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D E C I S I O N
of 15 April 2002

Case Number: T 0729/98 - 3.4.3

Application Number: 92300634.0

Publication Number: 0496637

IPC: H01L 29/40

Language of the proceedings: EN

Title of invention:
High purity conductive films and their use in semiconductors

Applicant:
KABUSHIKI KAISHA TOSHIBA

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Main request - inventive step (denied) - disclosed technical problem not addressed by the claimed subject-matter"
"First auxiliary request -inventive step (yes) - technical problem addressed by the claimed subject-matter"

Decisions cited:
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Catchword:
-

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Case Number: T 0729/98 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 15 April 2002

Appellant: KABUSHIKI KAISHA TOSHIBA
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 13 March 1998 refusing European patent application No. 92 300 634.0 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: R. K. Shukla
Members: M. Chomentowski
J. H. Van Moer

Summary of Facts and Submissions

I. European patent application No. 92 300 634.0 (Publication No. 0 496 637) was refused by a decision of the examining division dated 13 March 1998 on the ground of lack of inventive step having regard to prior art documents

D1: FR-A-2 530 383,

D3: Patent Abstracts of Japan, vol. 13, No. 24 (C-561), 19 January 1989 & JP-A-63227771, and

D4: Patent Abstracts of Japan, vol. 15, No. 86 (E-1039), 28 February 1991 & JP-A-230 20 42, 14 December 1990.

II. Claim 1 of the main request filed with the letter dated 19 September 1996 and claim 1 of the auxiliary request filed with the letter dated 22 January 1998, forming the basis of the decision, read as follows:

Main request

"1. A high purity conductive film useful as a contact barrier and/or as a gate electrode, which film is composed of conductive material whose content of:

(i) aluminium is $\leq 1 \times 10^{18}$ cm^{-3}."

Claims 2 to 10 are dependent claims.

According to dependent claims 3 and 4 of the main request, titanium silicide was such a conductive material.

Auxiliary request

"1. A semiconductor device including a contact barrier and/or a gate electrode either or both of which is constructed of high purity conductive film composed of conductive material whose content of:

(i) aluminium is $\leq 1 \times 10^{18}$ cm^{-3}."

Claims 2 to 10 are dependent claims.

According to dependent claims 4 and 5 of this auxiliary request, titanium silicide and combinations such as TiW can be used as the conductive material.

III. In the decision, it is argued essentially as follows:

The closest prior art is considered to be document D3, which discloses a titanium silicide target whereby the metallic impurities are restricted to ≤ 10 ppm for sputtering a conductive film in order "to suppress incorrect working by the influence of impurities".

The subject-matter of claim 1 of the main request differs therefrom in that the Al concentration of a conductive film is $\leq 1 \times 10^{18}$ cm^{-3}.

The objective problem to be solved by the present application may therefore be seen as providing a conductive film which is as pure as possible.

No positive contribution to inventive step can be seen in formulating this particular problem since it is well known in the field of semiconductor technology that impurities may influence the properties of conductive films. In this context, it is clear to the skilled person that the author of document D3, in disclosing explicitly the negative influence ("to suppress

incorrect working by the influence of impurities"), was concerned with obtaining a target of the highest purity possible.

The solution proposed in claim 1 of the main request cannot be considered as involving an inventive step since document D3 discloses that the metallic impurities in the target "are restricted to" ≤ 10 ppm. The claimed upper limit of the Al-concentration is just the result of standard trial-and-error experiments in order to find out the critical impurity concentration for a specific device, in the present case the critical impurity concentration influencing the leakage current of a diode.

Although document D3 does not disclose explicitly a conductive film made from the sputtering target, it is obvious that such a conductive film proportionally contains the types and concentration of the components of the target in the case that all other sputtering parameters are kept equal.

The limitation of the auxiliary request, i.e. the application of the conductive film to a contact barrier and/or a gate electrode, does not add inventive subject-matter. Conductive barriers and/or gate electrode are well known, cf. e.g. documents D1 and D4 both disclosing TiW barriers. The claimed upper limit for the aluminium impurity concentration does not involve an inventive step since the skilled person having the knowledge of document D3 would try to prepare the barriers disclosed in e.g. document D1 to be as pure as possible in order to avoid a possible negative influence of impurities, as already set forth here above.

It is considered that there is an obvious link between the composition of a target, as e.g. disclosed in document D3, and the Al impurity concentration in the conductive film prepared by sputtering.

Regarding the issue of the Al content of a film being higher than that of the sputtering target, as argued by the applicant with the declaration accompanying his letter dated 19 September 1996, this is immaterial to the question of inventiveness, since as established above, in a "high purity" film an impurity concentration which is as low as possible is generally to be sought after. Thus, the identification of a specific impurity with an upper limit for its concentration in a "high purity" conductive film does not involve an inventive step for the reasons given above.

Therefore, the subject-matter of claim 1 of both requests does not involve an inventive step.

IV. The applicant lodged an appeal against this decision on 12 May 1998, paying the appeal fee on the same day. A statement setting out the grounds of the appeal was filed on 8 July 1998.

The applicant requested that the decision under appeal be set aside and that a patent be granted on the basis of one of the submitted requests, with pages 1 to 38 and drawings sheets 1/10 to 10/10, as filed, with amendments of the description if necessary. The applicant's main request and first auxiliary request are identical with the main request and the auxiliary request forming the basis of the decision of the examining division, respectively.

The applicant also requested that in the event that the Board is not persuaded to hold the claims of the main request or the first auxiliary request allowable, oral proceedings should be appointed.

V. In the statement setting out the grounds of the appeal, the applicant essentially argued as follows:

The "problem and solution" approach to the assessment of inventive step by the examining division is wrongly based in both stating the problem and identifying the most relevant state of the art. The problem to be solved by the invention is not the formation of a conductive film as pure as possible, but rather to reduce or suppress leakage current in semiconductor devices. None of the cited prior art documents refers to this problem, so that the cited prior art is not relevant to the patentability of the claims.

Reasons for the Decision

1. The appeal is admissible.

2. *Main request - Inventive step*

Claim 1 concerns a high purity conductive film useful as a contact barrier and/or as a gate electrode, which film is composed of conductive material whose content of aluminium is $\leq 1 \times 10^{18}$ cm^{-3}.

The appellant has pointed out that from the present patent application (see page 2, second paragraph, page 5, second paragraph and page 6, penultimate paragraph) it is derivable that the leakage current of semiconductor devices causes malfunctions and reduced reliability, that it is an object of the present

invention to suppress and minimize leakage current in semiconductor devices and that the inventors have found that the magnitude of leakage current depends on the Al concentration in the contact barrier layer or gate electrode material. It was contended by the appellant that the formulation of the objective technical problem in the decision under appeal, i.e. the formation of a conductive film which is as pure as possible, is wrong as it did not take into account the technical effect, i.e. the suppression of leakage current, which has been described in the application.

The Board however does not accept the appellant's submission that the formulation of the objective technical problem in the decision under appeal was wrong for the following reasons:

It follows from the wording of claim 1, "A high purity conductive film **useful** as a contact barrier and/or a gate electrode..." that the high purity conductive film **as claimed** is not limited to its use as a contact barrier and/or a gate electrode in a semiconductor device. Consequently, the high purity conductive film as such may be used for a purpose which is in no way related to a semiconductor device, where the problem of leakage current may not even arise.

The Board therefore agrees with the finding in the decision under appeal that document D3 is a relevant prior art document. Document D3 discloses a high purity sputtering target which can be used for the formation of high purity titanium nitride films containing aluminium in the amount of 6 ppm. This has not been disputed by the appellant. Moreover, the Board agrees with the examining division that there is a clear teaching in document D3 that metallic impurities including aluminium in the sputtering target and

consequently in the sputtered film have detrimental effect on the working in general of the film. To a skilled person concerned with providing a high purity conductive film, it was therefore obvious to reduce the concentration of all the metallic impurities including aluminium as much as possible. As regard the upper limit of 1×10^{18} cm^{-3} for aluminium in the claim, in the Board's view, this is to be regarded as an arbitrary limit without any unexpected technical effect in a conductive film as claimed, i.e. in a conductive film which is not a contact barrier or a gate electrode.

For the foregoing reasons, in the Board's judgement, the subject-matter of claim 1 of the main request lacks an inventive step in the sense of Article 56 EPC.

3. *First auxiliary request*

The only issue concerning the first auxiliary request is that of inventive step.

3.1 In contrast to claim 1 of the main request, claim 1 of the first auxiliary request concerns a semiconductor device including a barrier contact or a gate electrode which is made of a high purity conductive film as set out in the claim.

As pointed out by the appellant, the description of the patent application (see for instance the second paragraph on page 2 and the statement on page 4, from line 3) discloses that the leakage current of semiconductor devices causes malfunctions and reduces reliability, and that therefore it is desirable to minimise leakage current, especially as the down-scaling of semiconductor devices continues in the future; in spite of known successful techniques, there is a need for further improvements.

As further pointed out by the appellant, the description of the patent application (see the passage beginning at the bottom of page 6) discloses that the inventors found that the problem of leakage current could be minimised or suppressed by a contact barrier and/or a gate electrode having an aluminium content $\leq 1 \times 10^{18}$ cm^{-3}. This is shown in particular in the leakage current characteristics of the semiconductor devices disclosed in the application. It also follows from the leakage current characteristics shown in the drawings that the leakage current is substantially reduced and remains substantially constant with an increasing voltage for aluminium content of $\leq 1 \times 10^{18}$ cm^{-3}. Thus, the upper limit of aluminium content is not an arbitrary value but has a significant unexpected effect on the leakage current.

In view of the above, the semiconductor device as claimed addresses the technical problem of minimising or suppressing the leakage current and provides a solution to the same by controlling the amount of aluminium as specified in the claim.

As contended by the appellant, document D3 does not attach any particular importance to aluminium as an impurity and in particular there is no disclosure in the document which links aluminium to giving rise to leakage currents in a semiconductor device. Furthermore, it is not derivable from the document that the content of aluminium has to be $\leq 1 \times 10^{18}$ cm^{-3} to reduce the leakage current. It was therefore not obvious to a skilled person to reduce the aluminium content in the target of document D3 with a view to reducing leakage current in the sputtered film.

The remaining prior art documents D1 and D4 cited in the decision under appeal relate to semiconductor devices employing conductive films e.g. TiW as barrier electrodes. These documents do not address the problem of leakage currents and hence are not relevant.

3.2 For the foregoing reasons, the Board comes to the conclusion that the subject-matter of claim 1 was not obvious to a person skilled in the art and, thus, it involves an inventive step in the sense of Article 56 EPC.

4. Consequently, claim 1 is patentable in the sense of Article 52(1) EPC.

Claims 2 to 10, which are dependent claims, are also patentable for the same reasons.

Since a patent can be granted on the basis of the claims of the first auxiliary request, the further auxiliary requests of the appellant, in particular the request for oral proceedings, need not to be considered (Article 97(2) EPC).

However, the description, which in particular is not restricted to semiconductor devices and wherein the content of aluminium in the film is disclosed as being less than 1×10^{18} cm^{-3} (see e.g. page 1, first paragraph and page 5, third paragraph), needs to be amended for consistency with claim 1 of the first auxiliary request.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the first instance with the order to grant a patent on the basis of the appellant's first auxiliary request consisting of:

Claims: Nos. 1 to 10 (auxiliary request), filed with the letter dated 22 January 1998;

Description: Pages 1 to 38 as filed, to be adapted to the claims.

Drawings: Sheets 1/10 to 10/10 as filed.

The Registrar: The Chairman:

D. Spigarelli R. K. Shukla

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