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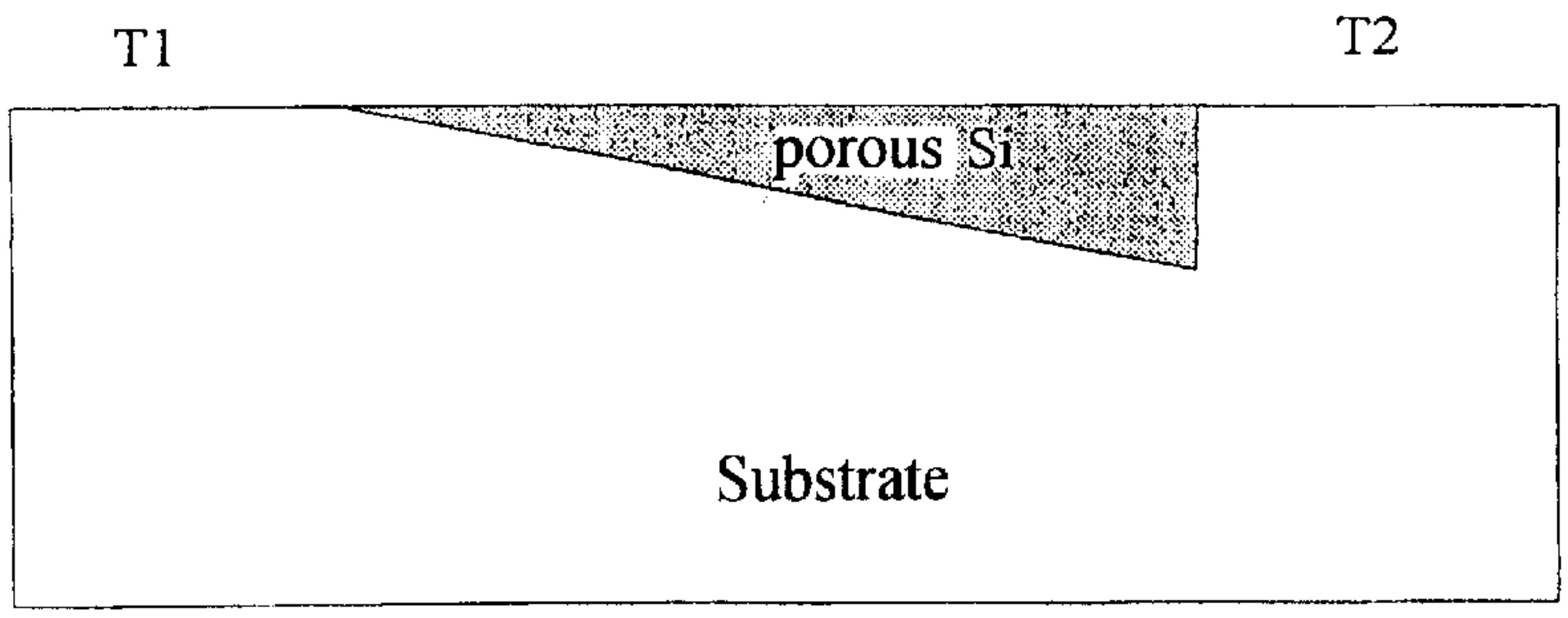
(54) **COUCHE A ZONE POREUSE, FILTRE INTERFERENTIEL RENFERMANT UNE TELLE COUCHE ET SON PROCEDE DE FABRICATION**

(54) **LAYER WITH A POROUS LAYER AREA, AN INTERFERENCE FILTER CONTAINING SUCH A LAYER AND A METHOD FOR THE PRODUCTION THEREOF**



(57) L'invention concerne une couche présentant une zone formée d'un matériau poreux s'étendant de la surface de la couche vers l'intérieur de cette couche, les dimensions de la zone poreuse dans le sens perpendiculaire à la surface de la couche présentant des valeurs différentes. L'invention concerne un procédé de fabrication d'une couche à zone poreuse ou d'un système de couche, caractérisé en ce que ladite zone poreuse est formée par attaque chimique, et en ce qu'on utilise des moyens agissant de telle façon qu'une grandeur physique en corrélation avec la vitesse de décapage du processus d'attaque soit choisie pour la formation d'au moins un gradient d'attaque.

(57) The invention relates to a layer with an area made of a porous material extending from the surface of the layer to the inside of the latter, wherein the dimension of the porous layer area in the direction perpendicular to the surface of the layer exhibits different values. The invention also relates to a method for producing a layer with a porous area or a layer system, wherein said porous layer area is formed by etching and means are used to choose a physical dimension in correlation with the etching speed of the etching process in order to form at least one etching gradient.

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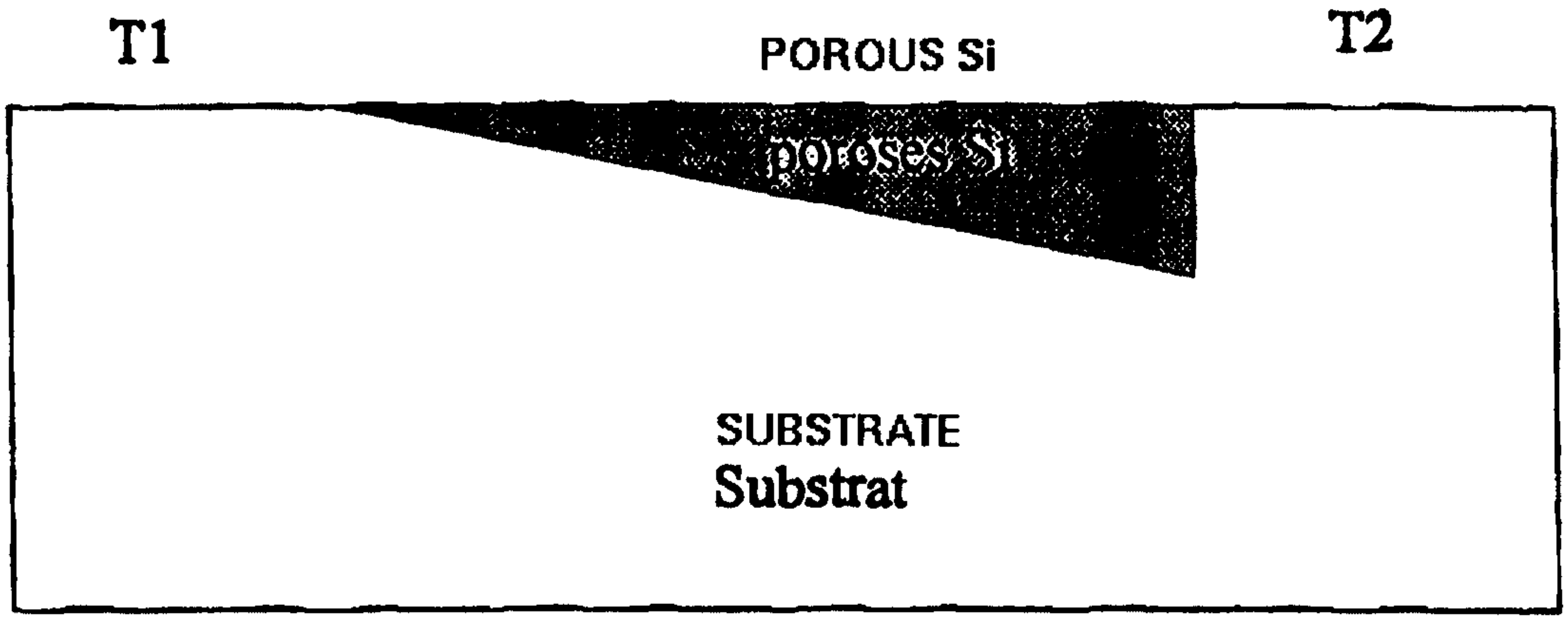
Veröffentlicht
Ohne internationalen Recherchenbericht und erneut zu veröffentlichen nach Erhalt des Berichts.

(54) Title: LAYER WITH A POROUS LAYER AREA, AN INTERFERENCE FILTER CONTAINING SUCH A LAYER AND A METHOD FOR THE PRODUCTION THEREOF

(54) Bezeichnung: SCHICHT MIT PORÖSEM SCHICHTBEREICH, EINE SOLCHE SCHICHT ENTHALTENDES INTERFERENZFILTER SOWIE VERFAHREN ZU IHRER HERSTELLUNG



(57) Abstract

The invention relates to a layer with an area made of a porous material extending from the surface of the layer to the inside of the latter, wherein the dimension of the porous layer area in the direction perpendicular to the surface of the layer exhibits different values. The invention also relates to a method for producing a layer with a porous area or a layer system, wherein said porous layer area is formed by etching and means are used to choose a physical dimension in correlation with the etching speed of the etching process in order to form at least one etching gradient.

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DESCRIPTION

Layer with a porous layer area, an interference filter containing such a layer and a method for the production thereof.

The invention relates to a layer with a porous layer area according to the preamble of claim 1. The invention further relates to an inference filter containing such a layer according to the preamble of claim 7. Finally, the invention relates to a process of manufacturing such a layer in accordance with the preamble of claim 8.

As state of the art porous silicon (PS) is known which, because of its compatibility with the highly developed Si-microelectronics and because it is easy and inexpensive to manufacture, is a promising material for use as sensors (M. Thust et al., Meas. Sci. Technol. 6, (1995), as well as Y. Duvault-Herrera et al., colloid. Surf., 50,197,(1990) and, because of its electroluminescence, is suitable for applications in the area of display technology (P. Steiner et al., Appl. Phys. Lett., 62(21), 2700,(1993). Furthermore, it is known to be used in connection with color-sensitive photo detectors (M. Krüger et al., EMRS 96, Thin Solid films) or passive reflection filters.

The manufacture of layer systems of PS has been demonstrated (M.G. Berger et al., J. Phys. D: Appl. Phys. 27, 1333, (1994), DE P 43 19 413.3 or M.G. Berger et al., Thin Solid Films, 255, 313, (1995)). These layer systems exhibit for example as layer systems a color-selective reflectivity depending on the manufacturing parameters. Furthermore, the structured manufacturing of PS is known, so that areas with different spectral behavior can be made (M.Krüger et al., EMRS 95, Thin Solid films).

Specifically, porous silicon consists of a foam-like skeleton of silicon crystallites, which include pores. The size of the crystallites and of the pores varies, depending on the doping and the manufacturing parameters, between some nanometers and some micrometers. If the wave length of the light is much greater than the structures in the PS, the PS appears to the light to be a homogeneous material ("effective medium") and its properties can therefore be described by an effective refraction index (W. Theiss: The Use of Effective Medium Theories in Optical Spectroscopy, in Festkörperprobleme/Advances in Solid State Physics, Volume 33, page 149, Vieweg, Braunschweig/ Wiesbaden), which depends on the refraction indices of the silicon crystallite, an oxide possibly present on the surface of the crystallite and of the material in the pores. Consequently, interference filters can be constructed from various porous layers, which extend parallel to one another and have different optical properties. The various layers are constructed parallel to one another and have, within the respective layer, a constant layer thickness normal to the layer surface. It is however disadvantageous that for each of the different spectral characteristics, a separate filter must be made in separate manufacturing steps.

It is also disadvantageous that, in the known methods, the manufacture of adjacent filters with different characteristcs can be achieved only by photolithographic steps, or respectively, by separate etching of the filter with certain particular characteristics.

It is therefore the object of the invention to provide a layer including a porous layer and an interference filter including such a layer as well as a process of manufacturing such an interference filter wherein a simplified establishment of interference filter functions of porous silicon with laterally gradually variable reflection and transmission characteristics is achieved.

The object is achieved by a layer in accordance with all the features of claim 1. The object is further achieved by an interference filter in accordance with all the features of claim 7. The object concerning the process is further achieved by a process in accordance with all the features of claim 8. Further suitable and advantageous embodiments or variations are contained in the sub-claims referring each to one of these claims.

It has been found that, based on the well known manufacture of layer systems of porous silicon, a method could be provided wherein a lateral change of the reflection and transmission capabilities are achieved.

In particular, a layer system with a well-defined laterally variable spectral characteristic is manufactured thereby in a single process step. In this process, a porous layer area according to claim 1 is so formed that the layer thickness assumes different values within this layer. In this way with such a porous area adjustable characteristics within this single layer can be achieved depending on desired boundary conditions and it is no longer necessary to manufacture several individual components individually which have different characteristics and which are then combined.

Furthermore, it may be advantageous in accordance with claim 2 to provide within the porous area several different porosity values in order to provide for individually desired characteristics in an controllable manner. Also, in accordance with claim 3, the degree of porosity may be established laterally for example in a continuous way. In accordance with claim 4, the area furthermore may have several partial layer areas with different degrees of porosity.

For a simplified manufacture, it may be advantageous to form the porous layer and/or the partial layer areas such that they are wedge-shaped in accordance with claim 5. In accordance with claim 6, preferably Al, GaAs, or SiGe can be used as the material, but most advantageous is the silicon which is used in many ways in microelectronics.

It has been realized that it is advantageous to establish for the manufacture of such a layer during the etching for making the material porous, a gradient with respect to a physical value which corresponds to the etching velocity of such an etching procedure as defined in claim 8. Alternatively, or additionally in accordance with claim 9, a value can be selected which corresponds to the porosity of the material. As physical value in accordance with claim 10, preferably the electric field is employed and, in accordance with claim 13, the temperature is used. In accordance with claim 16, the material of the substrate or, in accordance with claim 17, the doping of the material may be employed. The values may be employed individually or in combination together.

In accordance with claim 10, it is advantageous to utilize the electrodes provided for the electrochemical etching for the formation of the field gradient. In this case, a first electrode may be arranged in the electrolyte disposed above the surface to be etched, whereas a second electrode is disposed on the side of the substrate remote from this surface. Furthermore, such an electrode may be arranged in a tilted fashion so as to form a field gradient. Furthermore, in accordance with claim 12 the electrode or electrodes may be in the form of a net and may include a mesh structure to form gradients wherein the mesh openings are increasingly narrower in the direction of the gradient.

In accordance with claim 13, the layer system according to the invention can be made for example according to claim 14 by current flow with a lateral gradual change of the reflection- or respectively, transmission characteristic utilizing the temperature dependency of the etching process. As a result of the temperature dependency of the etching rate or, respectively, the porosity changes when the temperature of the electrolyte/substrate changes. Consequently, temperature gradients in the electrolyte or in the substrate can change locally the etching rate and, as a result, also the optical properties of a filter.

Alternatively, the layer system according the invention can be made with a laterally gradual change of the reflection and or, respectively, transmission characteristic utilizing a changed anode or, respectively, cathode arrangement. As a result of the dependency of the etching process on the field strength between the anode and the cathode, the etching rate or, respectively, porosity is changed between the electrode. Consequently, field strength gradients may change the etching rate between the electrodes and consequently also the optical properties of a filter.

The invention however is not limited to such processes. In accordance with the invention, alternative processes are possible wherein another value which affects the etching process is used to achieve a gradual change of the porosity. For example, the doping of the substrate material before the etching may be so selected that there is a lateral gradient in the substrate.

The invention is explained below in greater detail on the basis of figures and embodiments.

It is shown in:

Fig. 1: A layer arrangement according to the invention,

Fig. 2: A layer arrangement according to the invention,

Fig. 3: A layer arrangement according to the invention,

Fig. 4: A structure according to the invention.

<u>Embodiment:</u>

Fig. 1 shows, in a cross-sectional view, an interference filter formed on a wafer on which porous silicon was etched. Because of the different temperatures T_1 and T_2 and the changing etching rates resulting therefrom a wedge-shaped structure is formed.

Fig. 2 also shows, in a cross-sectional view, a filter according to the invention which however consists of a layer system with differently porous areas. Because of the different thicknesses of the individual layers, a laterally gradual change of the interference characteristics is achieved.

Finally, figure 3 shows, similar to the previous figures, a laterally gradual layer system with individual pixels made in a single manufacturing step.

Particularly, with regard to the invention as described in claims 9 - 12 and 17, the following comments are made:

Within the frame of the object of the invention to make laterally inhomogeneous layers or filters, particularly with laterally varying reflection characteristics, it has been found that the desired arrangement or formation or, respectively, the change of the rear contact, influences advantageously the structure of the subject of the invention, particularly of the filter.

In the structure according to the invention as shown in Fig. 4, the current flow from the local back-side contact to the porous layer differs since the charge carriers have paths of different length from the contact point to the porous layer. This behavior depends, on one hand, on the size of the porous structure and, on the other hand, on the distance of the back-side contact from the porous layer, and consequently, finally on the substrate resistance. In this manner, the etching rate is different at various points of the structure, which results in the formation of interference filters with laterally gradually variable characteristics.

In this way, with regard to the subject matter claimed in the claims, particularly with respect to the change of the electrical field, a wide application may reside in suitably forming the geometric pattern of the reflection characteristics of the structure according to the invention in a lateral direction. For example, as the contact geometry of the rear contact a plurality of individual local contacts may be provided at different locations on the backside. Furthermore, these local contacts may be formed while being subjected to different currents as defined in claim 19.

PATENT CLAIMS

1. An interference filter with a layer which includes a porous area which extends from the surface of the layer to the interior of this layer,
   characterized in that
   the interference filter includes one or several layers according to the preamble and the dimensions of the porous area in the direction normal to the layer surface have different values.

2. A process of manufacturing a layer with a porous layer area or layer system,
   characterized in that
   - this porous layer or, respectively, this layer area is formed by etching,
   - a physical value is selected which correlates to the etching speed,
   - means are employed which form a gradient during etching.

3. A process of manufacturing a layer with a porous layer area or layer system,
Characterized in that
- this porous or, respectively layer area is formed by etching,
- a physical value is selected which correlates to the porosity of the material,
- means are employed which form a gradient during etching.

4. A process for manufacturing a layer according to claim 2 or 3, wherein electrodes provided as means for the electrochemical etching are utilized for establishing a field strength difference or -gradient over the area to be etched.

5. A process according to claim 4, wherein, for the establishment of the field strength difference or -gradient over the area to be etched, the electrode disposed opposite the substrate surface area to be etched is arranged in a tilted manner.

6. A process according to claim 4 or 5, wherein, for the establishment of the field strength difference or -gradient over the area to be etched, a net-like electrode is selected and the meshes contained in this net-like electrode become narrower in the direction in which the gradient is to be established.

7. A process according to claim ~~8~~ 2 or ~~9~~ 3 x, wherein the substrate or the electrolyte provided for the etching

x not corrected on the [illegible]

are subjected over the area to be etched to a temperature gradient or temperature difference which is controlled from the outside.

8. A process according to one of the preceding claims, wherein the substrate is heated by an electric current at locally different rates.

9. A process according to one of the preceding claims, wherein a temperature gradient is established in the substrate or in the electrolyte by local heating of the substrate particularly by means of laser or microwaves.

10. A process according to claim 2 or 3, wherein a modified substrate material is selected.

11. A process according to claim 2 or 3, wherein the doping of the substrate is selected as the physical value.

12. A process according to one of the preceding claims wherein one or several areas which are structured by photolithography are subjected locally or globally to the gradient of the physical value.

13. A layer, interference filter or process according to one of the preceding claims with a laterally suitable geometry of the rear contact, pattern geometry of the reflection characteristic, particularly with a plurality of individual local contacts at different locations on the backside wherein these contacts are so formed that they can be subjected, if appropriate, to different currents.

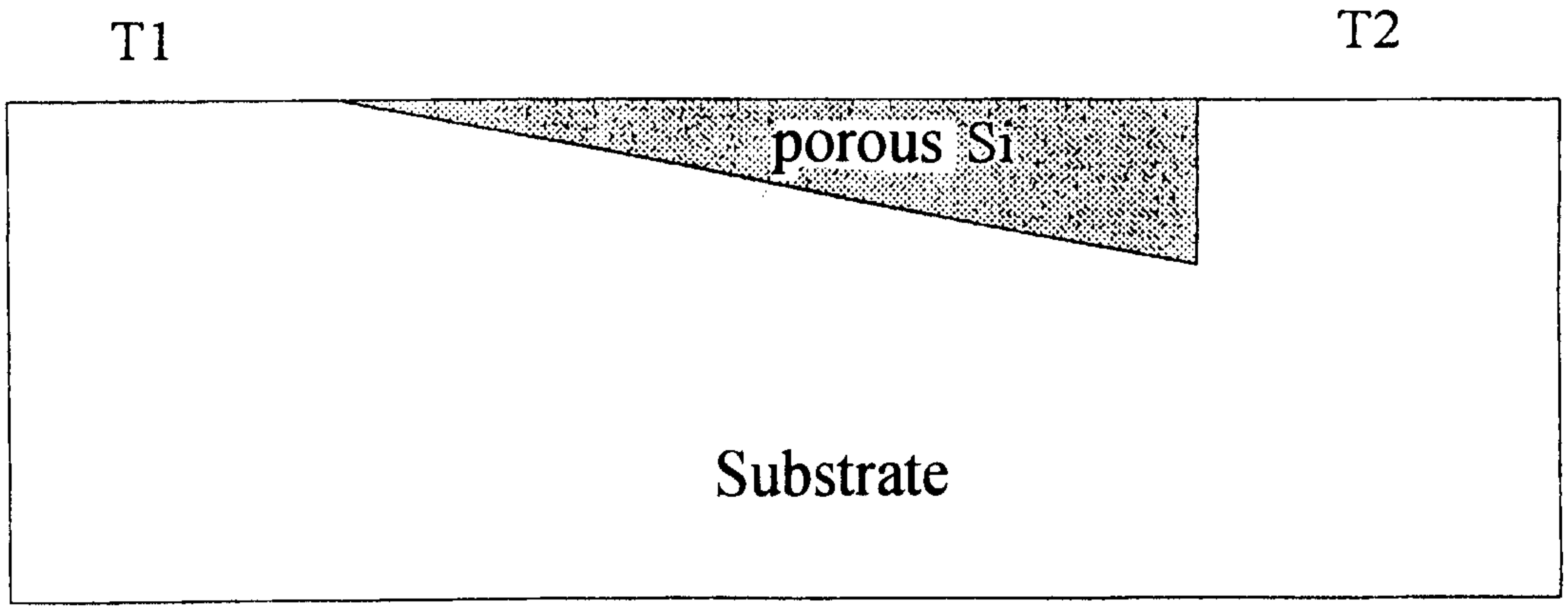

FIG. 1

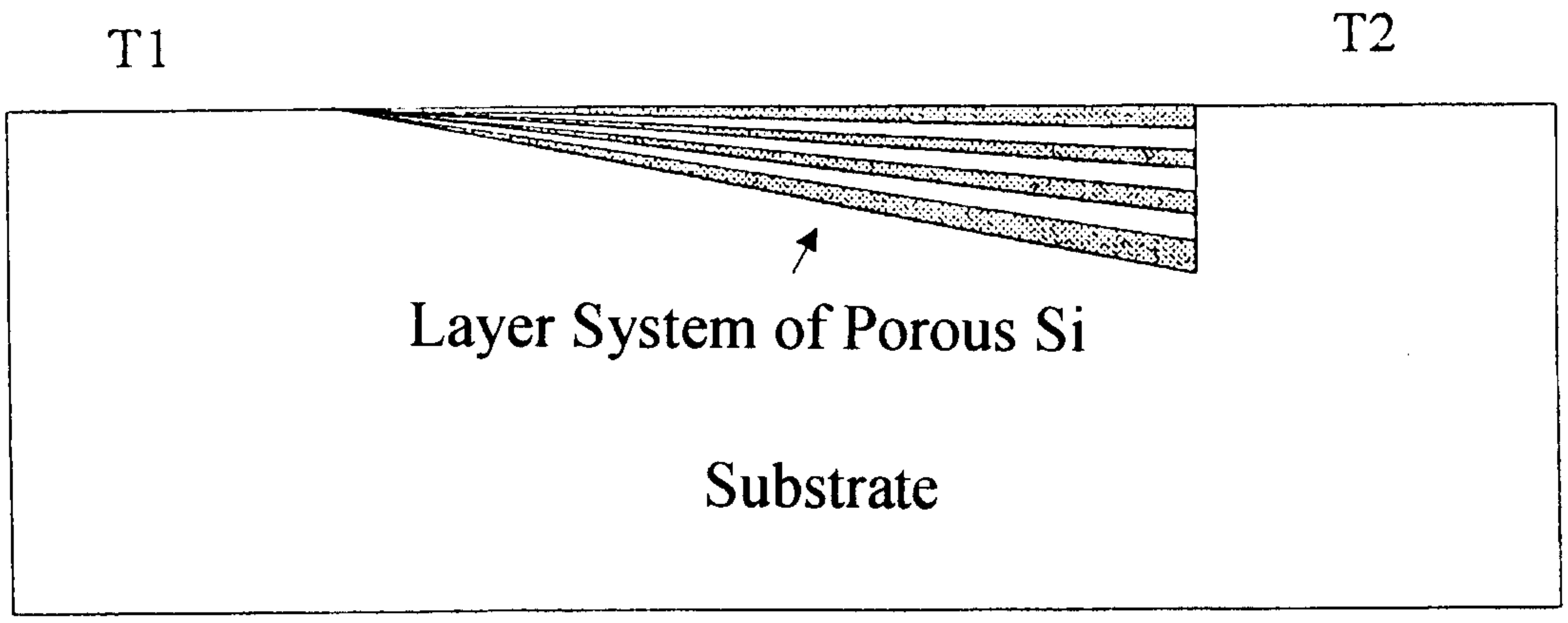

FIG. 2

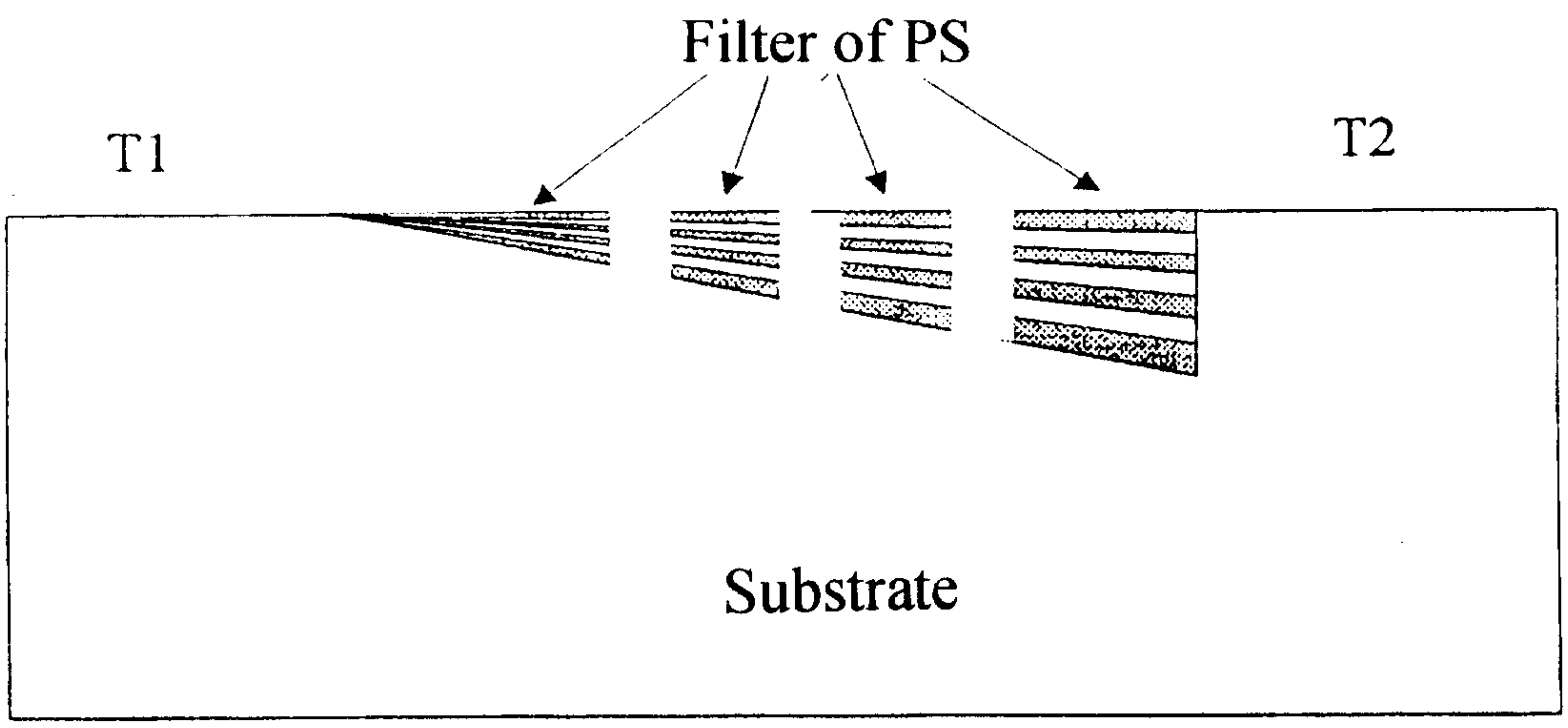

FIG. 3

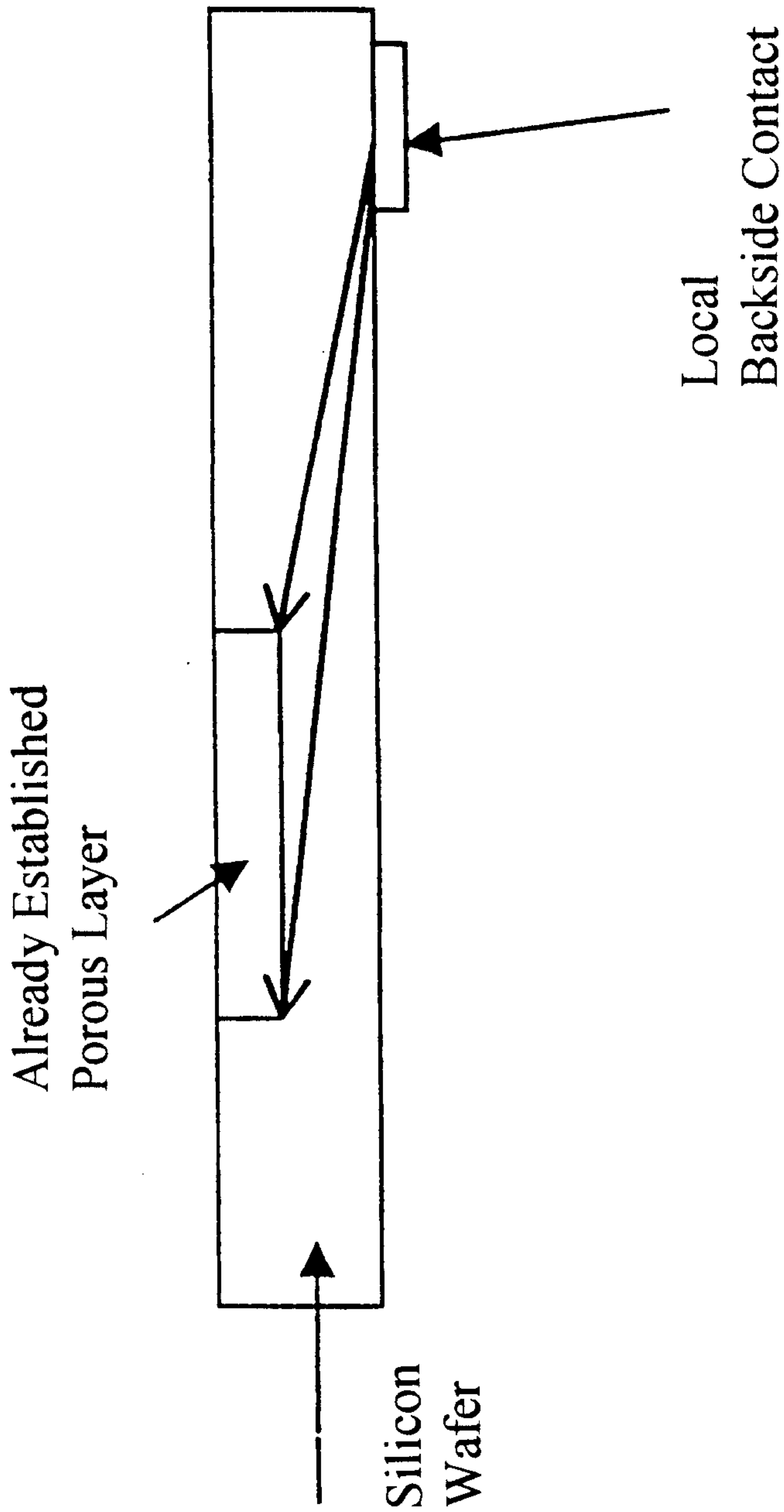
Local
Backside Contact
Already Established
Porous Layer
Silicon
Wafer

FIG. 4