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D E C I S I O N
of 22 February 2001

Case Number: T 0143/96 - 3.4.3

Application Number: 90306832.8

Publication Number: 0405848

IPC: H01L 21/306

Language of the proceedings: EN

Title of invention:
Method and apparatus for tapered etching

Applicant:
AT&T Corp.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 123(2), 56

Keyword:
"Added subject-matter extending beyond the content of the application as filed (no - after amendments)"
"Inventive step - (yes) - not obvious to try"

Decisions cited:
-

Catchword:
-

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0143/96 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 22 February 2001

Appellant: AT&T Corp.
32 Avenue of the Americas
New York, NY 10013-2412 (US)

Representative: Johnston, Kenneth Graham
5 Mornington Road
Woodford Green
Essex, IG OTU (GB)

Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 15 September 1995 refusing European patent application No. 90 306 832.8 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: R. K. Shukla
Members: M. Chomentowski
M. J. Vogel

Summary of Facts and Submissions

I. European patent application No. 90 306 832.8 (Publication No. 0 405 848)was refused by a decision of the examining division dated 15 September 1995 on the ground that the application was amended in such a way that it contained subject-matter extending beyond the content of the application as filed, contrary to Article 123(2) EPC.

Claims 1 and 5 of the set of claims forming the basis of the decision under appeal read as follows:

"1. A method of semiconductor device fabrication comprising:

forming a first layer upon a substrate;

forming a second layer containing aluminum upon said first layer;

etching both said first and said second layer with a gas mixture,

characterized in that

said first layer is made from a material chosen from the group consisting of titanium-tungsten and titanium nitride, and said gas mixture contains chlorine and trifluoromethane and said etching step produces a tapered profile in both said first and said second layers."

"5. The method of claim 1, wherein

the first (sic) contains titanium-tungsten with at least five percent titanium by weight;

said second layer is covered with an anti-reflective coating;

said anti-reflective coating is covered with a patterned mask, and mask having a thickness of 2 µm or less;

said aluminum-containing layer is exposed to boron trichloride; and

said gas mixture of chlorine and trifluoromethane is present in a plasma and said chlorine has a flow rate between 16 and 6 sccm and said trifluoromethane has a flow rate less than 60 sccm, said gas mixture creating a polymeric layer in contact with said aluminum-coating layer (read "aluminum-containing layer") and said titanium-tungsten-containing layer and creating a tapered sidewall having approximately the same slope on both said aluminum-containing layer and said titanium-tungsten-containing layer."

II. In the decision under appeal, the examining division reasoned essentially as follows:

Additional subject-matter

Claim 5 contains the feature that the etching step produces tapered sidewall having **approximately the same slope** on both said aluminum-containing layer and said titanium-tungsten-containing layer.

However, no basis could be found for this feature in

the original documents. The term "slope" does not appear therein and it is not evident that it is synonymous to "angle of tapering". In particular, the term "angle of tapering" implies a linear sidewall only, whereas the term "slope" would also be applicable to a curved sidewall. Furthermore, in the original documents, reference is only made in general terms to the tapered sidewall profile in the case of two or more layers, no clear and unambiguous information being given concerning the angles of tapering of each of the layers in the case of two or more layered structures. The passages of the original application concerning the etching of stacked metal structures do not provide information about the individual angles of tapering in the individual layers of a multi-layered structure.

Therefore, the objected amendment results in additional subject-matter which was not directly and unambiguously derivable from the application documents as filed, and is therefore not admissible.

Further comments

A method of semiconductor device fabrication is known from document D2: EP-A-0 099 558, comprising:

forming a layer containing aluminum upon a substrate;

etching said layer with a gas mixture, whereby said gas mixture contains chlorine and trifluoromethane (CHF_3), and

said etching step producing a tapered profile.

The method of claim 1 differs therefrom in that a layer

of titanium-tungsten or titanium nitride (i.e. a barrier layer) underlying the aluminum-containing layer is provided which is also etched with a tapered profile.

Therefore, the problem underlying the invention can be seen as to provide a barrier layer in the semiconductor device and to etch it with a tapered sidewall profile.

However, providing a barrier layer of the present type is generally known to people skilled in the art, for instance from document **D3**: "VLSI Technology", S. M. Sze, 2nd edition, McGraw-Hill, 1988, pages 400 to 413. Moreover, it is desirable that this underlying barrier layer be etched with a tapered sidewall profile for the same reasons as those for etching the aluminum layer, and, since the gas mixture of document **D2** used for aluminum apparently gives good results for etching an aluminum-containing layer, it would be obvious to use it also for the barrier layer, thereby arriving in an obvious way at the claimed method. Moreover, the feature that this etching step produces a tapered profile in the aluminum layer and in the barrier layer indicates only a desired result without specifying any concrete measure to achieve the result.

Therefore, the subject-matter of claim 1 does not involve an inventive step, and the same applies to the dependent claims.

III. The applicant lodged an appeal against this decision on 10 November 1995 paying the appeal fee on 9 November 1995, and filed a statement of the grounds of appeal on 16 January 1996.

IV. In response to communications from the Board, the appellant (applicant) filed new claims and amended pages of the description, and requests that the decision under appeal be set aside and a patent be granted on the basis of the following patent application documents:

Description: Page 1 filed on 18 April 2000;
Pages 2 and 5 filed on 11 January 2001;
Pages 3, 4, 6 and 7 as originally filed;

Claims: Nos. 1 to 5 filed on 18 April 2000;

Drawings: Sheets 1/3 to 3/3 as originally filed.

The appellant has submitted the following arguments in support of his request:

Additional subject-matter

The term "slope" has a clear and unambiguous meaning, and this meaning is derivable from the whole content of the application as filed. It is disclosed in the application as filed that the term "metal layer" is used to denote a layered structure having one or more layers of aluminum-rich compositions together with layers of titanium nitride or titanium tungsten or titanium. Moreover, it is shown, in Figures 1 to 3, that the reference numeral 13 corresponds to such metal layers and that these metal layers are tapered and have a sidewall with a constant slope. Thus, these indications, together with the information derivable from Figure 5 and the corresponding text concerning tapered angles as a function of the spacing between adjacent metal layers, leave no doubt that the

expression concerning the same slope on both said aluminum-containing layer and said titanium-tungsten-containing layer was well disclosed in the application as filed.

Inventive step

It is known, for instance from document **D3**, to form stacked layers with for instance a barrier layer of titanium nitride or titanium tungsten beneath an aluminum-containing layer. However, it is not known from this prior art to etch these stacked layers simultaneously to produce a tapered profile in the successive layers.

It is known from document **D2** to etch aluminum using a gas mixture containing chlorine and trifluoromethane. However, it is not known from document **D2** whether the particular etching gas mixture of this document is also working for producing a tapered profile in stacked layers of different metallic compositions. Since there is no indication in the art to try a single etching system for a succession of overlying layers of different metals, it cannot be considered that it was obvious to try.

Furthermore, the method of document **D2** is for avoiding production of anything other than straight sidewalls in the aluminum layer and, in particular, for avoiding undercutting, i.e. lateral etching beneath the photoresist. It is not derivable from this document that the method is for producing a tapered profile whereby the aluminum protrudes beyond the patterned photoresist, as in the submitted claim 1.

Therefore, the subject-matter of claim 1 involves an inventive step.

Reasons for the Decision

1. The appeal is admissible.

2. *Admissibility of the amendments (Article 123(2) EPC)*

In the decision under appeal the objection under Article 123(2) EPC was raised in respect of the amendments in the dependent claim 5, specifying that the gas mixture creates a tapered sidewall having approximately the same slope.

In the present amended claim 5 as filed during the appeal proceedings on 18 April 2000, the term "approximately" has been deleted from the expression "approximately the same slope" in claim 5 forming the basis of the decision. The present claim 5 thus contains the feature that the gas mixture creates a tapered sidewall **having the same slope** on both the aluminum-containing layer and the titanium-tungsten-containing layer. In this connection, as pointed out in the decision under appeal, the term "**slope**", especially in the corresponding expression concerning the same slope*,* is not mentioned *expressis verbis* in the application as filed. Therefore, it needs to be considered whether it is unambiguously derivable from the description and the Figures taken together that the tapered sidewall of a "metal" layer (13) has the same slope on both the aluminum-containing layer and the titanium-tungsten containing layer.

From the description of the embodiment of the invention on page 2, line 12 et seq., as filed, it follows that the expression "metal layer" having a reference numeral (13) as shown in Figures 1 to 3 may denote a layered structure having a layer containing titanium-tungsten or titanium nitride beneath a layer of aluminum-rich composition. In the subsequent description of Figure 2 on page 3, lines 15 to 27 and in Figure 2, the metal layer (13) after etching is shown to have a tapered sidewall (19) subtending an angle è with substrate surface (11), the tapered sidewall having a straight linear profile. Thus, the application as filed discloses an embodiment wherein a layered structure of metal having a layer containing titanium-tungsten beneath a layer of aluminum-rich composition has a tapered sidewall which is not curved, but is straight throughout the thickness of the layered structure. Thus the tapered sidewall has the same slope on both the aluminum-containing layer and the titanium-tungsten containing layer as specified in claim 5.

According to the contested decision, it was not evident that the term "slope" is synonymous with "angle of tapering", and is also applicable to a curved sidewall. In the application as filed, however, reference is only made in general terms to the tapered sidewall profile in the case of two or more layers, and no clear and unambiguous information is given concerning the angles of tapering of each of the layers.

In the Board's view, however, according to the wording of claim 5, the tapered sidewall has **the same** slope on both layers. As this is realised only when there is a single value of the slope, i.e. when the tapered sidewall has the same straight profile on both the

layers, a curved sidewall profile is not implied by the wording of the claim.

For the foregoing reasons, in the Board's judgment, the present application satisfies the requirement of Article 123(2) EPC that a European patent application may not be amended in such a way that it contains subject-matter which extends beyond the content of the application as filed.

3. *Clarity of the claims*

It is to be noted that errors in the claims and inconsistencies between the claims and the description have been corrected by the amendments provided by the appellant. Therefore, the Board is satisfied that the claims are clear in the sense of Article 84 EPC.

4. *Novelty*

A method according to claim 1 of the set having formed the basis for the contested decision does not form part of the state of the art, and novelty has not been contested in the appealed decision either. Since present claim 1 is in substance identical with said claim, it is new in the sense of Article 54 EPC.

5. *Inventive step*

5.1 A method of semiconductor device fabrication is known from document **D2** (see page 3, lines 1 to 26; page 10, line 19 to page 12, line 10; Figure 10 and the corresponding text). The method comprises:

forming a layer containing aluminum upon a substrate

consisting of a body (the silicon substrate) and of three successive layers (field oxide, polysilicon and phosphosilicate glass);

etching said layer with a gas mixture,
said gas mixture containing chlorine and trifluoromethane (CHF_3).

5.2 Thus, contrary to the method of present claim 1, in the method known from document **D2,** there is

no step of forming a first layer under the layer containing aluminum, especially whereby said first layer is made from a material chosen from the group consisting of titanium-tungsten and titanium nitride, and

no step whereby both said first and second layer are etched with a gas mixture and the etching step produces a tapered profile in both the first layer of titanium-tungsten or titanium nitride and the second layer containing aluminum.

5.3 Thus, in the opinion of the Board, when starting from the method of document **D2**, the objective technical problem addressed by the invention as claimed in claim 1 is to produce a tapered profile in an aluminum-containing layer and in the underlying layer of titanium-tungsten or titanium nitride by using the same etchant gas mixture.

This problem corresponds in substance to the object of the present application (see page 1, lines 27 to 31; see also page 7, lines 25 to 27), and one of its advantages is that, as also credibly stressed by the

appellant, it allows to taper certain stacked metal structures by etching without necessitating a change of chemistry.

5.4 It has not been contested by the appellant that the use of layers comprising e.g. titanium-tungsten or titanium nitride under an aluminum-containing layer is generally known in the art, for instance from document **D3** (see page 409, third paragraph).

However, the cited passage of document **D3** does not contain any indication about a step of etching both said aluminum-containing layer and the underlying first layer of titanium-tungsten or titanium nitride.

Moreover, the specific step of present claim 1 of etching with a gas mixture containing chlorine and trifluoromethane (CHF_3) to produce a tapered profile in both an aluminum-containing layer and in an underlying first layer of titanium-tungsten or titanium nitride is not to be found in the further prior art documents which teach etching either without providing a tapered profile or etching with other gas mixtures or selective etching of specific layers such as silicon.

Thus, contrary to the contention of the examining division in the decision under appeal, the skilled person had no reason to expect that the gas mixture known from document **D2** for etching aluminum-containing layers would produce a tapered profile in a titanium-tungsten or titanium nitride layer.

5.5 Therefore, having regard to the state of the art, the method of present claim 1 is not obvious to a person skilled in the art, so that it involves an inventive

step in the sense of Article 56 EPC.

Consequently, the claim is patentable in the sense of Article 52(1) EPC and a patent can be granted on this basis.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the Examining Division with the order to grant a patent on the basis of the following patent application documents:

Description: Page 1 filed on 18 April 2000;
Pages 2 and 5 filed on 11 January 2001;
Pages 3, 4, 6 and 7 as originally filed;

Claims: Nos. 1 to 5 filed on 18 April 2000;

Drawings: Sheets 1/3 to 3/3 as originally filed.

The Registrar: The Chairman:

L. Martinuzzi R. Shukla