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DECISION
of 25 November 2003

Case Number: T 0765/00 - 3.2.7

Application Number: 89300521.5

Publication Number: 0328257

IPC: C23C 14/56

Language of the proceedings: EN

Title of invention:

Magnetron sputtering apparatus and process

Patentee:

OPTICAL COATING LABORATORY, INC.

Opponents:

Edwards High Vacuum, International Limited
Deposition Sciences, Inc.

Headword:

-

Relevant legal provisions:

EPC Art. 54, 56

Keyword:

"Novelty (yes)"
"Inventive step (yes)"

Decisions cited:

-

Catchword:

-



Case Number: T 0765/00 - 3.2.7

D E C I S I O N
of the Technical Board of Appeal 3.2.7
of 25 November 2003

Appellant: Edwards High Vacuum International Limited
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Respondent: OPTICAL COATING LABORATORY, INC.
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Decision under appeal: Interlocutory decision of the Opposition
Division of the European Patent Office posted
16 May 2000 concerning maintenance of European
patent No. 0328257 in amended form.

Composition of the Board:

Chairman: A. Burkhardt
Members: K. Poalas
C. Holtz

Summary of Facts and Submissions

- I. Ôhe Appellant (Opponent I) lodged an appeal against the interlocutory decision of the Opposition Division on the amended form in which the European patent No. 0 328 257 can be maintained.

Oppositions were filed against the patent as a whole based on Article 100(a) EPC (lack of novelty and lack of inventive step), Article 100(b) EPC (lack of enabling disclosure) and Article 100(c) (extension beyond the content of the application as filed).

The Opposition Division held that the grounds for opposition mentioned in Articles 100(a), (b) and (c) EPC did not prejudice the maintenance of the patent as amended. The document

D2: JP 62-284076 A (the text-citations of document D2 in the present decision refer to the English translation of said document filed on 7 March 1995)

was taken into consideration.

- II. Oral Proceedings before the Board of Appeal took place on 25 November 2003.
- (a) The Appellant requested that the decision under appeal be set aside and the patent be revoked. The Appellant relied only on Article 100(a) EPC (lack of novelty and lack of inventive step).
- (b) The Respondent (Patent Proprietor) requested that the appeal be dismissed.

III. Independent claims 1 and 19 of the patent in suit as maintained by the Opposition Division read as follows:

"1. A sputter coating apparatus comprising: a vacuum chamber (11); a movable substrate support (14) mounted within the vacuum chamber and adapted for mounting substrates thereon for moving the substrates past at least first and second physically spaced work stations (26,27;28), the first work station providing a sputtering zone and the second work station providing a reaction zone for the sputtered material formed in the first work station; characterised in that a magnetron-enhanced sputter device (30) is positioned at the first work station and includes a target of selected material and means for generating a first plasma within the device, adjacent the work station and substantially throughout an extended region of the chamber including the physically spaced second work station for sputter depositing material on the substrates traversing the first work station; and an ion source device (30,40) is positioned at the second work station to apply a reactive gas along a relatively narrow zone adjacent the substrate support formed by a second locally intense plasma comprising ions of the reactive gas, the ion source device having means for applying a directed potential between the ion source and said second plasma for accelerating the reactive ions thereof to said substrates for completing said selected reaction with the sputter-deposited material during a single pass of the substrate support."

"19. A process for forming single layer films and multi-layer composite films on substrates in a vacuum chamber having a movable substrate support therein a first work station having a sputtering zone for forming a layer of sputtered material on a substrate and a second work station having a reaction zone for reacting the sputtered material formed on a substrate in the first work station; characterised in that at least one magnetron- enhanced sputter device is positioned at the first work station adjacent the substrate support for generating a first plasma adjacent the first work station and substantially throughout an extended region of the chamber including the physically spaced second work station for sputter depositing a selected material on a substrate, and at least one ion source device is positioned adjacent the substrate support at the second work station for providing a locally intense plasma to effect a selected chemical reaction with said selected material, the process comprising the steps of pulling a vacuum in the chamber; introducing working and reactive gases into the chamber; continuously moving the substrate support 5 past the devices; operating the sputter device with an associated relatively low partial pressure of the reactive gas to deposit a layer of said selected material on the substrate; and operating the ion source device having means for applying a directed potential between the ion source and said second plasma for accelerating the reactive ions thereof to said substrates with an associated relatively high 10 partial pressure of reactive gas to complete substantially the selected reaction during a single pass of the substrate support."

IV. The Opposition Division found that the following features of claim 1 of the patent in suit were not present in the apparatus according to Figure 3 of document D2:

- (a) means for generating an associated plasma throughout an extended region of the chamber including the physically spaced second work station,
- (b) ion source device to apply a reactive gas along a relatively narrow zone adjacent the substrate support formed by a second locally intense plasma,
- (c) the ion source device having means for applying a directed potential between the ion source and said second plasma for accelerating the reactive ions thereof to said substrates.

The Opposition Division found also that in addition to the features (a) and (c) the method step "continuously moving the substrate support past the devices" of claim 19 of the patent in suit was not disclosed by document D2.

V. The Appellant and the Opponent II, the latter being party to the appeal proceedings as of right according to Article 107 EPC, second sentence, argued in the written and oral proceedings essentially as follows:

(c) Claim 1

(i) Novelty

The partitions 14 shown in Figure 3 of document D2 have no specific function and cannot stop the plasma generated by the sputtering device from freely flowing to the ion source. According to the appellant's expert, in order to stop the sputtering plasma from reaching the ion beam the gap between the inner edge of the partitions 14 and the drum of the drum of Figure 3 of document D2 has to be less than 1mm. Scaling up the apparatus of Figure 3 of document D2 would mean that said gap would be in the order of 50 mm, which could not stop the sputtering plasma from reaching the ion gun. Besides that, the drum depicted in Figure 3 of document D2 is hexagonal in shape, and so there has to be a clearance between the tips of the hexagon and the inner ends of the partitions 14 to allow the drum to rotate. Due to such a clearance the sputtering plasma can not be stopped from reaching the ion source. Therefore, feature (a) is implicitly disclosed in document D2.

As it is shown in Figure 3 of document D2 the ion source 7 applies a second locally intense plasma to the substrate and therefore a reactive gas, see page 3, last paragraph of document D2, is applied along a part of the periphery of the drum at a relative narrow zone adjacent the substrate.

Consequently, feature (b) is also known from document D2.

Any ion gun applies an electrical potential applied to a plasma in order to accelerate ions to the target to be struck. Therefore, the ion gun mentioned in document D2 in relation with Figure 3 discloses automatically the above mentioned feature (c).

For the above mentioned reasons the subject-matter of claim 1 of the patent in suit is not novel over the apparatus of Figure 3 of document D2.

The conductance plate 33 in the apparatus according to Figures 4 and 5 of document D2 separates the ion beam irradiation chamber 19 from the film deposition chamber 31 (page 7, lines 25 to 27). This separation is not an airtight separation, since it allows argon gas to diffuse from the film deposition chamber into the ion beam irradiation chamber (page 9, lines 14 to 20) and consequently, also allows plasma to extend from the film deposition chamber into the ion beam irradiation chamber. Therefore, the feature (a) is also present in the apparatus according to Figures 4 and 5 of document D2.

The ion gun 13 shown in Figure 4 of document D2 accelerates ions to the substrate 45' via a second locally intense plasma applying oxygen direct onto said substrate, ie along a relatively narrow zone adjacent the substrate support. Features (b) and

(c) are therefore also present in the apparatus according to Figures 4 and 5 of document D2.

Consequently, the subject-matter of claim 1 of the patent in suit is also not novel over the apparatus according to Figures 4 and 5 of document D2.

(ii) Inventive step

Assuming that feature (a) is not known from document D2, the problem to be solved in the patent in suit is to modify the apparatus known from Figure 3 of document D2 so that a plasma extension between the sputter device and the ion source device can freely take place. Since document D2 does not teach that in the apparatus according to Figure 3 of document D2 the plasma generated in the film deposition chamber should not extend into the ion beam irradiation chamber, the skilled person, in order to enhance plasma propagation, would shorten or remove the partitions 14 without exercising an inventive activity.

(d) Claim 19

(i) Novelty

The curved arrow on the drum 4 shown in Figure 3 of document D2 is understood by the person skilled in the art as a continuous rotation of said drum. A non-continuous movement of the substrate past the sputtering and ion beam devices in Figure 3 of

document D2 would make technically no sense. Therefore, the feature of claim 19 "continuously moving the substrate support past the sputtering and ion beam devices" is present in the apparatus of Figure 3 of document D2.

Consequently, the subject-matter of claim 19 is not novel.

(ii) Inventive step

Assuming that feature (a) is not known from document D2, the process according to claim 19 does not involve an inventive step, for the same reasons as set out with respect to the subject-matter of claim 1.

VI. The Respondent argued in the written and oral proceedings essentially as follows:

(a) Claim 1

(i) Novelty

The features (a), (b) and (c) of claim 1 of the patent in suit are not disclosed in D2.

The embodiment of Figure 3 of document D2 does not disclose explicitly that the first plasma generated at the sputtering apparatus reaches the ion gun which contains the second plasma and there is no basis in document D2 for assuming an implicit disclosure of such a feature. The Figure 3 of document D2 is a highly diagrammatic

drawing which does not allow any deduction of dimensions from said figure. There is no disclosure in document D2 that the Figure 3 apparatus uses a reactive gas in the irradiation chamber. Besides that, diffusion of gas is not the same as diffusion of plasma. Thus, document D2's comment that argon gas may diffuse in the apparatus according to Figures 4 and 5 of document D2 and the location of the pump 12 in the Figure 3 tell nothing about the behaviour of the plasma in such an apparatus.

Figures 3 to 7 of document D2 show that the reaction zone in said document constitutes the entire space outside the deposition zone. Therefore, the reaction in document D2 occurs throughout a relatively wide zone.

The ion gun of document D2 does not disclose means for applying a directed potential between the ion source and the second plasma for accelerating the reactive ions to the substrates. A Kaufman ion gun as mentioned in document D2 cannot accelerate the reactive ions to the substrate.

(ii) Inventive step

The aim of the present invention is to provide an apparatus capable of sputtering substrates of any kind, ie without any restriction in the shape and size of the substrates to be treated.

Document D2 does not give any hint that the sputtering-plasma, which extends throughout a region of a chamber, must extend into a physically spaced second work station. On the contrary, document D2 teaches the skilled person to avoid propagation of the sputtering-plasma by partitions. Any diffusion of the sputtering-plasma through the gaps between the partitions and the rotating drum is clearly undesired.

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

(b) Claim 19

(i) Novelty

In addition to the features (a) and (c), the method step of "continuously moving the substrate support past the devices" is not disclosed in document D2. There is no reference in document D2 about a continuous rotation of the substrate support and the indication in document D2 that "after the metal ultra thin film has been deposited to the desired thickness, the substrate holder 43 is rotated" (page 8, 2nd full paragraph, 2nd sentence) clearly points to a stepwise rotation.

Therefore, the subject-matter of claim 19 is novel over the disclosure of document D2.

(ii) Inventive step

For the same reasons as set out with respect to the subject-matter of claim 1, the subject-matter of claim 19 involves an inventive step.

Reasons for the Decision

1. Articles 100(b) and (c) EPC

The Appellant no longer relied on the grounds for Opposition according to Articles 100(b) and (c) EPC. The Board therefore will not examine these grounds.

2. *Claim 1*

2.1 Novelty

Document D2 is directed to the sputtering of an ultra-thin metal or oxide onto a substrate and to subsequent irradiation of the ultra-thin film with an ion beam. The ion beam can be an ion beam of an inert gas such as argon, in order to relax stresses inside the ultra-thin film or to modify its packing density, (page 6, lines 12 to 14), or an ion beam of oxygen in order to compensate deficiencies in oxygen in an ultra-thin metal oxide film created by sputtering a metal oxide target (page 6, lines 14 to 18), or an ion beam of a reactive gas, such as oxygen or nitrogen, used to irradiate an ultra-thin metal film in order to convert a single metal into a metal oxide or a metal nitride (page 6, lines 19 to 21).

In document D2, three different kinds of apparatus are disclosed. The first is illustrated in Figure 3, the second in Figures 4 and 5, and the third in Figures 6 and 7.

The apparatus according to Figures 4 and 5 is described as being used to carry out the third of the three above-mentioned processes. In carrying out said process, metal can be deposited on a substrate in the deposition zone by sputtering or by evaporation (page 6, line 9). Said second apparatus uses a sputtering electrode 21 to sputter a substrate 45 (page 8, lines 20 to 21). A conductance plate 33 divides the chamber into a film deposition chamber 31 and an ion beam irradiation chamber 19 (page 7, lines 25 to 27; page 3, lines 12 to 15).

When used to carry out the third of the three above-mentioned methods, the sputtering zone of document D2 contains an inert gas, such as argon and the reaction zone contains a reactive gas, such as oxygen, at a substantially lower absolute pressure than that of the inert gas of the sputtering zone (page 9, lines 11 to 14). In order to provide such a pressure differential tight baffling is required between the sputtering and reaction zones of said apparatus. This tight baffling is accomplished with the conductance plate 33 in the apparatus according to Figures 4 and 5, whose objective is to form a film deposition chamber and an ion beam irradiation chamber, and also to produce a pressure differential between these two chambers (page 3, lines 12 to 15).

The apparatus according to Figures 6 and 7 is similar to the one according to Figures 4 and 5 and discloses a conductance plate 33' having first section 33'a for an airtight separation of the film deposition chamber 31 disclosing the sputtering electrode 21 and of the irradiation chamber 19 disclosing the ion beam 13.

Therefore, the conductance plates 33 and 33' in the apparatuses according to Figures 4 to 7 accomplishing tight baffling between the film deposition chamber and the ion beam irradiation chamber are intended to prohibit a plasma generated in the film deposition chamber from extending into the ion beam irradiation chamber.

The Appellant argued that since argon gas can diffuse from the film deposition chamber into the ion beam irradiation chamber also plasma can extend from the film deposition chamber into the ion beam irradiation chamber. However, in said chambers two separately controlled pressure regimes (page 8, lines 6 to 18) exist and therefore a baffling system has to separate the two chambers from each other in order to enable different pressure regimes. This is achieved by the conductance plate 33 as mentioned on page 7, last paragraph, first sentence and in claim 4, last four lines of document D2. Although on page 9, third complete paragraph, there is a reference to a possible argon gas diffusion from the film deposition chamber into the ion beam irradiation chamber, there is no information therein how such a diffusion can take place. The Board cannot accept the Appellant's allegation that the gap shown in Figure 4 between the conductance plate 33 and the substrate holder 43 and the gap between the

wall of the chamber 11 and the substrate holder 43 allow the gas and the plasma to pass over from the film deposition chamber into the ion beam irradiation chamber, since Figure 4 is a diagrammatic drawing allowing neither deduction of dimensions of the different parts of the apparatus shown therein nor a gas or plasma flow in a way not mentioned in the corresponding part of the description.

The Respondent argued that the reactive gas is spread throughout the whole ion beam irradiation chamber, ie throughout a wide zone, not anticipating the feature (b) of claim 1. However, from Figures 4 and 5 of document D2 it can clearly be derived that the ion beam is directed towards the substrate 45' applying a reactive gas onto the substrate along a relatively narrow zone adjacent the substrate support. Therefore, the Board takes the view that feature (b) of claim 1 of the patent in suit is disclosed in the apparatus according to Figures 4 and 5 of document D2.

As it was confirmed by the Respondent's expert during the oral proceedings, a Kaufmann ion gun used in the apparatus according to Figures 4 and 5 of document D2 (page 8, line 27) has not only a plasma inside said gun but also at the outside part of the gun directed towards the substrate to be treated, said latter plasma having ions accelerated towards said substrate. Therefore, the Board is of the opinion that feature (c) of claim 1 of the patent in suit is also disclosed in the apparatus according to Figures 4 and 5 of document D2.

There is very little disclosed about the apparatus according to Figure 3 in document D2 (page 7, lines 12 to 22). Within vacuum chamber 5 of said apparatus there are partitions 14 positioned between the sputtering electrode 8 and the ion gun 7 and it is stated that "the irradiation conditions (pressure) for the ion beam are set lower than ordinary sputtering pressure, so in this case an evacuation opening 10 should be installed on the ion beam side to provide a pressure gradient. 12 is the evacuation system and 14 is a partition." (page 7, lines 19 to 22).

The Board cannot see any other purpose for the partitions 14 in Figure 3 than the one of the conductance plates 33 or 33' of Figures 4 to 7, namely as a baffling between the parts of the apparatuses disclosing the sputtering electrode and the ion beam. Figure 3 is a diagrammatic drawing and not a working drawing. Therefore, no information about the width of the gap between the partitions 14 and the substrate holder 4, the dimensions and working conditions of the vacuum chamber can be deduced from Figure 3. Consequently, the calculations presented by the Appellant's expert about the minimum gap dimensions needed to prevent a plasma from spreading from the sputtering device up to the ion beam and the Appellant's arguments concerning the clearance between the tips of the hexagonal drum and the inner ends of the partitions 14 are meaningless. Furthermore, in the whole disclosure of document D2 there is no mention of any kind of plasma extension at all.

Moreover, no reactive gas is mentioned in the part of the description which refers to Figure 3 of document D2 (page 7, lines 12 to 22). The Board concludes from reading the above-mentioned passage of the description which refers to Figure 3 in combination with claim 1 of document D2 and with the passage of the description on page 6, lines 12 to 14 about stress annealing of the sputtered film by irradiating said film with an ion beam of an inert gas such as argon, that the apparatus according to Figure 3 of document D2 uses an ion beam of an inert gas in order to anneal the stress inside the sputtered film. Therefore, no reactive gas is used in the apparatus according to Figure 3 of document D2 and consequently, the features (b) and (c) of claim 1 of the patent in suit referring to a reactive gas are not present in said apparatus.

For the above mentioned reasons, a plasma extension from a sputtering device throughout an extended region of a chamber including the physically spaced second work station (ion beam) is not present in any of the apparatuses disclosed in document D2.

Consequently, the subject-matter of claim 1 is new and fulfils the requirements of Article 54 EPC.

2.2 Inventive step

2.2.1 Closest prior art

The closest prior art is represented by the apparatus according to Figures 4 and 5 of document D2, said apparatus comprising a vacuum chamber 11, a movable substrate support 43 mounted within the vacuum chamber

and adapted for mounting substrates thereon for moving the substrates past at least first and second physically spaced work stations, the first work station providing a sputtering zone 31 and the second work station providing a reaction zone 19 for the sputtered material formed in the first work station, wherein a sputter device 21 is positioned at the first work station and includes a target of selected material and means for generating a first plasma within the device, for sputter depositing material on the substrates traversing the first work station, and an ion source device 13 is positioned at the second work station to apply a reactive gas along a relatively narrow zone adjacent to the substrate support formed by a second locally intense plasma comprising ions of the reactive gas, the ion source device having means for applying a directed potential between the ion source and said second plasma for accelerating the reactive ions thereof to said substrate.

The use of a partition plate 33 between the film deposition chamber and the ion beam irradiation chamber in the apparatus according to Figures 4 and 5 of document D2 in order to produce a pressure differential between said two chambers restricts the variety of size and shape of the substrates which can be treated in said apparatus.

2.3 Problem

The problem underlying the invention of the patent in suit is to improve the apparatus according to Figures 4 and 5 of document D2 so that substrates having complex curvatures can also be treated, see patent in suit,

page 4, line 41; page 5, lines 44 and 45; page 6, lines 1 and 2.

2.4 Solution

In accordance with claim 1 of the patent in suit the above-mentioned problem is solved in that no partition plate is present between the first work station for film deposition and the second work station for ion beam irradiation so that the plasma generated at the first work station (sputtering electrode) spreads throughout an extended region of the chamber including the physically spaced second work station (ion beam).

Due to the elimination of the partition plate non-flat, curved substrates can also be coated.

2.4.1 The above-mentioned solution is not rendered obvious by document D2 for the following reasons:

The person skilled in the art starting from an apparatus according to Figures 4 and 5 of document D2 and seeking to solve the problem of the patent in suit finds no hint in said document to remove the conductance plate in order to enable the plasma generated at the sputtering electrode to spread throughout an extended region of the chamber including the physically spaced ion beam.

On the contrary, document D2 stipulates separate pressure regimes in the film deposition chamber and in the ion beam irradiation chamber imposing the use of a conductance plate (page 8, lines 9 to 11; page, lines 12 to 15). A removal of the conductance plate in

document D2 would go against the teaching in said document.

For the above-mentioned reasons, the subject-matter of claim 1 of the patent in suit involves an inventive step within the meaning of Article 56 EPC.

3. *Claim 19*

3.1 Novelty

The Board concurs with the opinion of the Appellant, that a non-continuous movement of the substrate past the sputtering and ion beam devices shown in the figures of document D2 is technically meaningless and concludes that a continuous movement of the substrate support past the sputtering and ion beam devices takes also place in the apparatus according to Figures 4 and 5 of document D2.

However, as is stated in point 2.1 above, the feature that the sputtering device generates a first plasma substantially throughout an extended region of the chamber including the physically spaced apart ion beam is not disclosed in document D2.

Therefore, the subject-matter of claim 19 is new and fulfils the requirements of Article 54 EPC.

3.2 Inventive step

For the same reasons as set out under point 2.4.1 above with respect to the apparatus according to claim 1, the process of claim 19 of the patent in suit also involves an inventive step within the meaning of Article 56 EPC.

4. Claims 2 to 18 and 20 to 32

Dependent claims 2 to 18 and 20 to 32 concern particular embodiments of the apparatus claimed in claim 1 and of the method claim 19 and involve an inventive step.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar:

The Chairman:

D. Spigarelli

A. Burkhardt