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D E C I S I O N
of 15 November 1999

Case Number: T 0791/95 - 3.4.1

Application Number: 90304044.2

Publication Number: 0393958

IPC: C23C14/35

Language of the proceedings: EN

Title of invention:
Method and apparatus for sputter coating stepped wafers - case a

Applicant:
Tokyo Electron Limited

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (yes)"

Decisions cited:
-

Catchword:
-

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Case Number: T 0791/95 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 15 November 1999

Appellant: Tokyo Electron Limited
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Decision under appeal: **Decision of the Examining Division of the European Patent Office dated 2 May 1995 refusing European patent application No. 90 304 044.2 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: G. Davies
Members: M. G. L. Rognoni
G. Assi

Summary of Facts and Submissions

I. The appellant (applicant) lodged an appeal, received on 10 July 1995, against the decision of the Examining Division, dispatched on 2 May 1995, refusing the application No. 90 304 044.2 (publication No. 0 393 958). The fee for the appeal was paid on 10 July 1995 and the statement setting out the grounds of appeal was received on 11 September 1995.

II. In the decision under appeal, the Examining Division held that the claimed subject-matter did not meet the requirements of Articles 52(1) and 56 EPC, having regard, in particular, to the following document:

D1: US-A-4 747 926

and to the skilled person's general knowledge.

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

Claims: No. 1 to 27 as filed with a letter dated 21 September 1999,

Description: pages 7, 7a, 11 and 11a as filed with the letter dated 21 September 1999,
pages 1, 14, 17, 18, 21, 26, 29 to 31, 33, 34, 40, 43, 46, 48, 49, 52, 55 and 58 as filed with a letter dated 10 February 1994,
pages 2 to 6, 8 to 10, 12, 13, 15, 16, 19,

20, 22 to 25, 27, 28, 32, 35 to 39, 41, 42, 44, 45, 47, 50, 51, 53, 54, 56, 57, 59 and 60 as originally filed;

Drawings: Sheets 1/7 to 7/7 as originally filed.

IV. The wording of claim 1 reads as follows:

"1. A sputtering target (21) adapted to conform as a replacement item in a magnetron sputtering apparatus (10) comprising a single unitary piece of sputtering material having a sputtering surface (22) which is smoothly contoured and symmetrical about a central axis at least over the regions thereof from which the sputtering takes place, which piece is varied in thickness along a cross-section perpendicular to the sputtering surface, the target (21) having an inner sputtering region (94) and an outer sputtering region (95), the thickness of the sputtering material underlying the outer region (95) continuously increasing outwardly from the inner region (94) to a thickness greater than that underlying the inner region (94), characterised in that the sputtering surface (22) is concave curved and of continuously varying slope in a plane containing the axis of symmetry at least over the regions thereof from which sputtering takes place."

The wording of claim 9 reads as follows:

"9. A magnetron sputtering apparatus (10) comprising a target (21) as claimed in any preceding Claim, means (40) for generating first and second plasma supporting magnetic fields (89, 90) adjacent, respectively, first

and second target regions (94, 95) on the sputtering surface (22) and means (50, 51) for energising the target (21) to sputter material from the first and second regions (94, 95) in accordance with the generation of the respective magnetic fields (89, 90) onto a substrate (14) supported in a plane in spaced relationship with the sputtering surface (22)."

The wording of claim 22 reads as follows:

"22. A method of depositing a desired distribution of material from a target onto one or more surfaces of a substrate spaced therefrom by means of a sputtering process comprising providing, within a magnetron sputtering apparatus, a replaceable unitary one-piece sputtering target having a thickness which is varied along a cross-section perpendicular to the sputtering surface, providing the piece with a sputtering surface which is smoothly contoured and symmetrical about a central axis at least in a first inner and a second outer sputtering regions thereof, the thickness of the sputtering material underlying the outer region continuously increasing outwardly from the inner region to a thickness greater than that underlying the inner region, energizing the target, and providing controlled magnetic fields in said first and second regions, characterised in that sputtering is conducted from regions of the sputtering surface (22) which are concave curved and of continuously varying slope in a plane containing the axis of symmetry."

V. The appellant's arguments may be summarized as follows:

A constant problem faced in the sputtering art was the

achievement of a uniform coating on the substrate surface. Particular difficulties arose when the substrate was not flat, but included steps and holes, the sides of which needed to be coated. Since none of the cited prior art documents suggested solving the above problem by providing a sputtering target as specified in claim 1 of the present application, the subject-matters of claims 1 and 9, and of the corresponding method claim 22, involved an inventive step within the meaning of Article 56 EPC.

Reasons for the Decision

1. The appeal is admissible.

2. Claims 1 and 22 differ from the corresponding claims considered in the contested decision in that it is now specified that the sputtering surface is "symmetrical about a central axis" and of continuously varying slope "in a plane containing the axis of symmetry". These amendments find support in the application as filed and are, therefore, admissible under Article 123(2) EPC. Claim 9 is unchanged.

3. The present application deals, inter alia, with the problem of achieving uniformity in the coating applied to the surface of a substrate comprising grooves or holes, i.e. "steps", which need to be coated to provide for electrical conduction between various conductive circuit layers joined by stepped surfaces.

The invention is based essentially on the realization that a sputtering target with a concave curved surface

of continuously varying slope results in better proximity and sputtering angles for the differently facing surfaces of stepped substrates.

4.1 D1 addresses the problem of "improving step coverage of the outer side step in the periphery of a wafer as a film forming object so as to provide an even film on an entire wafer" (D1, column 1, line 67 to column 2, line 3). The sputtering targets shown in D1 comprise all the features recited in the preamble of claim 1.

Furthermore, it is specified in D1 that "the target has an inclined surface composed of at least two parts of conical side faces" (D1, column 2, lines 5 to 6). In the embodiment shown in Figure 5 "the entire target surface faces the wafer center and consists of two inclined surfaces 13, 13' having different inclination angles, respectively. Target surfaces 13, 13' are smoothly connected so that a sharp oblique junction is not made, thereby preventing electric field concentration at a junction 18 and so selective sputtering" (D1, column 3, lines 29 to 35).

In other words, D1 teaches to use a sputtering target with a surface comprising two **frusto-conical** sections and a **smooth junction** between them.

4.2 Hence, the subject-matter of claim 1 differs from the target according to D1 in that:

"the sputtering surface is concave curved and of continuously varying slope in a plane containing the axis of symmetry over the regions thereof from which sputtering takes place".

5.1 According to the Examining Division, it was obvious to the skilled person, wishing to avoid any undesirable concentration of the electric field on the sputtering surface, to extend the teaching of D1 to the whole surface and, thus, to arrive at a concave shape with a continuously varying slope. The Examining Division further argued that any possible further technical effects brought about by the claimed target shape would merely constitute a bonus effect which, as such, did not imply an inventive step.

5.2 However, although it teaches that a smooth curved surface **at the junction** between two inclined surfaces of a sputtering target should be provided, D1 does not imply that the "flat" portions of the sputtering target could be advantageously replaced by a concave surface of continuously varying slope in order to avoid electric field concentration. In fact, a person skilled in the art had no reason to expect that a concave curved surface according to claim 1, i.e. a surface with a finite radius of curvature, should provide an electric field which was more homogeneous than the field obtainable with a "flat" surface, i.e. a surface with an infinite radius of curvature.

Furthermore, there is no suggestion in the available prior art that a concave curved surface could improve coating uniformity of stepped substrates or provide any other beneficial effects.

5.3 Since, in the Board's opinion, it was not obvious in the light of the cited prior art to arrive at a sputtering target falling within the terms of claim 1, the subject-matter of this claim involves an inventive

step within the meaning of Article 56 EPC.

6. Claim 9 relates to a magnetron sputtering apparatus comprising the claimed sputtering target. Claim 22 is based essentially on the same features of claims 1 and 9 expressed in terms of method steps. For the same reasons given above, their subject-matters equally fulfil the requirements of Article 56 EPC.

7. Claims 2 to 8, 10 to 21 and 23 to 27 are dependent and, therefore, their subject-matters also involve an inventive step.

8. Hence, the Board concludes that the appellant's request is allowable and that a patent can be granted on the basis thereof.

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: No. 1 to 27 as filed with the letter dated 21 September 1999;

Description: pages 7, 7a, 11, 11a as filed with the letter dated 21 September 1999;

pages 1, 14, 17, 18, 21, 26, 29 to 31, 33, 34, 40, 43, 46, 48, 49, 52, 55 and 58 as filed with the letter dated 10 February 1994;
pages 2 to 6, 8 to 10, 12, 13, 15, 16, 19, 20, 22 to 25, 27, 28, 32, 35 to 39, 41, 42, 44, 45, 47, 50, 51, 53, 54, 56, 57 59 and 60 as originally filed;

Drawings: Sheets 1/7 to 7/7 as originally filed.

The Registrar: The Chairman:

M. Beer G. Davies