PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G21B 1/00	A1	(11) International Publication Number: WO 97/20320
		(43) International Publication Date: 5 June 1997 (05.06.97)

(21) International Application Number: PCT/IT96/00226

(22) International Filing Date: 26 November 1996 (26.11.96)

(30) Priority Data:
MI95A002502 30 November 1995 (30.11.95) IT

(71) Applicant *(for all designated States except US)*: SGS-THOMSON MICROELECTRONICS S.R.L. [IT/IT]; Via C. Olivetti, 2, I-20041 Agrate Brianza (IT).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: MASTROMATTEO, Ubaldo [IT/IT]; Via Brera, 18, I-20010 Cornaredo (IT).

(74) Agents: BOTTI, Mario et al.; Porta, Checcacci & Botti S.r.l., Viale Sabotino, 19/2, I-20135 Milan (IT).

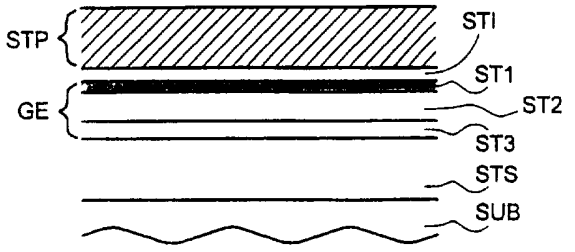
(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

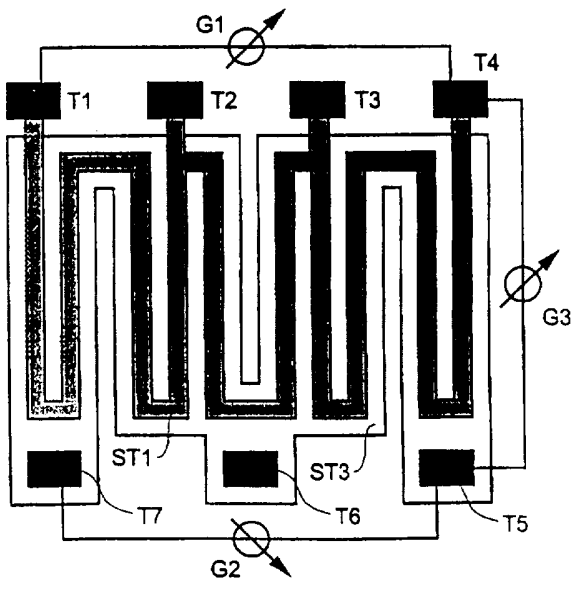
Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: MONOLITHICALLY INTEGRATED DEVICE

(57) Abstract

The monolithically integrated device according to this invention comprises a first substrate (SUB) and, at least in a portion: a) a first structure (ST1) of a first material in solid form suitable to absorb hydrogen with ensuing generation of thermal energy, superposed to said substrate (SUB); b) a second structure (ST2) of a second material in solid form suitable to release hydrogen when it reaches a temperature higher than a prefixed temperature, superposed to said substrate (SUB); c) a third structure (ST3) of a third material in solid form suitable to generate thermal energy when it is submitted to the passage of electric current, so placed as to be thermally coupled at least to said second structure (ST2); wherein said first structure (ST1) and said second structure (ST2) are in contact, at least partly, with one another.





FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	**GB**	United Kingdom	**MW**	Malawi
AT	Austria	**GE**	Georgia	**MX**	Mexico
AU	Australia	**GN**	Guinea	**NE**	Niger
BB	Barbados	**GR**	Greece	**NL**	Netherlands
BE	Belgium	**HU**	Hungary	**NO**	Norway
BF	Burkina Faso	**IE**	Ireland	**NZ**	New Zealand
BG	Bulgaria	**IT**	Italy	**PL**	Poland
BJ	Benin	**JP**	Japan	**PT**	Portugal
BR	Brazil	**KE**	Kenya	**RO**	Romania
BY	Belarus	**KG**	Kyrgystan	**RU**	Russian Federation
CA	Canada	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CF	Central African Republic			**SE**	Sweden
CG	Congo	**KR**	Republic of Korea	**SG**	Singapore
CH	Switzerland	**KZ**	Kazakhstan	**SI**	Slovenia
CI	Côte d'Ivoire	**LI**	Liechtenstein	**SK**	Slovakia
CM	Cameroon	**LK**	Sri Lanka	**SN**	Senegal
CN	China	**LR**	Liberia	**SZ**	Swaziland
CS	Czechoslovakia	**LT**	Lithuania	**TD**	Chad
CZ	Czech Republic	**LU**	Luxembourg	**TG**	Togo
DE	Germany	**LV**	Latvia	**TJ**	Tajikistan
DK	Denmark	**MC**	Monaco	**TT**	Trinidad and Tobago
EE	Estonia	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**UG**	Uganda
FI	Finland	**ML**	Mali	**US**	United States of America
FR	France	**MN**	Mongolia	**UZ**	Uzbekistan
GA	Gabon	**MR**	Mauritania	**VN**	Viet Nam

Title: Monolithically integrated device

DESCRIPTION

Technical Field

This invention relates to a monolithically integrated device capable of generating thermal energy, based on a physical phenomenon attributed to cold nuclear fusion reactions.

Reactions of cold nuclear fusion have been noticed in several physical phenomena: the article by G.F. Cerofolini and A. Foglio-Para, "Can binuclear atoms solve the cold fusion puzzle?", FUSION TECHNOLOGY, Vol. 23, pp. 98-102, 1993, illustrates shortly such phenomena and the associated chemical and nuclear reactions; interesting articles are also mentioned in the literature.

The technical and patent-related literature on the matter is very rich, given the practical interest of the subject.

Background Art

The first studies on cold nuclear fusion, as such, are due to M. Fleischmann and S. Pons and have been made known in 1989; the phenomenon they have considered is the loading of deuterium by electrodes made of palladium or titanium; during such phenomenon an unexpected generation of thermal energy is noticed, which is attributed to nuclear fusion reactions between the deuterium atoms, to form helium.

The physical phenomenon on which this invention is

based is just this one.

In the experiments made till now several materials capable of absorbing hydrogen and its isotopes have been used successfully for the realization of the electrodes, among which: palladium, titanium, platinum, nickel, niobium.

In the experiments made till now, the deuterium was always obtained from a gaseous state fuel, for instance gaseous mixes of hydrogen or fluid fluels, for instance solutions of electrolytic compounds of hydrogen in heavy water; the drawback of these "fuels" lies in the dissipation of the fusion material. i.e. hydrogen. In fact, this releases and escapes in gaseous form close to the electrode just when in its inside the concentration reaches values useful for triggering the fusion. Besides, on the increase in the temperature of the electrode, fluids boil, while in gases the concentration of the atoms decreases; this hinders the fusion.

Disclosure of Invention

Object of this invention is to provide a monolithically integrated device capable of effectively generating thermal energy by exploiting the aforementioned phenomenon and of overcoming the aforementioned drawbacks.

Such object has been reached through the device having the characteristics set forth in claim 1; further advantageous aspects of this invention are set forth in the dependent claims.

By utilizing a structure of a solid form material

suitable to release hydrogen when it reaches a temperature higher than a prefixed temperature, and putting it in contact with another structure from another solid form material suitable to absorb hydrogen with ensuing generation of thermal energy, and if the "releasing" material is, at least for a short time, at least in one part, at a temperature exceeding said prefixed temperature, there is generation of thermal energy by the other material, which generation lasts in the time, and its amount is remarkable, as hydrogen, the fusion material, cannot easily escape in solid materials and the working temperature threshold is very high and corresponds to the melting of one of the solid form materials.

The invention will be more clearly stressed by the following description, considered together with the attached drawings, wherein:

Brief Description of Drawings

Fig. 1 shows the section of a first device according to this invention,

Fig. 2 shows the top view of the device of Fig. 1,

Fig. 3 shows the section of part of a second device according to this invention,

Fig. 4 shows the top view of the device of Fig. 3,

Fig. 5 shows the section of part of a third device according to this invention,

Fig. 6 shows the bottom view of the device of Fig. 5,

Fig. 7 shows the section of a greater part of the

device of Fig. 1,

Fig. 8 shows the section of a greater part of the device of Fig. 3,

Fig. 9 shows the section of a greater part of the device of Fig. 5,

Fig. 10 shows schematically the top view of the whole part of generation of thermal and electric energy of the device of Fig. 8,

Fig. 11 shows schematically the top view of the whole device of Fig. 8, and

Fig. 12 shows schematically the top view of a thermopile of a known type utilizable in the device of Fig. 10.

Modes for Carrying Out the Invention

The invention starts from the recognition that in the field of integrated electronic circuits the fact is known that, during the fabrication of the same, some component materials, such as for instance boron nitride, silicon carbide, silicon nitride, aluminium arsenide, gallium arsenide enrich in hydrogen, causing degradations of the performances; such phenomenon is explained, for instance, in S. Manzini's article, "Active doping instability in n+-p silicon surface avalanche diodes", Solid form Electronics, Vol. 32, Nr. 2, pp. 331-337, 1995 and in the articles mentioned in the references.

We have then planned to usefully exploit this "noxious" property of such materials.

A process step, typical of the techniques of fabrication of electronic integrated circuits, which leads to the formation of hydrogen-rich materials is the PECVD (Plasma Enhanced Chemical Vapor Deposition); details on this process step and also on all the fabrication techniques of silicon-based integrated electronic circuits may be drawn from S.M. Sze's book, "VLSI Technology", McGraw-Hill, 1988; in addition, fabrication techniques that are specific of the integrated electronic circuits based on germanium and gallium arsenide are well known in the literature.

A typical chemical reaction between hydrogen compounds using the PECVD technique is the following one:

[1] $AH_n + BH_m \Rightarrow A_xB_y + A\text{-}H_j + B\text{-}H_k + H_2$

Such oxidoreduction reaction [1] takes place from leftside to rightside if we reach a rather high temperature T1, for instance 400°C, and if we cause the two leftside reagents to be in the plasma phase instead that in the gaseous phase; At such "low" temperature T1, the reaction [1] is not complete and stoichiometric and many bonds remain therefore between hydrogen and the A and B elements; generally, these bonds are single, i.e. "j" and "k" are equal to one; from reaction [1] a solid composition is obtained that has a high content of chemically bound hydrogen (and therefore of deuterium and tritium) and of gaseous state hydrogen, which does not remain in high amount in the composition.

If the so obtained solid composition is heated afterwards (even after a possible cooling at room temperature) up to a temperature T2 higher than the previous one, for instance 800°C, reaction [1] becomes

complete and stoichiometric, i. e. the following reaction takes place:

[2] $A\text{-}H_j + B\text{-}H_k \Rightarrow A_xB_y + H_2$

with release of the hydrogen contained.

At temperatures comprised between T1 and T2 only the more weakly bound atoms will be released.

Of course, temperatures T1 and T2 depend on the A and B elements utilized; besides, it must be taken into account that there are no critical values which cause abrupt variations in the reaction speed for reactions [1] and [2].

Therefore, the method according to this invention proposes to utilize a first structure from a first material in solid form suitable to absorb hydrogen with ensuing generation of thermal energy, and to utilize a second structure from a second material in solid form suitable to release hydrogen when it is at a temperature higher than a prefixed temperature, to put in contact at least partly to one another said first and said second structure, and to heat at the start at least said second structure, at least until it has exceeded said prefixed temperature in at least one part; the starting heating may also be caused by the environment where the two structures are placed.

The starting heating causes in the second structure the release of some hydrogen; such hydrogen will move, for instance by diffusion in the solid state, in the second structure and pass, at least partly into the first structure, as this one is in contact with the second structure.

The first structure absorbs hydrogen and starts generating thermal energy, because of the presumed nuclear fusion reactions, and then starts heating.

As the two structures are in contact, the second structure will be heated by the first structure and therefore the process of hydrogen release goes on; as a consequence, the first structure goes on heating. If the first structure should not be in condition of heating the second structure sufficiently, the "starting" heating can be expected to go on, for instance, for the whole duration of the process of thermal energy generation.

Of course, the aforementioned silicon nitride-based solid composition is only one of the possible second materials that stresses such release properties; of course, such second materials may be produced according to different techniques, among which the PECVD.

In the same way, as first material one can choose among: palladium, titanium, platinum, nickel, and alloy thereof, and any other material showing such absorption property.

The fact that the starting heating of the second structure may involve, in some cases, a starting heating also of the first structure through their contact, is an advantage as, in such cases, the hydrogen absorption by the first structure is spurred; such heating may also be spurred, if necessary, by a suitable arrangement of the materials and the thermal energy source.

Relying on the spontaneous movement of hydrogen in the second structure towards the first structure may lead

to an insufficient generation of thermal energy.

To obviate this drawback, it is convenient that at least part of the second structure be submitted to an electric field with field lines having such shape and direction as to spur the movement of the nuclei of such hydrogen released in the second structure towards the first structure.

The intensity of the electric field can be fixed beforehand on the basis of the thermal power wished.

If the thermal power generated is not suitably removed, the temperature of the two structures will continue to increase until they are melted and the apparatus is destroyed; should one wish to obtain different thermal powers at different times, controlling through the intensity of the electric field the thermal energy generated is very advantageous; Through field inversion it is even possible to cancel the effect of the spontaneous movement of hydrogen, and therefore to inhibit entirely the generation of thermal energy.

With reference to the case in which the second material is a silicon nitride-based solid composition, the hydrogen and its isotopes that are released through reaction [2] are absorbed by the first absorbing material with good efficiency, as the two materials are in contact with one another and both of them are solid.

It is of the essential that the concentration of hydrogen in the second material, in terms of atoms per cubic centimeter, be sufficient to originate an appreciable number of fusion phenomena per volume unit of the first material.

In the case of silicon nitride and nickel, a concentration of 10^{22} may be chosen for the hydrogen in the silicon nitride and the nitride massmay be caused to be 9 times greater than the nickel mass; in this way, the number of hydrogen atoms that can be released is about equal to the number of nickel atoms available; in fact, the density of nickel is equal to 9×10^{22}.

Actually, to the purposes of the use as solid fuel, the presence of the A_xB_y compound in the solid composition is not strictly indispensable; what matters if the presence of $A\text{-}H_j$ + $B\text{-}H_k$: therefore, it would be theoretically possible to utilize only either $A\text{-}H_j$ or $B\text{-}H_k$.

Of course, one cannot exclude the presence in the solid composition of other chemical elements or compounds which might not take part, absolutely or to a relevant extent, in the chemical reaction between the A, B, H elements.

To the purposes of the use as solid fuel it is of the essential to cause reaction [1] not to complete in reaction [2], so as to trap much hydrogen in the resulting solid composition; of course, should some not chemically bound hydrogen be trapped in the composition but, for instance, in atomic and/or molecular and/or ionic form, this would be no problem, but on the contrary an advantage, as surely it would be released once the composition has been heated up to a temperature higher than T1.

With silicon nitride and utilizing the aforementioned PECVD techniques, hydrogen concentrations equal to 10^{22} atoms per cubic centimeter are easily reached.

The above set forth method can be realized by means of a monolithically integrated device comprising a substrate and, at least in one part:

a) a first structure of a first material in solid form suitable to absorb hydrogen with ensuing generation of thermal energy, superposed to said substrate, and

b) a second structure of a second material in solid form suitable to release hydrogen when it reaches a temperature higher than a prefixed temperature, superposed to said substrate,

and wherein the first and the second structure are in contact at least partly with one another.

In Figs. 1, 2, 3, 4, 5, 6, the first structure is indicated by ST1 and the second structure by ST2, while the substrate is indicated by SUB; its function is to support the device and it may be realized, for instance, from silicon.

There exist several methods to put structure ST1 in contact with structure ST2; in the embodiment of Fig. 1, they are superposed, and therefore the hydrogen released in structure ST2 follows a substantially vertical path to pass to structure ST1; in the embodiment of Fig. 3, they are placed side by side, and therefore the hydrogen follows a substantially horizontal path; in the embodiment of Fig. 5, structure ST2 surrounds structure ST1, and therefore the hydrogen follows a path which depends on its starting position and which may be either horizontal or vertical or oblique.

The whole of structure ST1, structure ST2 and, possibly a third structure ST3, of which we shall speak later on, forms a generator GE of thermal energy.

Between generator GE and substrate SUB an insulating structure STS or thermally insulating material is advantageously placed, for instance a thick layer of silicon dioxide, so as to prevent the thermal energy generated by such generator GE from dissipating through conduction in substrate SUB or damaging it; in the embodiments of Figs. 1, 3, 5, the material of structure STS is usefully also an electric insulator, to prevent current dissipations; this is true for silicon dioxide.

To obtain the already mentioned starting heating, the device should usefully furtherly comprise, at least in the part occupied by generator GE, a a third structure ST3 of a third material in solid form suitable to generate thermal energy when it is submitted to the passage of electric current, so placed as to be thermally coupled at least to said second structure ST2; said third material may be, for instance, polysilicon or doped polysilicon; structure ST3 is a resistor realizible therefore in any of the numeros ways well known in the sector of integrated circuits.

In the embodiment of Figs. 1, 2, structure ST1 and structure ST3 are shaped as a line, preferably bent, and are practically fully superposed; the width of line of structure ST3 is much greater than the width of line of the first structure ST1, so that it is possible to obtain a good heating; structure ST2 occupies the resting part of the space and is shaped as a substantially rectangular and flat plate.

In the embodiment of Figs. 3, 4, structures ST1, ST2,

ST3 are substantially all shaped as a bent line and are placed side by side; a variant consists in the realization of structure ST1 in the shape of a "comb" whose teeth insert in the loops of the bent line, as shown in the figures; another variant consists in giving structures ST1 and ST2 the same shape.

In the embodiment of Figs, 5, 6, structures ST1 and ST3 have substantially the same shape and are formed by a plurality of cells, for instance and as shown in the figures, having a square form, connected to one another, for instance, by narrower and thinner channels; structure ST2 occupies the resting part of the space.

Alternatively or in addition to the heating function, structure ST3 may have, in combination with structure ST1, the function of polarization of the material of structure ST2; by applying to these suitable potentials an electric field may generate with field lines having such shape and direction as to spur the movement of the nuclei of such hydrogen released in structure ST2 towards structure ST1.

In the embodiment of Figs. 5, 6, a part of structure ST3, in particular the cells, is prevailingly used for the polarization function, and another part of the same, in particular the channels, is prevailingly used for the heating function. In the embodiments of Figs, 1, 2 and Figs, 3, 4, structure ST3 performs both of the functions.

With reference to the embodiment of Figs. 1, 2, structure ST1 is provided with at least two terminals T1, T4, and structure ST3 is provided with at least two terminals T5, T7; besides, there is a first voltage

generator G1 coupled to the two terminals T1, T4 of structure ST1, a second voltage generator G2 coupled to the two terminals T5, T7 of structure ST3, and a third voltage generator G3 coupled to terminal T4 and terminal T5; one notices that structure ST1 and structure ST3 form approximately a condenser with two flat parallel plates in which a dielectric is interposed constituted by structure ST2.

Generator G2 performs the heating function, while generator G3 performs the polarization function; generator G1 may be advantageously utilized, in case of necessity, to optimize the polarization function; in fact, as the potential of structure ST3 changes from point to point because of generator G2 and as, in general, the materials of structure ST1 and of structure ST3 are different, it may be important to check, through generator G3, the intensity of the electric field and therefore the polarization of structure ST2 when the position changes, for instance to obtain a uniform generation of thermal energy.

Fig. 2 shows also terminals T2 and T3, additional for structure ST1, and terminal T6 additional for structure ST3; such additional terminals in combination with the "normal" terminals, may be advantageously utilized both to better control the polarization of structure ST2, and to better control the heating of structure ST1, as well as to better control the generation of thermal energy, for instance by excluding completely only part of structure ST3 from the generation of thermal energy.

Of course, to exploit all the opportunities offered by the device of Figs. 1, 2, it is necessary to provide all the control circuits for the generators connected

to the above terminals.

Also in the embodiments of Figs. 3, 4 and Figs. 5, 6, structures ST1 and ST3 may be provided with like terminals, even though they are not shown in said figures.

The most typical and advantageous application of a generator GE as the above described one is the generation of electric energy.

To obtain this result it is necessary to provide the device according to this invention with a converter of thermal energy into electric energy, suitable to convert at least part of the thermal energy generated by structure ST1. If the converter STP is realized substantially by means of a thermopile system, the integrability in monolithic form is facilitated; such thermopile system should be so located that its hot contact regions are thermally coupled with at least structure ST1, the real heat source.

By thermopile system one means, in general, a plurality of thermopiles serially connected with one another; it cannot be excluded that, with a suitable choice of materials and in some applications, the thermopile system may be formed by one only thermopile. Thermopiles are well known devices which operate generally by exploiting the Seebeck effect.

In Figs. 1 and 7, generator Ge is placed on structure STS and covered by a structure ST1 from electrically insulating and thermally conductive material, for instance, diamond; the thermopile converter STP is placed with its hot contact part on structure ST1, which ensures a good thermal coupling, and the resting

part on structure STS.

In Figs. 3, 8, generator GE is placed on structure ST1, which in its turn is placed on structure STS; structure ST1 extends much beyond the edge of generator GE; the thermopile converter STP is place sideways on generator GE, and more particularly with its hot contact part on structure ST1, which ensures a good heat transfer, and the resting part on structure STS.

In Figs. 5, 9, generator GE is placed on structure ST1, which ensures a good thermal coupling, which, in its turn, is placed on the hot contact part of the thermopile converter STP; converter STP is placed on structure STS.

Fig. 12 shows schematically the top view of a thermopile TP; this comprises a fourth flat structure ST4 made from a fourth electric conductive material shaped an "L", a sixth flat structure ST6 from a sixth electric conductive material, other than the fourth one, shaped as an "L", and a fifth flat structure ST5 from electrically conductive material; structure ST5 has a shape complementary to structure ST6 and flanks the latter on both sides of the "L"; structure ST4 is superposed to the two other structures, so as to have a region of electric contact with structure ST6 at a first extremity, called region of hot contact; at the second extremity, structures ST4 and ST6 present respectively a first terminal P1 and a second terminal P2. If the first extremity of structures ST4 and ST6 is brought to a temperature higher than the temperature of their second extremity, a difference of potential creates between terminals P1 and P2, generally of the order of hundreds millivolts, which depends on the

difference of temperature; hence the necessity of the serial connection. The materials utilizable for elements E1 and E2 are well known in the literature.

It is obvious from what has been set forth that the thermopiles operate also as temperature sensors of generator GE.

If generator GE and the thermopile converter STP are placed sideways on one another as shown in Fig. 8, it is advantageous to choose the material of structure ST4 equal to the material of structure ST1, the material of structure ST4 equal to the material of structure ST1, the material of structure ST6 equal to the material of structure ST3, so that both the thermopiles TP and generator GE can be realized through the same process steps.

The same aim may be reached by choosing the material of structure ST4 equal to the material of structure ST3, the material of structure ST5 equal to the material of structure ST2, the material of structure ST6 equal to the material of structure ST1.

Fig. 10 shows a structure which might constitute a complete device encloseable in a package and suitable to feed an electric or electronic circuit.

This comprises a generator GE, for instance that shown in Figs. 3, 4, 8, connected to, for instance, four electric lines, to feed the terminals of structures ST1 and ST3, which, as a whole, form a bus BC for the control of the generation of thermal energy, and comprises a thermopile converter STP formed by fifteen thermopiles TP crown-arranged around the generator GE, electrically insulated from one anotherm electrically

insulated from generator GE, but thermally coupled to the same; the crown is open to allow the passage of bus BC.

The thermopiles TP are serially connected with one another, i.e.: terminal P2 of one of them is connected to terminal P1 of the adjoining one; terminal P1 of the first one is connected to a positive line LP; terminal P2 of the last one is connected to a negative line LN. Lines LP and LN may therefore be utilized ar terminals of a voltage generator.

The structure of Fig. 10 may alternatively be utilized inside a conventional integrated system as feeding source.

Fig. 11 shows the structure of one such integrated circuit, which structure comprises: a generator GE, a control bus BC connected to generator GE, a converter STP, two lines LP and LN - positive and negative - connected to converter STP, control circuit SC monolithically integrated, connected to bus BC and lines LP and LN, two feeding and mass lines VCC and GND connected to circuit SC, an applicative circuit CC monolithically integrated, suitable to perform analogic and/or logic electric functions of a conventional type and connected to lines VCC and GND to be fed by them.

Circuit SC, which in a simple embodiment might also be omitted, can perform the following functions: take the current required by circuit CC, send to the terminals of the structures of generator GE suitable voltages through bus BC, take the temperature of generator GE through lines LP and LN, receive the voltage generated by converter STP through lines LP and LN, stablize the voltage supplied to lines VCC and GND.

CLAIMS

1. A monolithically integrated device comprising a substrate (SUB) and, at least in a portion:

a) a first structure (ST1) of a first material in solid form suitable to absorb hydrogen with ensuing generation of thermal energy, superposed to said substrate (SUB), and

b) a second structure (ST2) of a second material in solid form suitable to release hydrogen when it reaches a temperature higher than a prefixed temperature, superposed to said substrate (SUB),

and wherein said first (ST1) and said second (ST2) structure are in contact at least partly with one another.

2. The device according to claim 1, wherein said first (ST1) and said second (ST2) structure are superposed to one another at least partly.

3. The device according to claims 1 or 2, furtherly comprising, at least in said portion, an insulating structure (STS) of thermally insulating material interposed between said first (ST1) and said second (ST2) structures and said substrate (SUB).

4. The device according to claims 1 or 2 or 3, furtherly comprising, at least in said portion, a third structure (ST3) of a third material in solid form, suitable to generate thermal energy when it is submitted to tha passage of electric current, so placed as to be thermally coupleable at least to said second structure (ST2).

5. The device according to claim 4, wherein said first (ST1) and said third (ST3) structures are shaped as a line, preferably bent, and are practically fully superposed and wherein the width of line of said third structure (ST3) is much greater than the width of line of said first structure (ST1).

6. The device according to claim 4, wherein said first structure (ST1) is provided with at least two terminals (T1, T4), said structure (ST3) is provided with at least two terminals (T5, T7), and furtherly comprises a first voltage generator (G1) coupled with the two terminals (T1, T4) of said first structure (ST1), a second voltage generator (G2) coupled with the two terminals (T5, T7) of said third structure (ST3), and a third voltage generator (G3) coupled with a terminal (T4) of said first structure (ST1) and with a terminal (T5) of said third structure (ST3), and a control circuit (SC) for said voltage generators (G1, G2, G3).

7. The device according to claim 6, wherein said first structure (ST1) is provided with a plurality of terminals (T1, T2, T3, T4).

8. The device according to any of the preceding claims, furtherly comprising a converter (STP) of thermal energy into electric energy suitable to convert at least part of the electric energy generated by said first structure (ST1).

9. The device according to claim 8, wherein said converter (STP) comprises a thermopile system so placed that its hot contact regions are thermally coupled to at least said first structure (ST1).

10. The device according to claim 9, wherein said

thermopile system comprises:

a) a fourth structure (ST4) of a fourth material,

b) a fifth structure (ST5) of an electrically insulating material, and

c) a sixth structure (ST6) of a sixth material other than said fourth material,

and is placed at least partly under said first (ST1) and second (ST2) structures.

11. The device according to claim 9, wherein said thermopile system comprises:

a) a fourth structure (ST4) of a fourth material equal to said first or said third material,

b) a fifth structure (ST5) of an electrically insulating material equal to said second material, and

c) a sixth structure (ST6) of a sixth material other than said fourth material and equal to said third or said first material,

and is placed at least sideways on said first (ST1) and said second (ST2) structures.

12. The device according to any of the claims 8 through 11, comprising a circuitry (CC) monolithically integrated on said substrate (SUB) and powered by said converter (STP).

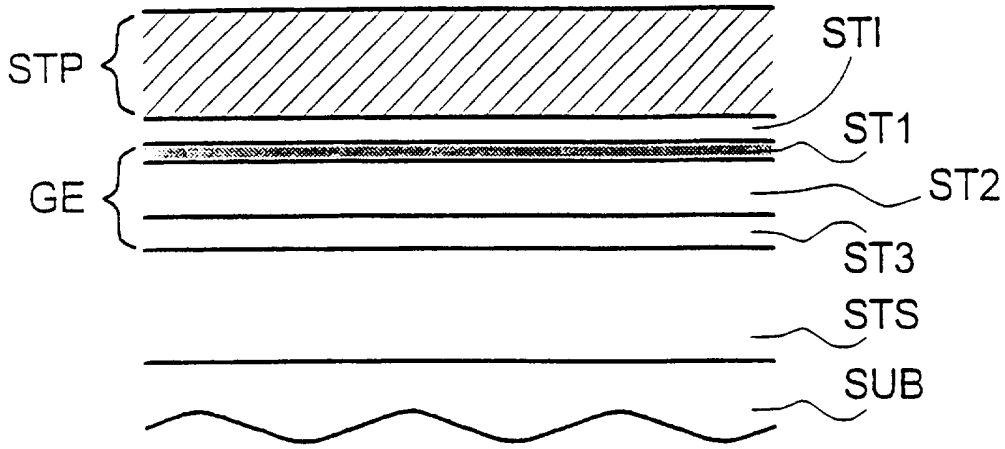


Fig.1

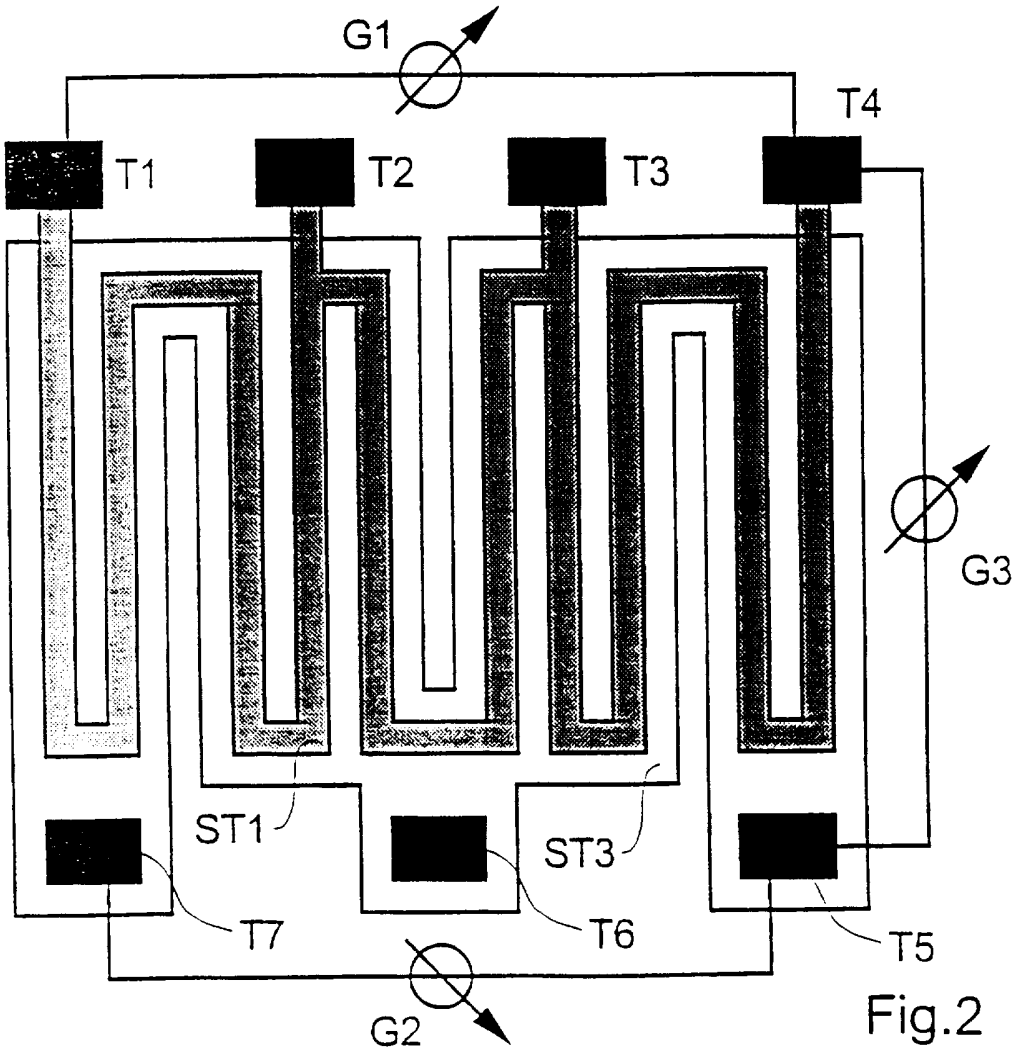


Fig.2

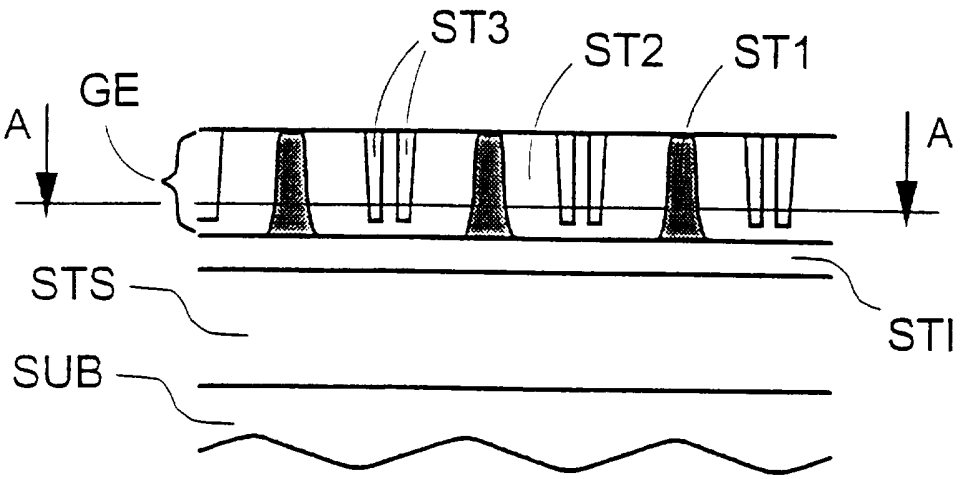


Fig.3

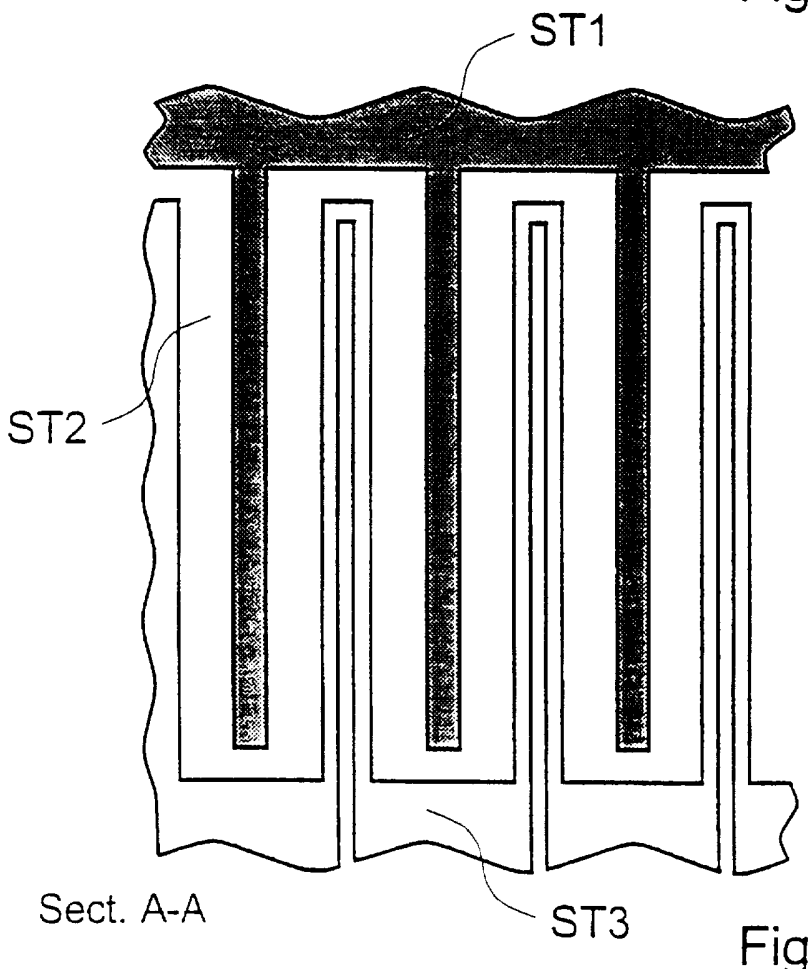


Fig.4

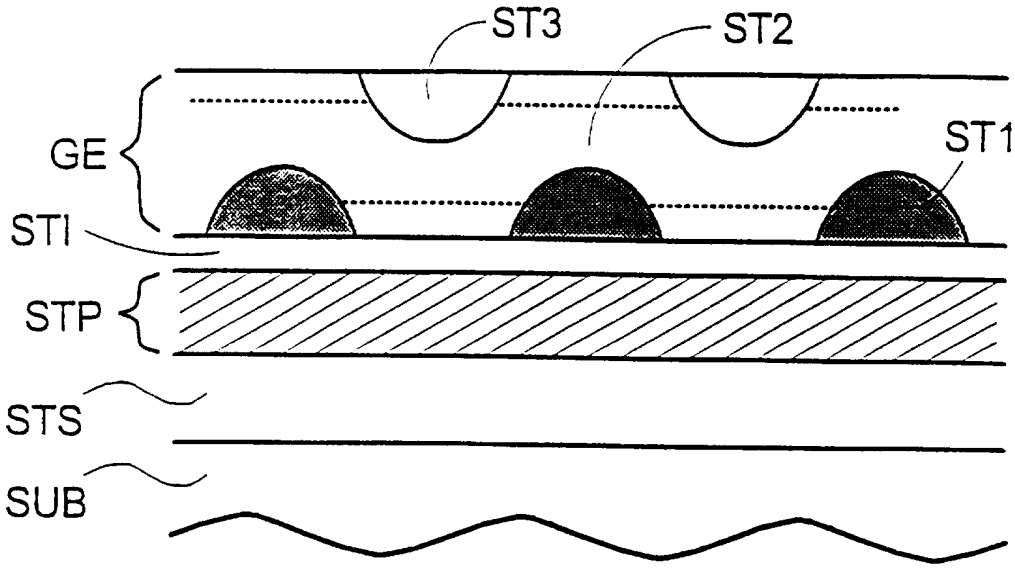


Fig.5

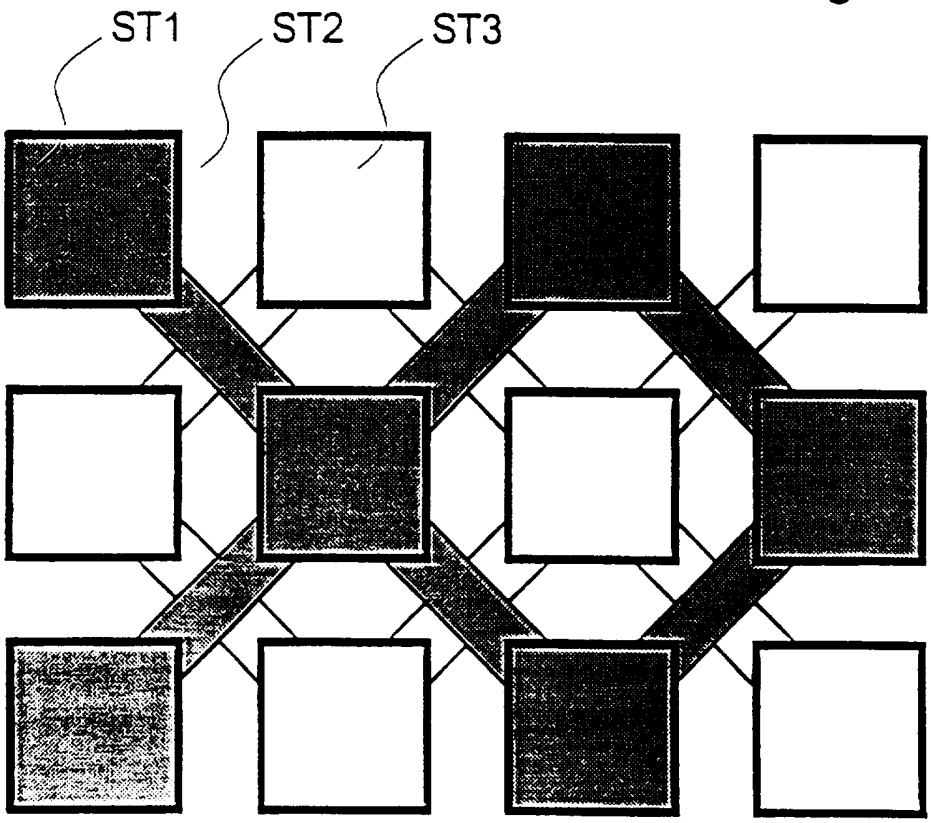


Fig.6

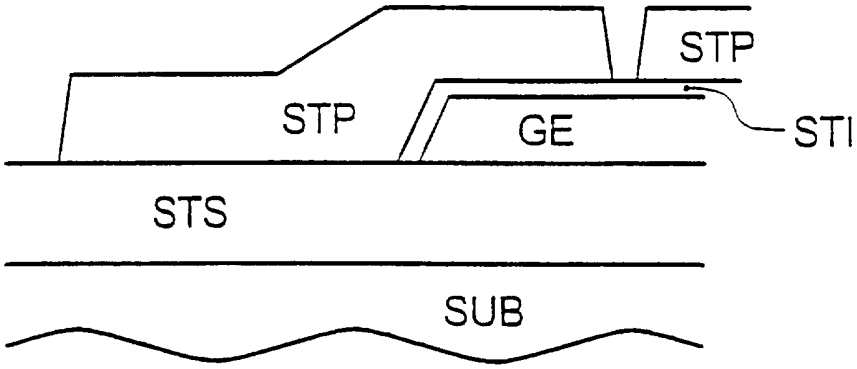


Fig.7

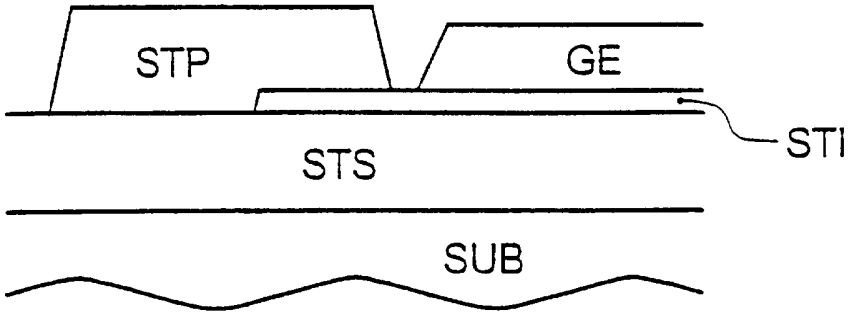


Fig.8

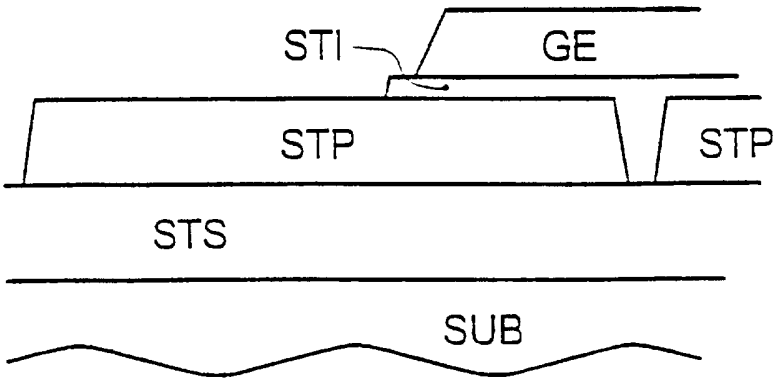


Fig.9

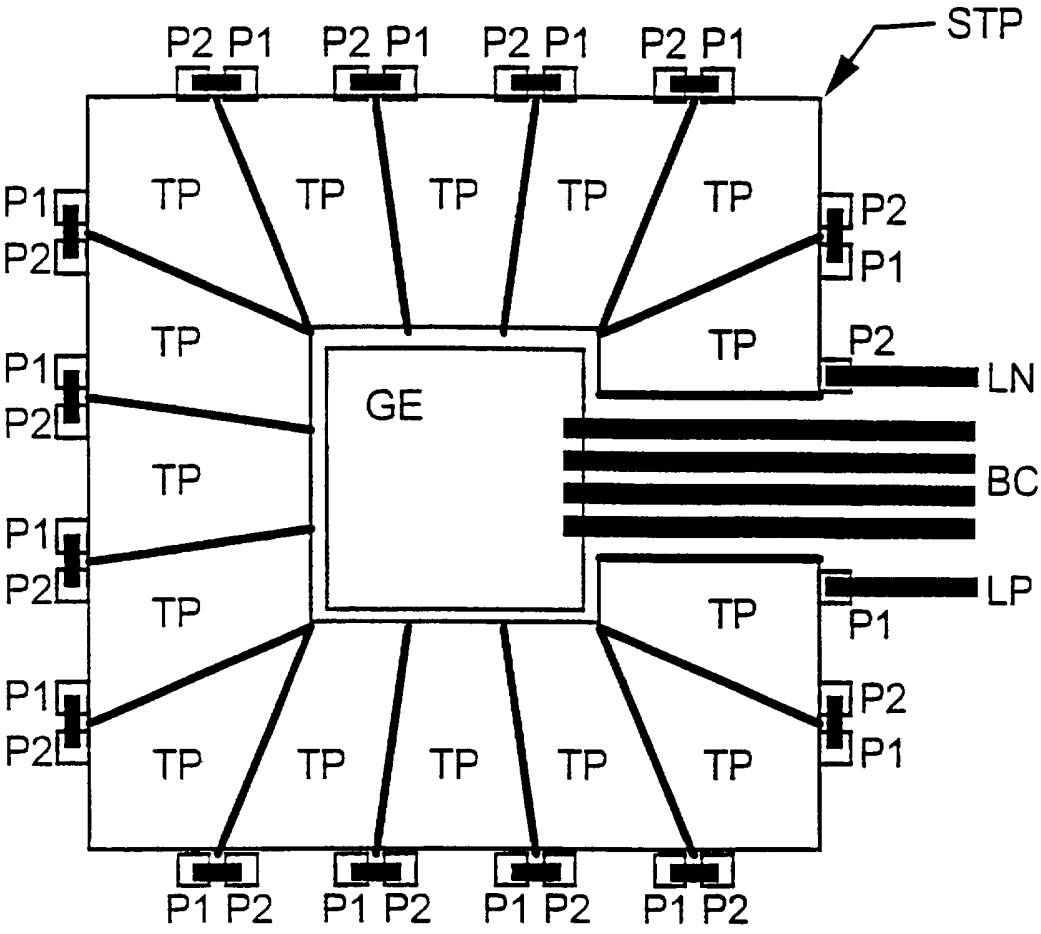


Fig.10

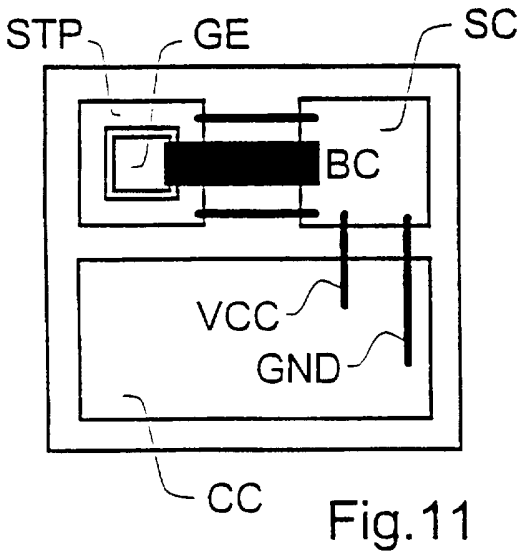


Fig.11

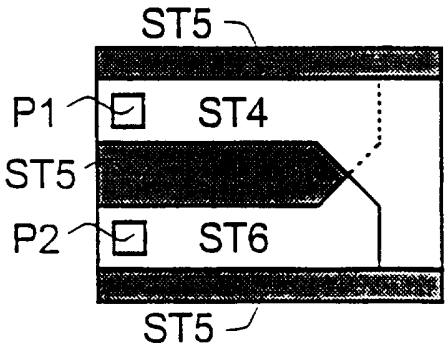


Fig.12

INTERNATIONAL SEARCH REPORT

Int tional Application No
PCT/IT 96/00226

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G21B1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	PATENT ABSTRACTS OF JAPAN vol. 012, no. 308 (E-647), 22 August 1988 & JP 63 076443 A (NEC CORP), 6 April 1988, see abstract ---	1-4
Y	PATENT ABSTRACTS OF JAPAN vol. 018, no. 439 (P-1787), 16 August 1994 & JP 06 138269 A (HIROSHI KUBOTA), 20 May 1994, see abstract --- -/--	1-4

[X] Further documents are listed in the continuation of box C. [ ] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
25 March 1997	04.04.97

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+ 31-70) 340-3016	Capostagno, E

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DATABASE WPI Section EI, Week 9224 Derwent Publications Ltd., London, GB; Class U14, AN 92-197770 XP002027876 & SU 1 364 168 A (AS BELO ELTRN INST) , 23 September 1991 see abstract -----	5,8,9

1