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D E C I S I O N
of 19 August 1997

Case Number: T 0654/95 - 3.4.2

Application Number: 89106186.3

Publication Number: 0336437

IPC: G01L 9/06

Language of the proceedings: EN

Title of invention:

Pressure sensing transducer employing piezoresistive elements
on sapphire

Applicant:

Sahagen, Armen N.

Opponent:

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Headword:

-

Relevant legal provisions:

EPC Art. 123(2), 84, 54, 56

Keyword:

"After amendment: subject-matter extended (no)"

"Clarity (yes)"

"Novelty (yes)"

"Inventive step (yes)"

Decisions cited:

-

Catchword:

-



Case Number: T 0654/95 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 19 August 1997

Appellant: Sahagen, Armen N.
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Decision under appeal: Decision of the Examining Division of the
European Patent Office posted 7 February 1995
refusing European patent application
No. 89 106 186.3 pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: E. Turrini
Members: M. Chomentowski
B. J. Schachenmann

Summary of Facts and Submissions

- I. European patent application No. 89 106 186.3 (publication No. 336 437) was refused on the grounds that the subject-matter of the application had been extended by amendments beyond the content of the application as filed and that the subject-matter of the submitted claims lacked an inventive step having regard to D4 = US-A-3 654 579 and D1 = US-A-4 127 840.

The Examining Division pointed out particular formal deficiencies and took the following view concerning inventive step:

Starting from D4, which does not teach the use of crystalline sapphire for a diaphragm of a piezoresistive pressure transducer, the skilled person would be incited to use this measure, which is well known from e.g. D1, which concerns the replacement, which is applicable to a wide variety of force and pressure sensors, of silicon diaphragms with diffused piezoresistance by composite diaphragms having an epitaxially grown thin layer of doped silicon on a monocrystalline layer of sapphire or similar material. Therefore, the submitted independent device claim as well as the independent method claim, redefining the same transducer in terms of a method, lacked an inventive step.

Concerning the particular feature, in a dependent claim, of a sealed vacuum cavity of a transducer, reference was made to D6 = "Les capteurs en instrumentation industrielle", Bordas, Paris, 1982, paragraph 13.5.1.4, a document cited by the Examining Division during the examination procedure.

II. The appellant (applicant) lodged an appeal against this decision.

III. With communication dated 19 April 1996, the Board of appeal expressed the opinion that the appellant's main and auxiliary requests comprising claims filed with the statement of grounds of appeal did not appear to be allowable because they resulted from amendments introducing an unallowable extension of the subject-matter and that the claims lacked clarity, but that a new set of amended claims with amended pages of the description, annexed to the communication, could meet these objections and could be allowable in view of the arguments submitted by the appellant.

IV. With letter dated 27 June 1996, the appellant agreed to the amendments and filed retyped pages accordingly, whereby the only independent claims of the set of 28 claims, i.e. claims 1 and 23, read as follows:

"1. A piezoresistive pressure transducer (10) for monitoring a fluid pressure, comprising a pressure cell base (20) in a surface of which a cavity (22) is defined, a force collector diaphragm (18) mounted on the base over the cavity, the diaphragm having a first major surface facing towards the base and a second major surface facing away from the base and towards the pressure to be monitored such that the monitored pressure causes the diaphragm to flex towards the cavity, at least one layer of piezoresistive material (44) formed on a region of the first major surface which overlies the cavity, contact pads (48) formed on a peripheral region of the first major surface of the diaphragm, the contact pads being connected to the piezoresistive material by electrically conductive paths, and the peripheral region being bonded to the surface of the base around the cavity, feed through tubes (26) formed through the base at positions spaced

from the cavity, and electrical leads (24) which extend from respective contact pads and through respective feed through tubes in the base, characterised in that the diaphragm is formed from crystalline sapphire and insulates with the bonded surface of the base the electrically conductive paths, the contact pads (48) and the electrical leads (24) from the fluid to be monitored, and the cavity is defined by a recess in the base which forms a hermetically sealed vacuum chamber with the diaphragm."

"23. A method for forming a piezoresistive pressure transducer (10) for monitoring a fluid pressure, wherein a cavity (22) is defined in a surface of a pressure cell base (20), feed through tubes (26) are formed through the base at positions spaced (read "spaced") from the cavity, a diaphragm (18) is formed having a first major surface and a second major surface, at least one layer of piezoresistive material (44) is formed on a region of the first major surface of the diaphragm, contact pads (48) are formed on a peripheral region of the first major surface of the diaphragm, the contact pads being connected to the piezoresistive (read "piezoresistive") material by electrically conductive paths and to respective electrical leads (24) which extend from the diaphragm, and the diaphragm is mounted on the base over the cavity with the first major surface facing the cavity, the layer of piezoresistive material overlying the cavity, and the electrical leads extending through the feed through holes (read "tubes") in the base, characterised in that the diaphragm is formed from crystalline sapphire and insulates with the bonded surface of the base the electrically conductive paths,

the contact pads (48) and the electrical leads (24) from the fluid to be monitored, the cavity is defined by a recess in the base such that it forms a hermetically sealed chamber with the diaphragm, and the sealed chamber is evacuated."

- V. The appellant had submitted the following arguments concerning inventive step in support of his request that the decision under appeal be set aside and that a patent be granted:

A piezoresistive pressure transducer for monitoring a fluid pressure according to the first part of claim 1 is known from D4. The diaphragm of the known transducer is not specified as being formed from crystalline sapphire, but for instance from a semiconductor material, and the cavity in said known transducer is not defined by a recess in the base which forms a hermetically sealed vacuum chamber with the diaphragm, but by a hole open at its both ends; moreover, although the structure in D4 is mentioned as being used to "mechanically isolate the electrical leads from the transducer assembly", the advantage mentioned in the document is derivable as concerning an isolation which is not related with an insulation from the medium to be monitored.

An object of the present invention is the protection of the piezoresistive elements, the contact pads and the lead wires from the fluid to be monitored, and this is achieved by insulating said elements by the sapphire diaphragm from the fluid to be monitored which is applied on the other major surface of said diaphragm.

It is admitted that the person skilled in the art of D4 could be incited, for instance by the teaching of D1 to substitute a diaphragm formed from crystalline sapphire for the diaphragm made from semiconductor material.

However, it is to be noted that the diaphragm in the transducer of D1 is not submitted to compressional forces, but to tensile forces. Moreover, in D1, the hermetic sealing is not achieved by bonding to the component support part the side of the diaphragm carrying the contacts, but by bonding thereto the opposite side of the diaphragm, which does not carry in particular any conductors. Thus, the particular problem addressed by the present invention, which is that of ensuring the integrity of vacuum seals despite the fact that the piezoresistive active portions of the device face into the vacuum enclosure and electrical connections must be made to those active portions, is not solved by the combination of the teachings of D4 and D1. Moreover, a modification of the structure of the transducer in accordance with D6 showing a vacuum sealed cavity, would not be obvious because, in any case, the conductors therein are not derivable as being protected from the fluid to be monitored. Therefore, the subject-matter of the independent claims involves an inventive step.

Reasons for the Decision

1. The appeal is admissible.
2. *Allowability of the amendments*

It is to be noted that the deficiencies objected to by the Examining Division have been met by amendments provided by the appellant in the claims filed with the statement of grounds of appeal, and that the deficiencies objected to by the Board have been met by further amendments. Thus, present claim 1 is based primarily on original claims 1, 6 (which was dependent from claim 1) and 18, together with the indications in

the original application (see in particular page 6, third paragraph to page 7, first paragraph; page 8, second paragraph; see also page 23, last paragraph) specifying more closely the features concerning the sealed cavity and the electrical elements therein insulated from the fluid to be monitored. Present claim 23, which is based on original claim 15, defines the invention in terms of a method for forming a pressure cell and comprises features corresponding to those of claim 1. Therefore, the present application satisfies the requirement of Article 123(2) EPC that a European patent application may not be amended in such a way that it contains subject-matter which extends beyond the content of the application as filed.

3. *Clarity*

A problem derivable from the present application (see page 6, third paragraph to page 7, first paragraph; page 8, second paragraph; see also page 23, second paragraph) is that there is a need for insulating and protecting the piezoresistive elements, the contact pads and the lead wires from the fluid to be monitored; this problem is solved by using a sapphire diaphragm, whereby the fluid to be monitored is applied on the other major surface of said diaphragm with respect to said components and elements. Present claims 1 and 23 comprise features concerning the insulation of the electrically conductive paths, the contact pads (48) and the electrical leads (24) from the fluid to be monitored, i.e. concerning the solution of the stated problem. Since the independent claims otherwise define correctly the matter for which protection is sought, these claims are clear in the sense of Article 84 EPC.

4. *Novelty*

A transducer or a method for forming a transducer comprising all the features of present claim 1 or claim 23, respectively, is not known from the documents of the prior art. Therefore, the subject-matter of these claims is new in the sense of Article 54 EPC.

5. *Inventive step*

5.1 A piezoresistive pressure transducer for monitoring a fluid pressure is known from D4 (see column 1, line 73 to column 2, line 23; column 2, line 47 to column 5, line 48; column 6, lines 12 to 25; Figures 1, 2 and 8; see also Figures 3 to 5); this transducer comprises a pressure cell base (84) in a surface of which a cavity is defined; a force collector diaphragm (80) mounted on the base over the cavity, the diaphragm having a first major surface facing towards the base and a second major surface facing away from the base and towards the pressure to be monitored such that the monitored pressure causes the diaphragm to flex towards the cavity; at least one layer of piezoresistive material (10, 11, 12, 13) is formed on a region of the first major surface which overlies the cavity; contact pads (17, 18, 19, 22, 23) are formed on a peripheral region of the first major surface of the diaphragm, the contact pads being connected to the piezoresistive material by electrically conductive paths; it is derivable in particular from Figure 8 that the peripheral region of the known transducer is bonded to the surface of the base around the cavity; feed through tubes are formed through the base (84) at positions spaced from the cavity, and electrical leads (82) which extend from respective contact pads and through respective feed through tubes in the base.

However, contrary to the transducer of present claim 1, the diaphragm (80) of the known transducer is not specified as being formed from crystalline sapphire, but for instance from a semiconductor material, and the cavity in said known transducer is not defined by a recess in the base which forms a hermetically sealed vacuum chamber with the diaphragm, but by a hole remaining open at its rear end. Moreover, as pointed out by the appellant, although the structure in D4 (see column 6, lines 12 to 25 and Figure 8; see also column 1, lines 51 to 64 and column 2, lines 19 to 23) is mentioned as being used to "mechanically isolate" the electrical leads (82) "from the transducer assembly", the advantage mentioned in the document is derivable as concerning to an isolation which is not related with an insulation from the medium to be monitored.

5.2 As argued by the appellant and as derivable from the application (see page 6, third paragraph to page 7, first paragraph; page 8, second paragraph; see also page 23, second paragraph) an object of the present invention is that of protecting the piezoresistive elements, the contact pads and the lead wires from the fluid to be monitored, and this is achieved by insulating said elements by the sapphire diaphragm from the fluid to be monitored which is applied on the other major surface of said diaphragm.

5.3 As admitted by the appellant, the person skilled in the art of D4 could be incited, for instance by the teaching of D1 (see column 1, lines 5 to 10; column 3, lines 1 to 17 and 27 to 38), to substitute a diaphragm formed from crystalline sapphire for the diaphragm made from semiconductor material. Indeed, in the present context, semiconductor and sapphire can be considered as equivalent diaphragm materials.

It is also to be noted that in the transducer known from D1 (see column 6, lines 1 to 28; Figure 1) the upper face of the diaphragm (10), which carries the piezoresistive elements (62, 64), is exposed to the reference pressure in the chamber (48) which is preferably evacuated. It is further to be noted that it is derivable from D1 (see column 4, lines 13 to 44; column 8, line 1 to column 9, line 36; Figures 1, 2 and 4) that hermetic sealing between diaphragm (10), on the one hand, and support member (20) and further supporting elements (30), on the other hand, is important. Thus, although as pointed out by the appellant the diaphragm (10) in the transducer of D1 is not submitted to compressional forces, but to tensile forces, the person skilled in the art of D4 could anyway be incited to provide in his transducer a reference pressure in the form of an evacuated chamber on the side of the diaphragm which is not in contact with the fluid to be monitored.

- 5.4 However, as convincingly argued by the appellant and as derivable from the text locations of D1 cited here above, the hermetic sealing is not achieved, according to the prior art, by bonding to the component support part (20, 30) the side of the diaphragm (10) carrying the contacts, but by bonding to said component support part (20, 30) the opposite side of the diaphragm, which does not carry in particular any conductors. Thus, the particular problem addressed by the present invention, which according to the appellant is that of ensuring the integrity of vacuum seals despite the fact that the piezoresistive active portions of the device face into the vacuum enclosure and electrical connections must be made to those active portions through the base, is not solved by the combination of the teachings of D4 and D1.

As further convincingly argued by the appellant, in the transducer of D6 (see Figures 13, 12), the conductors ("metallisation") are not derivable as being protected from the fluid to be monitored (arrow "P"), so that this document is not relevant either to the problem to be solved by the present invention.

Therefore, the subject-matter of present claim 1 is considered as involving an inventive step in the sense of Article 56 EPC. The same applies to the subject-matter of present claim 23, which defines the invention specified by present claim 1 in terms of a method for forming a piezoresistive pressure transducer for monitoring a fluid pressure.

- 5.5 Therefore, the claims are allowable and a patent can be granted, so that oral proceedings requested auxiliarily are not necessary (Articles 52(1) and 97(2) EPC).

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 following documents:

Description:

Pages 1 to 4, 8 to 22 and 24 as originally filed;
Page 7 filed with applicant's (appellant's) letter of 18 August 1994; Pages 5, 6 and 23 filed with appellant's letter of 27 June 1996;

