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Aktenzeichen / Case Number / N° du recours : T128/83

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Bezeichnung der Erfindung:
Title of invention: A method of manufacturing a semiconductor device.
Titre de l'invention :

ENTSCHEIDUNG / DECISION

vom / of / du 8 November 1984

Anmelder/Patentinhaber:
Applicant/Proprietor of the patent: Fujitsu Limited.
Demandeur/Titulaire du brevet :

Stichwort / Headword / Référence :

EPÜ / EPC / CBE Articles 52(1) and 56.
"Inventive step".

Leitsatz / Headnote / Sommaire

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Case Number: T 128 / 83

DECISION
of the Technical Board of Appeal 3.4.1
of 8 November 1984

Appellant: FUJITSU LIMITED
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Decision under appeal: Decision of Examining Division 048 of the European Patent Office dated 14 April 1984 refusing European patent application No 80 304 016.1 pursuant to Article 97(1) EPC

Composition of the Board:

Chairman: R. Kaiser
Member: J. Roscoe
Member: F. Benussi

Summary of Facts and Submissions

I. European patent application No. 80 304 016.1, filed on 11 November 1980 and published on 20 May 1981 under publication number 0 028 934, claiming a priority of 12 November 1979 from a application (JP 146 347/79) made in Japan, was refused by a decision of the Examining Division 048 of the European patent Office dated 14 April 1983. That decision was based on Claims 1-4 received on 21 October 1982.

II. The reason given for the refusal was that the subject-matter of Claim 1 did not involve an inventive step having regard to an article by H. Tamura, et al. in Journal of Applied Physics, Vol. 50 of May 1979, pages 3783-3784.

III. On 13 June 1983 the applicant lodged an appeal against the decision and paid the appeal fee in due time. Statement setting out the grounds of appeal as received on 17 August 1983 together with an alternative set of claims and description.

IV. In a communication sent with the summons to oral proceedings the Rapporteur raised objections against the patentability of the claimed subject-matter. In a reply filed in due time on 18 October 1984 the appellant presented two sets of documents to replace the existing claims and description. The first set headed "proposed amended main request" consists of claims numbered 1-3 and an adapted description, and the second (auxiliary) set of a single claim and an associated description headed "proposed amended auxiliary request".

The only independent claim of the main set, Claim 1, reads as follows:

1. A method of manufacturing a semiconductor device, in which a impurity is ion implanted into a semiconductor substrate and the impurity is activated by heating the substrate by irradiation with a laser beam through a light transmitting film formed on the surface of the substrate, characterised in that the impurity is selectively implanted into a region of the substrate using an insulating film as a mask for the ion implantation, and the light transmitting film is formed on the substrate and on the insulating film to a thickness of a value equal to, or substantially equal to ^{m} /4n, where m is an odd integer (including unity), _ is the wave length of the laser beam and n is the index of refraction of the light transmitting film.

The single claim of the auxiliary set differs from the above claim in that the light transmitting film "is of photoresist".

V. At the oral proceedings, held on 8 November 1984, the representative of the appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the following documents: Claims 1-3 and description headed "proposed amended main request", received on 18 October 1984, and the five drawings as published (main request). Alternatively, he requested that a patent be granted on the basis of Claim 1 and description headed "proposed amended auxiliary request", received on 18 October 1984, and the five drawings as published. In addition he requested that the appeal fee be refunded.

IV. The main arguments presented by the appellant in the written proceedings and developed further at the oral proceedings were as follows:

The invention is concerned with modifying a prior art laser annealing process performed on a semiconductor body into which impurity ions have been implanted through a hole in an oxide mask thereon. In the known process the laser beam impinges not only on the hole but also on the surrounding areas of oxide. Damage is caused in these areas due to excessive heating of the seimconductor. Applicant attributes this overheating to the oxide acting as an anti-reflection coating the effectiveness of which depends on its thickness. In the hole, where maximum heating effect is desired, a certain amount of reflection occurs. In accordance with the invention the damage is avoided by performing the annealing through a light transmitting film an odd number of quarter wavelengths thick extending over the hole and over the oxide masking. Within the hole the film acts as an anti-reflection coating and this enables the laser beam energy required for full annealing to be reduced. In the surrounding areas it tends to reduce the amount of beam energy reaching the semiconductor, if the oxide film itself is approximately an odd number of quarter wavelengths thick and would be, in the absence of the light transmitting film, a highly effective anti-reflection film.

The overheating problem was not recognised in the prior art and the skilled man not placed in a position to appreciate it by the disclosure in the Tamura article. Even had he become aware of the problem that article would not have provided him with the solution claimed.

Since the problem is confined to the oxide coated regions it would be logical for him to seek only to minimise the penetration of laser radiation into these regions. He could have achieved this result by removing the masking oxide before annealing, by forming the oxide to a thickness providing minimum transmission, or by replacing the masking oxide layer by, or disposing on top of it, a reflecting film. It would not however occur to the skilled man to tackle the problem by providing a light transmitting film over the entire surface of a thickness calculated to maximise transmission within the hole.

The essential argument concerning selection of photoresist material for the light transmitting film (auxiliary claim) was that this was not a material which would recommend itself as suitable for use in anti-reflection films as an alternative to silicon dioxide. Anti-reflection films had hitherto been made generally, if not exclusively, of inorganic materials, the available prior art afforded no evidence of the use of photoresists in them, or indeed in any application where no use was made of their light sensitivity, and the applicant was not aware of any such use.

In addition photoresists were known to deteriorate at much lower temperatures than those that the skilled man would expect to occur during annealing at the interface between the semiconductor and the anti-reflection film. Furt ermore, when used conventionally to form masks, they are applied to a thickness several times greater than the optimum thickness of /4n for an anti-reflection film. Hence, the skilled man would not even consider them worthy of a trial.

Reasons for the decision

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

(2) Th subject-matter of all the claims now on file is disclosed in the original documents. Therefore no formal objection can arise under the terms of Article 123(2).

(3) In the method of making a device according to prior art technology described with reference to Figure 1 of the application, after selective implantation of impurity ions into a region of the semiconductor substrate through a hole in an insulating oxide mask, the impurity is activated (annealed) by heating the substrate by irradiation with a laser beam. The method has all the features of the preamble of main claim 1, except for the light transmitting film, and comprises in addition the selective implantation feature of the characterising part of the claim.

(4) According to the second paragrah on page 1 of the original description, in such a method, contrary to what might be assumed, the amount of laser radiation penetrating to the semiconductor surface is greater in the oxide coated area than in the hole, and in certain instnces the substrate can be damaged in this area as a result.

(5) The problem of damage is overcome by effecting irradiation through a light transmitting film, referred to in the preamble of main claim 1, having a thickness and

extent as set out in the characterising part of the claim.

(6) The article by Tamura, intended to give information to be considered in device fabrication, describes annealing a phosphorus ion implanted silicon body by directing a laser beam on its surface. During annealing the surface is coated with a silica film, and the efficiency of annealing, i.e. of activating implanted ions, is shown to vary periodically with film thickness in a manner closely corresponding to the variation of energy transmissivity through the film calculated from an equation well-known in optics. Maximum efficiency occurs at a film thickness of 1100A. This closely corresponds to the 1200A shown by the equation to give maximum energy transmissity and which,as the skilled man will know and can deduce from the given values of wavelength and refractive index, is about /4n. Calculated transmissivity exhibits further maxima at 3 (N=1) and 5 (N=2) times this thickness. Thus, as optical wave theory predicts, the film functions for such thicknesses as an anti-reflection film, and the skilled man would therefore expect films of other transparent materials of similar refractive index to exhibit similar behaviour. Direct application of the confirmed theory to analysis of the prior art process of Figure 1 would reveal that reflection occurs in the hole, where annealing and hence maximum beam penetration is required, whereas elsewhere proportion of the beam energy enters the oxide-coated silicon, especially if the oxide happens to be about ^{m} /4n thick. The skilled man is therefore made ware of the inefficiency of annealing according to the state of the art as outlined in Figure 1 of the application and alerted to the risk

of the potentially damaging over-expousre of the regions of the silicon which at first sight seem to be shielded by the oxide.

(7) The art is constantly striving to improve the efficiency of manufacturing processes and it would be evident from Tamura that an immediate gain in efficiency is attainable by providing an oxide film /4n thick in the hole. The beam energy, conventionally chosen to be the minimum commensurate with full annealing, could then be reduced with the direct consequence of reducing exposure in the surrounding areas.

Since provision of such a film confined to the hole would call for the use of further masking in registry with the implantation masks, the skilled man must be expected to consider the consequences of the simpler procedure of depositing the film over the entire surface.

On the basis of Tamura, and being aware that the masking and overlying oxide, having closely similar or identical refractive indices, will behave optically as a single film of their combined thickness, the skilled man would conclude that where the masking oxide is itself strongly anti-reflecting, i.e. about /4n thick, the effect of the overlying oxide /4n thick would be to produce a substantial reduction in transmission thus further reducing the risk of damage. In these circumstances the Board is forced to conclude that provision of the film over the entire surface does not involve an inventive step (Article 56) and hence that the main Claim 1 is not allowable (Article 52(1)).

(8) Main Claims 2 and 3 are also not allowable, since they are dependent on Claim 1.

(9) The single auxiliary claim additionally requires the light transmitting film to be of photoresist material.

The skilled man will, as a matter of routine, investigate the possibility of forming this film of other materials having optical properties similar to silicon dioxide and known to be compatible with semiconductor materials, in the hope of further improving or simplifying the process.

Photoresists are extensively used in the art, and are known to be optically transparent in the thicknesses under discussion and to have refractive indices close to that of silica. Well established techniques which do not involve the use of high temperatures are available both for their application as thin films and their subsequent removal.

Even were the skilled man to fear that they might not withstand the short-term exposure to the high temperatures to be expected in laser annealing, or doubt that thy could be produced in the requisite thickness, this would not in the Board's opinion dissuade him from carrying out, with the equipment already at his disposal, the simple experiments necessary to confirm or dispel his doubts.

For these reasons, and in the absence of an solid evidence that the use of photoresist produces any surprising beneficial effects, it is concluded that the subject-matter of the auxiliary claim is also lacking

inventive step and the claim thus not allowable.

(10) The request for reimbursement of the appeal fee must be refused since Rule 67 makes no provision for such reimbursement in the event of the Board of Appeal dismissing the appeal.

Order

For these reasons it is decided that:

1. The appeal is dismissed

2. The appeal fee will not be reimbursed.

The Registrar: The Chairman:

J. Rückerl R. Kaiser