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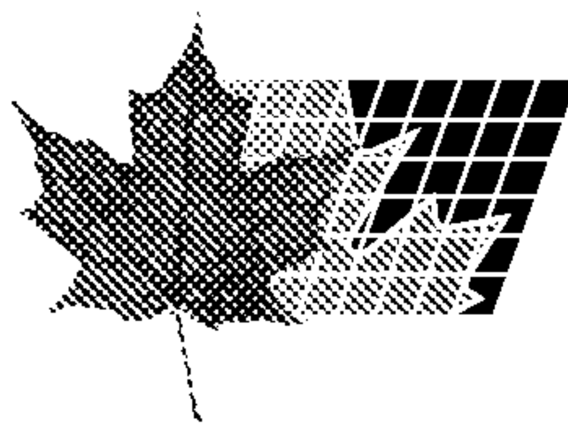

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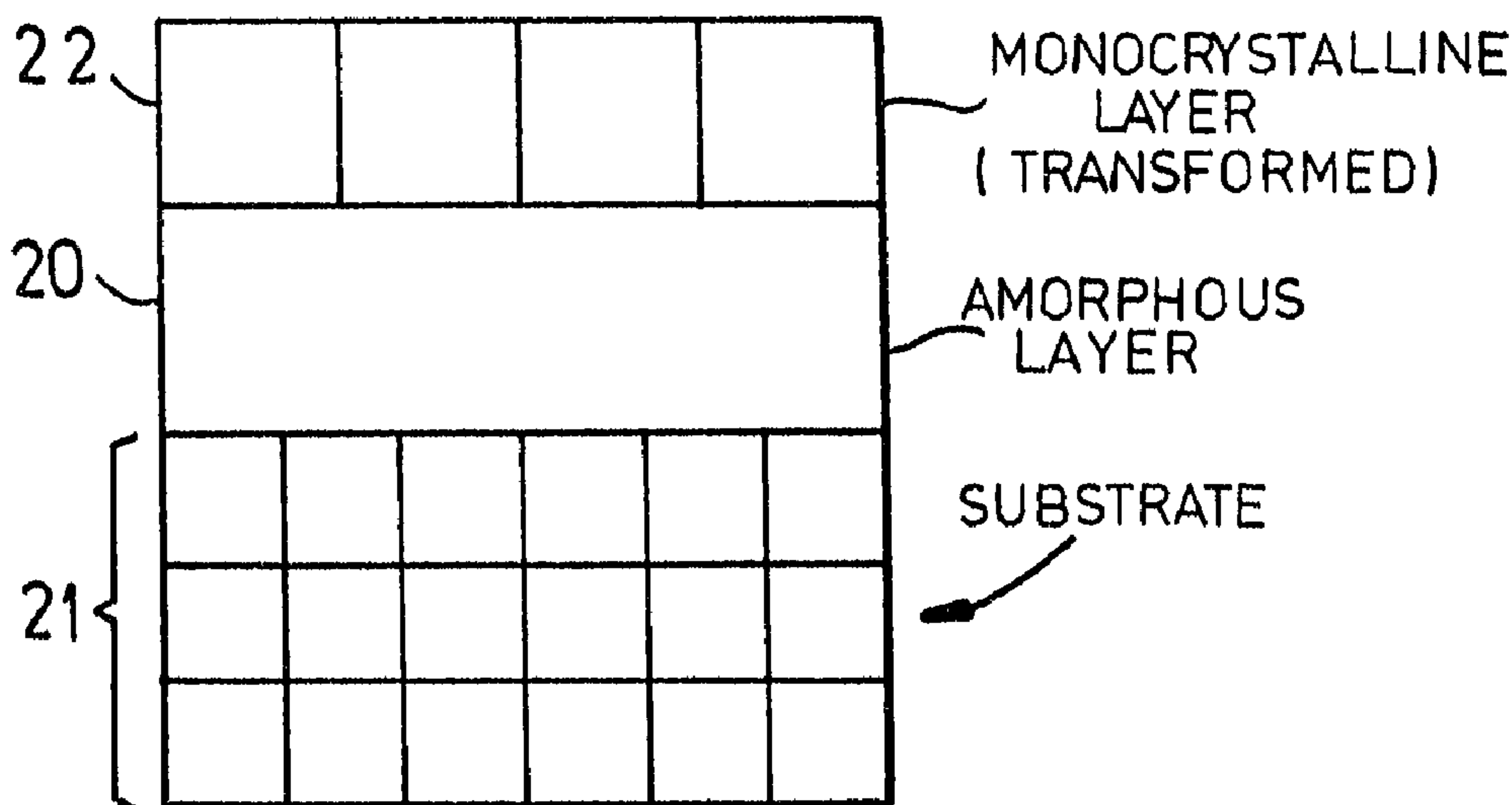
(54) **METHODE DE FABRICATION DE COMPOSANTS ELECTRONIQUES, ELECTRO-OPTIQUES ET OPTIQUES**

(54) **METHOD OF PRODUCING ELECTRONIC, ELECTROOPTICAL AND OPTICAL COMPONENTS**



(57) A buried amorphous layer on a crystalline substrate shields a subsequently applied monocrystalline layer, which is transformed into a mixed-crystal or chemical compound, from transmission of lattice defects from the substrate even where the lattice parameters of the substrate and the monocrystalline layer are not matched.

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ABSTRACT OF THE DISCLOSURE

A buried amorphous layer on a crystalline substrate shields a subsequently applied monocrystalline layer, which is transformed into a mixed-crystal or chemical compound,
5 from transmission of lattice defects from the substrate even where the lattice parameters of the substrate and the monocrystalline layer are not matched.

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METHOD OF PRODUCING ELECTRONIC, ELECTROOPTICAL AND OPTICAL COMPONENTS

SPECIFICATION

Field of the Invention

5 The present invention relates to a method of producing an article which can be used in the production of electronic, electrooptical or optical components and, especially, a crystalline structure or a structure provided with a crystalline film which can be used for electronic,
10 electrooptical or optical circuit elements. Specifically the invention relates to a method of producing a structure having a crystalline substrate and a crystalline film deposited on this substrate.

Background of the Invention

15 The production of articles consisting of a crystalline substrate and a crystalline film on such substrate are known to be useful for the production of electronic, electrooptical and optical components by semiconductor techniques such as ion implantation and the
20 deposition of semiconductor elements or the like on such

articles. By and large the quality of the film which may be the active component of the article is affected by the characteristics of the substrate. For example, lattice defects and other lattice parameters of the substrate may detrimentally affect the crystalline film which is deposited. A case in point is the fact that epitaxial deposits on silicon wafers of crystalline films can only be carried out under special conditions because undesirable properties or lattice parameters of the wafer can affect the film or the formation thereof.

For example, if the lattice parameters of the applied layer are not matched to those of the substrate, lattice defects can develop at the interface in the newly formed layer and as this layer grows, these defects will be propagated and can be detrimental to the electrical and especially the optical characteristics of the layer. Other approaches such as deposition upon porous silicon have not been successful in overcoming these problems.

Objects of the Invention

It is, therefore, the principal object of the present invention to provide an improved method of forming a monocrystalline film of desired properties on a crystalline substrate whereby the transmission of lattice characteristics and especially lattice defects of the substrate to the newly grown film can be avoided.

Another object of the invention is to provide a method which obviates the drawbacks described above.

Summary of the Invention

These objects are attained, in accordance with the
5 invention by providing a buried amorphous layer on a crystalline substrate and upon this buried layer a monocrystalline layer. According to the invention the monocrystalline layer is transformed into a mixed-crystal structure or a chemical compound which either corresponds
10 to the desired crystalline film or, in its lattice structure, comes closer to the desired crystalline film than the original monocrystalline film. More particularly, the method of making a crystalline element for an electronic, electrooptical or optical component comprises:

15 (a) providing a crystalline substrate having a buried amorphous layer formed therein and a monocrystalline layer on the amorphous layer and separated from the substrate by the amorphous layer; and

(b) transforming the monocrystalline layer into a
20 mixed-crystal structure or a crystalline chemical compound.

In the transformation according to the invention of the monocrystalline surface layer into an alloy crystal (mixed crystal) or a crystalline chemical compound, the nonmatched crystal lattice of the surface layer is
5 separated by the amorphous layer from the substrate and the transmission of a defect network from the substrate is precluded as is the development of a defect network at the interface with the amorphous layer since there are no coherent stresses at the crystalline/amorphous interface
10 which can be transmitted to the newly grown crystal structure to provide a defect network therein.

The newly formed layer can itself be the desired product, i.e. the desired film for electrical, electronic, electrooptical or optical purposes, or can form a new base
15 (buffer layer) for the growth of a further layer forming the desired film. In that case it constitutes a seed layer for the further monocrystalline growth of the desired film.

The transformation of the monocrystalline layer can be effected in various ways. It is, for example, possible
20 to deposit the substances or components of the mixed-crystal or chemical compound upon the monocrystalline layer and simultaneously or subsequently to heat the layer to effect thermal diffusion and/or chemical reaction and homogenization of the crystal layer or the formation of the
25 mixed-crystal or the chemical compound.

Alternatively, the compounds for the formation of the mixed-crystal or chemical compound can be applied by ion implantation in the monocrystalline layer, the ion implantation being followed by an annealing treatment. In the formation of the mixed-crystal (alloyed crystal) the concentrations of the components can be varied in the direction of growth whereby in a nonideal lattice matched system in the transformed layer, a gradient of the lattice parameters in the grown direction can result.

In a further alternative approach to transformation of the monocrystalline layer, the components required for formation of the mixed-crystal or the chemical compound can be deposited by epitaxy and, during or following the epitaxial deposition, an annealing treatment can be carried out.

It has been found that, with the present invention, the lattice parameters of the transformed layer can differ very significantly from those of the substrate material so that a substantially higher crystal quality of the transformed crystal layer can be obtained than with earlier systems. This layer can have higher temperature resistance for example.

Through the use of a substrate with an electrically insulating buried amorphous layer, for example with SIMOX wafers the new film is dielectrically isolated from the substrate, the articles made in accordance with the invention an have all of the inherent advantages of the SIMOX structure (isolation electronics) for microelectronic applications, for example high frequency properties.

Brief Description of the Drawing

The above and other objects, features and advantages of our invention will become more readily apparent from the following description, reference being made to the accompanying highly diagrammatic drawing in which:

FIG. 1 is a diagram illustrating the prior art approach in which a monocrystalline layer is applied by heteroepitaxy to a substrate which has not been lattice matched therewith; and

FIG. 2 is a diagram showing the approach taken by the invention.

Specific Description

As can be seen from FIG. 1, it is not possible to apply a monocrystalline surface layer of unmatched lattice parameters to the crystalline structure without the development of a defect network at the interface 10 or boundary between the substrate 11 and the monocrystalline layer 12. In the diagrams of FIGS. 1 and 2 the difference in lattice structures and parameters is represented by boxes of different sizes representing, for example, the crystalline cells.

By comparison, where an amorphous layer 20 is provided with the substrate 21 and the monocrystalline layer 22, there is no transmission of defect structures.

The monocrystalline layer or film 22 can thus be modified as described to form the mixed-crystal or compound

Example 1

Monocrystalline Si-Ge mixed-crystal on SiO_2

5 insulating layer.

The substrate is a SIMOX-wafer (SIMOX = separation by implantation of oxygen). This commercially available substrate consists of a silicon wafer having a buried amorphous silicon dioxide layer and a monocrystalline

10 silicon surface layer.

The monocrystalline silicon surface layer is initially thinned to a thickness of 20 nm by plasma etching. The substrate thus prepared is then cleaned in an epitaxy apparatus by means of molecular beam epitaxy (MBE)

15 as is common in Si epitaxy to provide a perfect and clean surface at 450°C, Si and Ge are deposited in a ratio of 80:20. With subsequent tempering at 1100°C for 30 seconds there is a complete homogenization of the Si seed layer and the applied Si-Ge film. The resulting Si-Ge layer can be

20 used directly for Si-Ge electrooptical devices or can serve as an intermediate layer for further epitaxial growth of heterostructures and other crystalline structures.

Example 2

Monocrystalline cobalt silicide on silicon dioxide.

The starting material is again a silicon substrate with buried SiO_2 layer, namely, a SIMOX wafer.

5 The monocrystalline Si surface layer is first chemically cleaned and then reduced to the desired thickness by plasma etching. In a vapor deposition apparatus under ultra high vacuum conditions, Co is deposited by vapor deposition. Silicide formation is

10 effected by thermal treatment in the apparatus. The layer thicknesses depend upon the systems used. $CoSi_2$ resulted when a 100 nm Si starting layer was coated with 28 nm of a Co film and after solid body epitaxy had a silicide layer thickness of about 100 nm. For complete reaction of the

15 $CoSi_2$ layer a temperature of 600°C and 30 minutes was used. The resulting component had a monocrystalline silicide layer of especially high electrical and crystalline quality and an electrically insulating SiO_2 layer.

We claim:

1 1. A method of making a crystalline element for an
2 electronic, electrooptic or optical component, comprising:
3 (a) providing a crystalline substrate having a
4 buried amorphous layer formed therein and a monocrystalline
5 layer on said amorphous layer and separated from said
6 substrate by said amorphous layer; and
7 (b) transforming said monocrystalline layer into a
8 mixed-crystal structure or a crystalline chemical compound.

1 2. The method defined in claim 1 wherein the layer
2 transformed in step (b) forms a desired crystalline film.

1 3. The method defined in claim 1 wherein the layer
2 transformed in step (b) forms a crystalline film close in
3 lattice structure to a desired crystalline film, said
4 method further comprising the step of applying to the layer
5 transformed in step (b) said desired crystalline film.

1 4. The method defined in claim 1 wherein the
2 transforming of said monocrystalline layer in step (b) is
3 effected by depositing at least one substance of said
4 mixed-crystal structure or said crystalline chemical
5 compound and applying heat to effect a thermal diffusion
6 and/or a chemical reaction for homogenization of the
7 resulting crystalline layer, the formation of the
8 mixed-crystal structure or the formation of the compound.

1 5. The method defined in claim 4 wherein the heat
2 is applied simultaneously with the deposition of said
3 substance.

1 6. The method defined in claim 4 wherein the heat
2 is applied subsequent to the deposition of said substance.

1 7. The method defined in claim 1 wherein the
2 transformation in step (b) includes ion implantation in
3 said monocrystalline layer.

1 8. The method defined in claim 7 further
2 comprising annealing the monocrystalline layer after ion
3 implantation.

1 9. The method defined in claim 1 wherein the
2 formation of the mixed-crystal structure or said
3 crystalline compound is effected by depositing substance on
4 said monocrystalline layer by epitaxy and, during the
5 epitaxial deposition, said monocrystalline layer is
6 subjected to an annealing heating.

1 10. The method defined in claim 1, further
2 comprising the step of modifying a thickness of said
3 monocrystalline layer prior to transformation in step (b).

1 11. The method defined in claim 10 wherein the
2 modification of the thickness of said monocrystalline layer
3 is effected by plasma etching.

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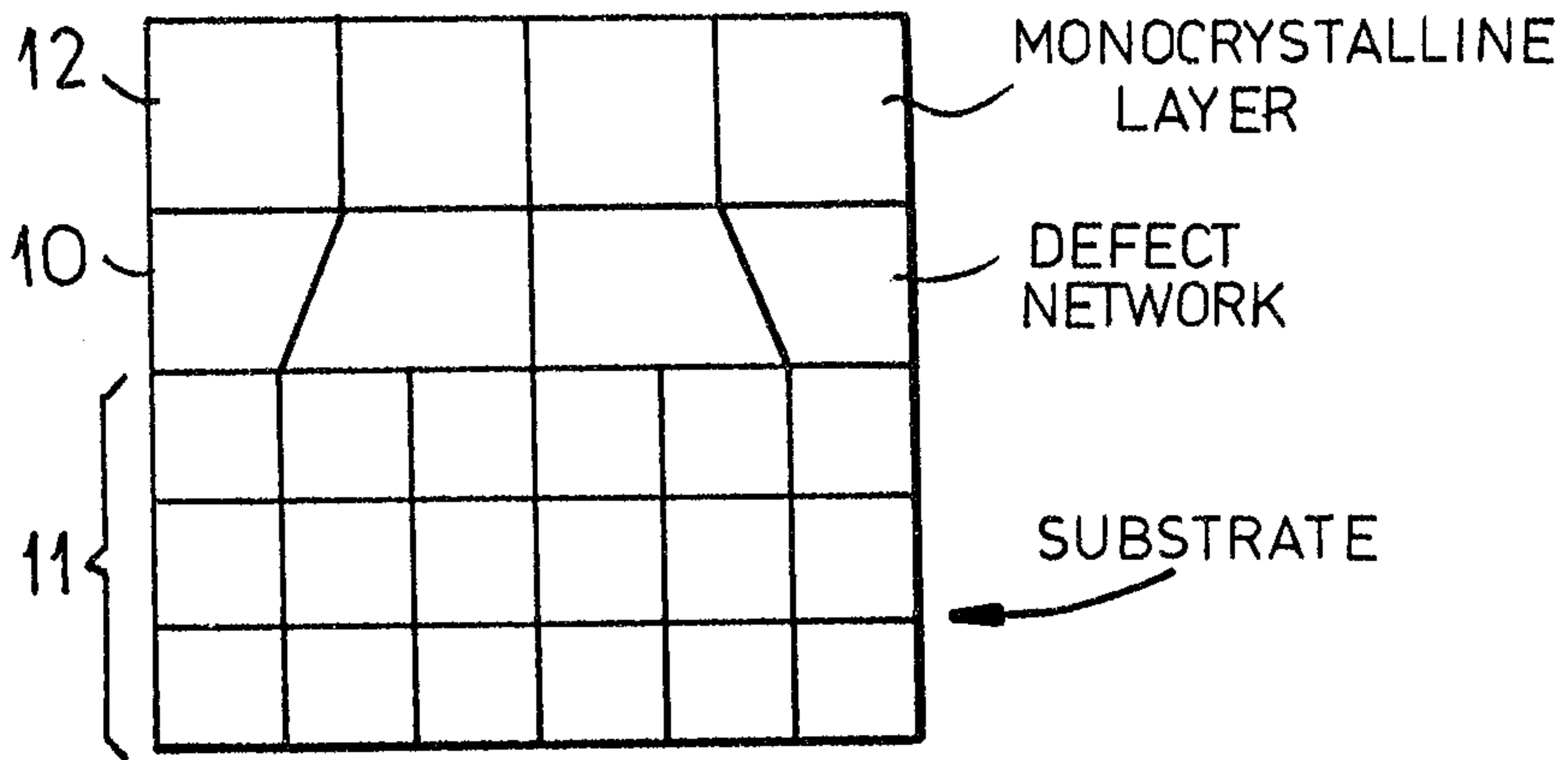


FIG.1 PRIOR ART

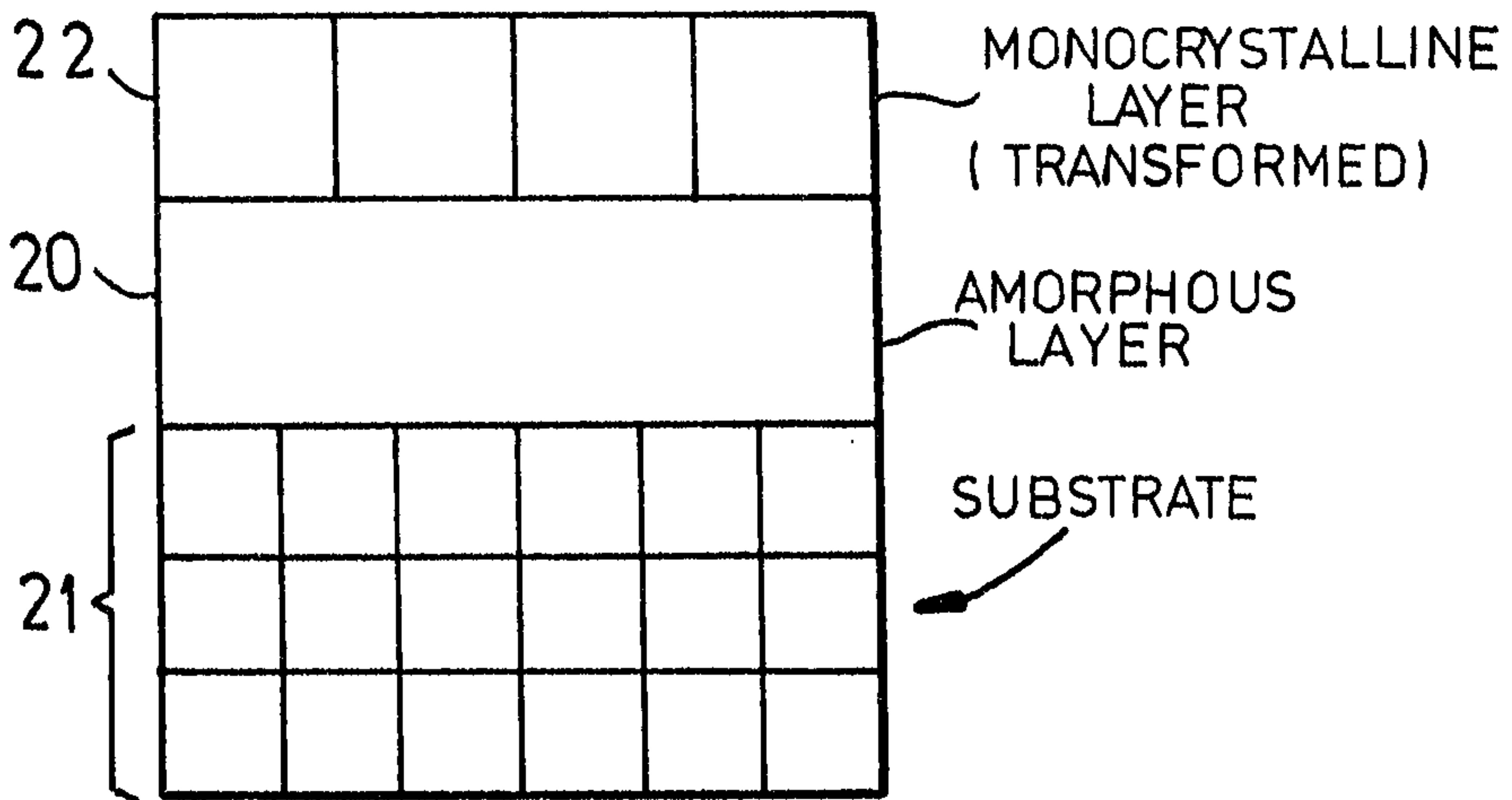
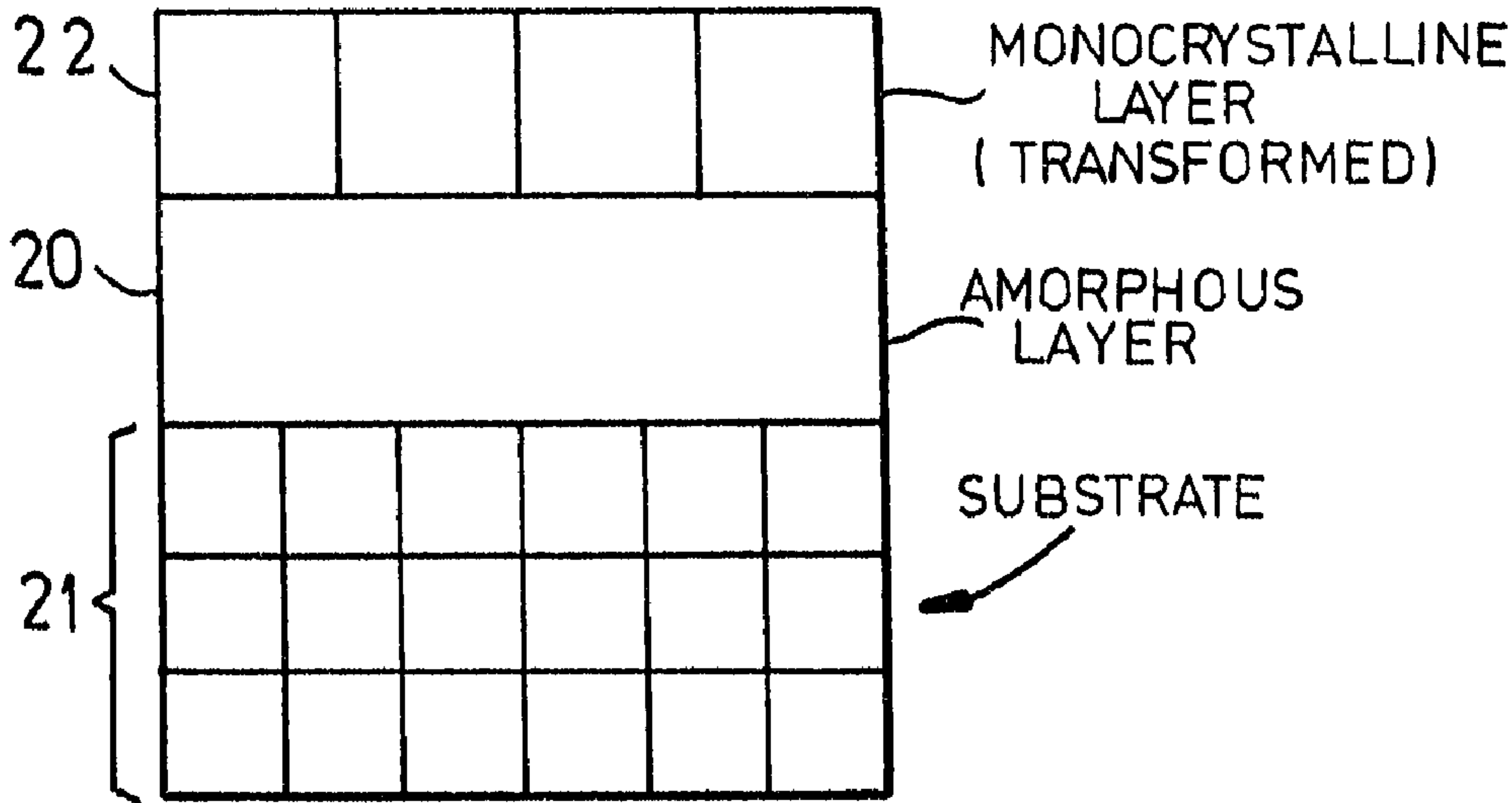


FIG.2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20
21
MONOCRYSTALLINE LAYER (TRANSFORMED)
AMORPHOUS LAYER
SUBSTRATE