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**D E C I S I O N**  
**of 15 May 1995**

**Case Number:** T 0524/92 - 3.4.1

**Application Number:** 85300172.5

**Publication Number:** 0150088

**IPC:** H01L 21/316

**Language of the proceedings:** EN

**Title of invention:**

A semiconductor device comprising a dielectric layer

**Applicant:**

BRITISH TELECOMMUNICATIONS public limited company

**Opponent:**

-

**Headword:**

Arsenosilicate glass/BRITISH TELECOMMUNICATIONS

**Relevant legal provisions:**

EPC Art. 84

**Keyword:**

"Lack of support in the description - (no)"

"Functional definitions in claims - clarity (yes)"

**Decisions cited:**

-

**Catchword:**

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Case Number: T 0524/92 - 3.4.1

**D E C I S I O N**  
of the Technical Board of Appeal 3.4.1  
of 15 May 1995

**Appellant:**

BRITISH TELECOMMUNICATIONS public limited  
company  
81 Newgate Street  
London EC1A 7AJ (GB)

**Representative:**

Roberts, Simon Christopher  
BRITISH TELECOM  
Intellectual Property Unit  
13th Floor  
151, Gower Street  
London, WC1E 6BA (GB)

**Decision under appeal:**

Decision of the Examining Division of the European  
Patent Office dated 14 January 1992 refusing  
European patent application No. 85 300 172.5  
pursuant to Article 97(1) EPC.

**Composition of the Board:**

**Chairman:** G. D. Paterson  
**Members:** R. K. Shukla  
H. J. Reich

## Summary of Facts and Submissions

- I. European patent application No. 85 300 172.5 was refused by a decision of the Examining Division on the ground that the subject-matter of independent Claims 1 and 2 of the main request and independent Claim 1 of the auxiliary request (which is identical to Claim 2 of the main request) did not fulfil the requirement of Article 84 EPC regarding clarity and support by the description.

The Examining Division referred, inter alia, to the following prior art documents in the decision:

D1 = US-A-4 355 454

D2 = DE-A-2 937 989

D3 = Solid State Technology, October 1981, pages 123 to 128

- II. Independent Claims 1 and 2 forming the basis for the above decision read as follows.

### Claim 1

"Use of arsine to control the reaction type which predominates in reactions between silane and oxygen in a non-plasma-assisted chemical vapour deposition process for the production of an arsenosilicate glass from a reactant mixture comprising silane, oxygen and arsine, the arsine being used to inhibit homogeneous reactions between silane and oxygen so that the arsenosilicate glass is produced as a conformal coating."

**Claim 2**

"A method of producing an arsenosilicate glass in a chemical vapour deposition process without plasma-assistance, the method involving the reaction of silane, oxygen and arsine, characterized in that the reaction takes place in the presence of a diluent gas, and in that the reaction conditions and the composition of the reactant mixture are selected such that the arsenosilicate glass is produced as a conformal coating as the result of a predominantly heterogeneous reaction, and that the reactor type and the reaction conditions are such that in the absence of arsine the reaction between silane and oxygen is predominantly homogeneous."

III. According to the above decision, it follows from the description of the application in suit and from the prior art represented by document D3, that in a chemical vapour deposition process many reaction parameters are responsible for the reaction type and thereby for obtaining a conformal coating. The skilled person therefore has to select correct values of several deposition parameters, and it is thus insufficient only to select a value of the arsine concentration in order to control the reaction. Claim 1 is therefore not properly supported by the description. Furthermore, the Examining Division held that Claim 2 is not sufficiently defined since the skilled person wishing to carry out the claimed method would have to choose a large number of interrelated parameters, and there is no indication in the claim where this selection should begin. The skilled person would thus be presented with an undue burden in carrying out the claimed method of producing an arsenosilicate glass. The subject-matter of Claim 2 is therefore not supported by the description.

Moreover, according to the decision, even if Claim 2 was considered as supported by the description, its subject-matter would not appear to involve an inventive step, since following the submissions by the Appellant that the skilled person was in a position to achieve a heterogeneous reaction by routine experimentation, the claimed subject-matter represented a well-known desideratum of forming a conformal glass coating and the skilled person starting with disclosure of document D3 was able to find the specific parameters needed to produce such a conformal coating of arsenosilicate glass by a heterogeneous reaction.

- IV. The Applicant lodged an appeal against the decision and submitted essentially the following arguments in the Statement of grounds of appeal.

The important feature of the invention is that the glass produced is deposited as a conformal coating on a substrate. It is not disputed that several reaction parameters are relevant to reaction rate, deposition rate etc., but there is no reason to require these parameters to be recited in the claims. The deposition parameters are disclosed in the description such that a skilled person is able to carry out the invention. However, to require the deposition parameters to be included in the claims would deprive the applicant of a fair protection for the invention - which is for the use of arsine to control the reaction type between silane and oxygen so that a conformal coating of arsenosilicate glass is formed.

With regard to inventive step, the Appellant argued that document D3 discloses a specific design of the gas injector which is responsible for preventing homogeneous gas phase reaction and thereby for forming a conformal coating of phosphorus doped silicon dioxide glass. There

is no suggestion in document D3 that arsine can be used to change the reaction from homogeneous to heterogeneous one, so that a conformal coating is obtained.

V. In a communication pursuant to Article 110(2) EPC, the Board informed the Appellant that since Claim 1 did not specify that the arsine **concentration and the reaction conditions** have to be so chosen that homogeneous gas phase reactions between silane and oxygen are inhibited, the claim was not supported by the description as required by Article 84 EPC. It was also pointed out in the communication that the expression "the reactant mixture" in Claim 2 had no antecedent so that the claim was not clear, and that Claim 15 contravened Article 123(2) EPC.

VI. In response to the above communication, the Appellant submitted on 16 January 1995 a new set of 14 claims containing amended independent Claims 1 and 2, an unamended independent Claim 4 and amended pages 7 and 7a of the description. The Appellant thus requests the grant of a patent based on the following documents:

Description: pages 1 to 6 and 14 to 18 as published;  
pages 10,11 and 13 filed with the letter of 23 March 1989;  
pages 8, 9 and 12 filed with the letter of 20 July 1990; and  
pages 7 ,7a filed with the letter of 16 January 1995;

Claims: 1 to 14 filed with letter of 16 January 1995 but with Claim 1 amended as set out below ;

Drawings: Sheets 1/8 to 8/8 as published.

The amendments to Claim 1 referred to above were agreed with the Representative of the Appellant in a telephone consultation dated 10 May 1995, and are underlined in the wording of the claim 1 below.

Amended independent Claims 1 and 2, and unamended independent Claim 4 have the following wording:

**Claim 1**

"In a reaction of a mixture comprising silane, oxygen and arsine in a chemical vapour deposition process without plasma assistance to produce an arsenosilicate glass on a substrate, the use of arsine in a sufficient concentration and of reaction conditions, such that homogeneous gas phase reactions between silane and oxygen are inhibited, so that the arsenosilicate glass is produced as a **conformal** coating on the substrate."

**Claim 2**

"A method of producing an arsenosilicate glass in a chemical vapour deposition process without plasma-assistance, the method involving the reaction of a reactant mixture of silane, oxygen and arsine, characterized in that the reaction takes place in the presence of a diluent gas, and in that the reaction conditions and the composition of the reactant mixture are selected such that the arsenosilicate glass is produced as a conformal coating as the result of a predominantly heterogeneous reaction, and that the reactor type and the reaction conditions are such that in the absence of arsine the reaction between silane and oxygen is predominantly homogeneous."

**Claim 4**

"A method of producing a conformal arsenosilicate glass coating in a chemical vapour deposition process involving reactions between silane and oxygen without plasma assistance, the reaction mixture including arsine, wherein the reactions between silane and oxygen are predominantly of a heterogeneous nature, this being achieved via selection of the gas concentrations to lie in the range such that the volume ratio of silane to arsine is between 3.8 to 1 and 11.7 to 1 and the volume ratio of oxygen to silane is between 18.5 to 1 and 41 to 1."

**Reasons for the Decision**

1. *Amendments*

During the examination proceedings and the appeal proceedings, amendments have been made to the claims and the description as filed. In particular, a new claim (Claim 1) relating to the use of arsine to control the reaction type and a new method claim (Claim 4) for producing a conformal arsenosilicate glass have been added. The description has been amended for consistency with the new claims and to comply with the requirements of Rule 35(12) EPC.

In the examination proceedings, the Examining Division did not raise any objection pursuant to Article 123(2) EPC against the amended set of claims. The Board having examined the amended subject-matter of the claims forming the basis of the decision and of the claims under consideration (as in section VI above) is also

satisfied that the amendments do not extend beyond the content of the application as filed so that the claims meet the requirement of Article 123(2) EPC.

2. *Clarity and support by the description*

2.1 *Claim 1*

2.1.1 The invention relates to the formation of an arsenosilicate glass coating and is based on the discovery that arsine can suppress homogeneous gas phase reactions between silane and oxygen in a non-plasma chemical vapour deposition (CVD) process, such that the resulting arsenosilicate glass is formed as a conformal coating on a substrate (see page 4, lines 19 to 26 and page 5, lines 22 to 26 of the published patent application).

In the Board's view, the description of the formation of conformal coatings of arsenosilicate glass (see in particular page 11, line 1 to page 13, line 19) supports the statement in Claim 1 that the concentration of arsine used and reaction conditions are such that homogeneous gas phase reactions between silane and oxygen are inhibited, for the following reasons:

According to the table on page 13 of the application in suit, the reactions between silane and oxygen are heterogeneous for the runs A and C, whereas for the runs B, D and E the reactions are homogeneous. In run B the flow rate of arsine is only half its value in run A. Although the flow rates of arsine and oxygen are the same in the runs A, C, D and E, it is evident from the increase of the flow rate of silane in these runs that the concentration of arsine in fact decreases in relation to that of silane from the runs A to E. The results of the runs therefore support the statement in

the description (see page 13, lines 5 and 6) that an increase in arsine concentration (in relation to silane or oxygen concentration) favours heterogeneous reactions.

Moreover, in Figure 4 and the description on page 11, deposition rate vs. substrate temperature curve obtained with silane-arsine-oxygen system is compared with the curve obtained with silane-oxygen system. As can be seen from Figure 4, the rate of deposition is practically independent of the substrate temperature in the system where no arsine is used, indicating a homogeneous gas phase reaction. In the system using arsine on the other hand, the rate of deposition is strongly dependent on the substrate temperature, which indicates that the reaction is heterogeneous.

In the Board's view, it is thus evident from the description that it is the presence of arsine in an appropriate concentration which is essential for inhibiting a homogeneous gas phase reaction and for producing a conformal coating by way of heterogeneous surface reactions.

The Board agrees with the Examining Division that according to the description of the invention arsine inhibits homogeneous gas phase reactions only when used in correct proportions and when other parameters are appropriately adjusted. However, in the present case, this does not justify a restriction of the claim to any specific deposition parameters, because in the Board's view, on the basis of the information provided in the application (see pages 9 to 13), a skilled person is in a position to produce conformal coatings of arsenosilicate glass outside the disclosed reactant volume ratios (such as on page 12). Consequently, a restriction of the claim to the disclosed specific

deposition parameters would deprive the Applicant of a fair protection for his invention, and is not necessary in order to satisfy Article 84 EPC.

- 2.1.2 As to the functional definition in Claim 1, namely that arsine is used in a sufficient concentration and reaction conditions are "such that homogeneous gas phase reactions between silane and oxygen are inhibited, so that the arsenosilicate glass is produced as a conformal coating on the substrate", it is well established that such a functional definition is permissible when it would otherwise be difficult or impossible to define the invention in another way without unduly restricting the scope of the claim. As discussed above, in the present case a specification in the claim of the deposition parameters as disclosed in the application on pages 12 and 13, would have unduly reduced the scope of the claim and would have deprived the applicant of a fair protection.

The Board is also of the view that the result to be achieved is clearly defined in the claim in that an expert can easily verify the conformal or non-conformal nature of the glass coating, for example, by examination of the coating in an electron microscope. This in turn can provide information about the type of reaction, that is, heterogeneous or homogeneous, between silane and oxygen. It will be also possible for the expert to determine whether or not a particular concentration of arsine influences the type of reaction by varying the concentration of arsine while maintaining the other reaction conditions the same.

- 2.1.3 In view of the above considerations, in the Board's judgment, Claim 1 is supported by the description and is clear, as required by Article 84 EPC.

2.2 *Claims 2 and 4*

Claim 2 relates to a method of producing an arsenosilicate glass using a reactant mixture of silane, oxygen and arsine, and as can be seen from the wording of the claim, namely, "the reaction conditions and the composition of the reactant mixture are selected ... is predominantly homogeneous." arsine is used to control the reaction between silane and oxygen so that it is predominantly a heterogeneous reaction as in Claim 1. The reasons given under section 2.1 above concerning Claim 1 are therefore also applicable to the subject-matter of Claim 2, which accordingly satisfies the requirements of support in the description and clarity (Article 84 EPC).

The above considerations also apply to independent Claim 4 incorporating essentially all the features of Claim 2 and additionally specifying the volume ratios of silane to arsine and oxygen to silane. Claim 4 therefore meets the requirements of Article 84 EPC.

3. *Inventive step*

3.1 Each of the independent Claims 1,2 and 4 relates to the production of a conformal coating of arsenosilicate glass from a mixture comprising silane, oxygen and arsine by a CVD process without plasma assistance. Furthermore, according to the claims the reaction conditions and the concentration of arsine are such that reactions between silane and oxygen are predominantly heterogeneous so that a conformal coating is produced.

Document D1, which represents the closest prior art, discloses the deposition of arsenosilicate glass on a substrate by a low temperature deposition method using silane, oxygen and arsine (see column 4, lines 4 to 11).

There is no disclosure in the document concerning the type of reaction between silane and oxygen and whether or not the deposition process produces a conformal coating. On the contrary, it would appear from document D1 (see column 4, lines 11 to 15) that the coating is non-conformal, since subsequent to its formation, the coating is reflowed by placing the substrate in a high temperature furnace at about 850-900°C in order to give the coating a smoother topology.

The claimed invention is thus distinguished over the closest prior art in that arsine is used for inhibiting homogeneous reactions between silane and oxygen so that a conformal arsenosilicate glass coating is formed on a substrate.

The invention thus solves the problem of directly forming a conformal coating on a substrate so that any subsequent heat treatment to this end is not required.

- 3.2 Document D3 discloses that a conformal coating of phosphosilicate glass can be produced by a relatively low temperature CVD process in which homogeneous gas phase reactions are eliminated. However, in the CVD system disclosed in document D3, a gas injector having a special design is used to provide separate laminar flow ports for oxygen and hydride gas streams whereby homogeneous gas phase reactions are eliminated (see page 123, left-hand column). In the Board's view, there is, therefore, no indication in document D3 which would lead the skilled person to the conclusion that arsine can be used to inhibit homogeneous gas phase reactions between silane and oxygen and thereby produce a conformal coating.

Document D2 discloses that a mixture of silane, arsine, oxygen and nitrogen can be used to form an arsenic doped glass coating. There is however no indication in this document that the glass is formed in a heterogeneous reaction and that the coating is conformal.

Therefore, in the Board's judgment, the claimed invention is not rendered obvious by the cited prior art and the subject-matter of the independent Claims 1, 2 and 4 therefore involve an inventive step within the meaning of Article 56 EPC.

The remaining Claims 3 and 5 to 14 are dependent claims and include all the features of one or more of the Claims 1, 2 and 4. Therefore, Claims 3 and 5 to 14 fulfil the requirement of inventive step.

#### **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 with description, claims and drawings as specified in section VI above.

The Registrar:

The Chairman:

M. Beer

G. D. Paterson