefore, the skilled person could only infer from reading the application as filed that any of the aluminium compounds mentioned in column 2, lines 52 to 58 as possible aluminium sources would be suitable for this purpose, and that none of the aluminium compounds mentioned has particularly favourable effects on the etching process.

3.11 For the above reasons, the subject matter of claim 1 does not involve an inventive step within the meaning of Article 56.

The subject matter of independent claim 2 does not involve an inventive step for the same reasons as for claim 1.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

U. Bultmann V. L. P. Frank