DESCRIPTION

TITLE: **Process For Preparing A Support Substrate Made Of Polycrystalline Material And Process For Manufacturing A Composite Structure Including Said Support Substrate**

FIELD OF THE INVENTION

The present invention relates to the field of semiconductor materials for microelectronic components. It relates in particular to a process for preparing a support substrate made of polycrystalline material, in particular SiC, that can be used for the manufacture of a composite structure including a thin single-crystal layer transferred onto said support substrate.

TECHNOLOGICAL BACKGROUND OF THE INVENTION

SiC is being increasingly widely used for manufacturing innovative devices (power components, radiofrequency components, etc.), to meet the requirements of growing fields of application in electronics, such as electric vehicles in particular. This is because power devices and integrated power-supply systems based on single-crystal silicon carbide are able to handle a much higher power density than their conventional silicon equivalents and can do this with smaller active regions.

Nevertheless, high-quality single-crystal SiC (c-SiC) substrates intended for the microelectronics industry remain costly and difficult to supply in a large size. It is thus advantageous for layer transfer solutions to be employed to produce composite structures typically comprising a thin layer of single-crystal SiC (obtained from the high-quality c-SiC substrate) on a lower-cost support substrate, for example one made of polycrystalline SiC (p-SiC). The electronic components then can be produced on and/or in the thin layer. It should also be noted that a composite structure may provide additional performance and functions, in particular by affording a support substrate having advantageous mechanical, electrical and/or thermal properties.

A well-known thin-layer transfer solution is the Smart Cut™ process, which is based on light ion implantation and the joining, by direct bonding, of a single-crystal donor substrate and a support substrate at a bonding interface.

To be compatible with a thin-layer transfer process, the support substrate must have the lowest-possible degree of curvature or deformation. Low curvature is also important in order to guarantee performance in the steps in the manufacture (for example, photolithography) of the components on/in the thin layer of the composite structure.

Document FR3132381 proposes a process for manufacturing a non-deformable p-SiC wafer.
Starting from a p-SiC slab detached from its growth substrate, this process comprises a heat treatment step at a temperature of between 1650°C and 2000°C, followed by a thinning step including in particular a very coarse grinding, coarse grinding, and fine grinding. The heat treatment is liable to cause deformation of the slab. The thinning was then adapted to include a correction of said deformation by means of a localized, fine-tuned removal of material.

SUBJECT OF THE INVENTION

The present invention proposes a process for preparing a support substrate made of polycrystalline material, in particular p-SiC, in an alternative to the processes of the prior art that promotes low curvature of the support substrate and minimizes manufacturing costs. The invention also relates to a process for manufacturing a composite structure including said support substrate.

BRIEF DESCRIPTION OF THE INVENTION

The invention relates to a process for preparing a support substrate made of polycrystalline material, the preparation process comprising the following steps:
a) providing a raw disk made of polycrystalline material, having two sides;
b) coarse grinding at least one of the sides of the raw disk to obtain a ground disk having at least one ground side, the coarse grinding inducing, on said ground side, the formation of a surface damaged region, the surface damaged region comprising a surface work-hardened layer and an underlying stressed layer;
c) applying a heat treatment to the ground disk, the temperature and duration of the heat treatment being defined so as to relieve the stresses present in the stressed layer, step c) affording an annealed disk comprising on the - at least one - ground side a first surface annealed layer in place of the work-hardened layer and an underlying second annealed layer in place of the stressed layer;

d) thinning the annealed disk on the - at least one - ground side to remove the first annealed layer, step d) affording the support substrate in which all or part of the second annealed layer is preserved.

According to other advantageous and non-limiting features of the invention, taken alone or according to any technically feasible combination:

- step a) comprises the following substeps:
  a1) the chemical vapor deposition of a layer formed from the polycrystalline material on a growth substrate,
  a2) removing the growth substrate to obtain the raw disk;
- the polycrystalline material is silicon carbide or aluminum nitride;
- step b) is applied to both sides of the raw disk and/or step d) is applied to both sides of the raw disk;
- the coarse grinding is carried out with a grinding wheel, the abrasive grains of which have an average size of greater than or equal to 10 µm, or even greater than or equal to 18 µm;
- the coarse grinding applied to one side and/or to the other side of the raw disk removes a first thickness greater than or equal to 150 µm;
- the heat treatment in step c) is carried out at a temperature greater than or equal to 1600°C, preferably greater than or equal to 1700°C, more preferably greater than or equal to 1800°C, more preferably greater than or equal to 1850°C, even more preferably greater than or equal to 2000°C;
- the thinning in step d) includes fine grinding carried out with a grinding wheel, the abrasive grains of which have an average size of less than or equal to 5 µm, less than or equal to 4 µm, or even less than or equal to 3 µm;
- the fine grinding applied to one side and/or to the other side of the annealed disk removes a second thickness less than or equal to 50 µm;
- the second thickness is less than or equal to 20 µm, preferably between 5 µm and 20 µm;
- step d) comprises, after the fine grinding, a preparation of the surface comprising polishing, cleaning, annealing, etching and/or deposition of a film, so as to obtain a surface finish on the support substrate that is compatible with direct joining to another substrate;
- step d) comprises, after the fine grinding, a preparation of the surface comprising just cleaning and/or annealing and/or plasma activation and/or deposition of a film, so as to obtain a surface finish on the support substrate that is compatible with direct joining to another substrate.

The invention also relates to a process for manufacturing a composite structure, comprising the following steps:

- preparing a support substrate made of a polycrystalline material as above, and
- transferring a thin layer of single-crystal material from a donor substrate onto said support substrate.

The polycrystalline material is advantageously selected from silicon carbide and aluminum nitride.
The single-crystal material is advantageously selected from silicon carbide, gallium nitride, gallium oxide, diamond, silicon, germanium, and indium phosphide.

The manufacturing process may also comprise the formation of electronic components in or on the thin layer.

BRIEF DESCRIPTION OF THE FIGURES

Other features and advantages of the invention will become apparent from the detailed description of the invention that follows, with reference to the appended figures, in which:

[Fig. 1a]
[Fig. 1a']
[Fig. 1b]
[Fig. 1c]
[Fig. 1d] Figure 1a, Figure 1a', Figure 1b, Figure 1c, and Figure 1d show a process for preparing a support substrate according to the present invention;

[Fig. 2a]
[Fig. 2b] Figure 2a and Figure 2b show composite structures obtained from a manufacturing process according to the invention;

[Fig. 3a]
[Fig. 3b] Figure 3a and Figure 3b show cross sectional images obtained by scanning electron microscopy of disks ground after step b) of a process according to the present invention; in particular, the surface work-hardened layer can be observed.

In the figures, the same reference signs may be used for elements of the same type. Certain figures are schematic representations that for the sake of legibility are not to scale. In particular, the thicknesses of the layers along the z-axis are not to scale with respect to the lateral dimensions along the x- and y-axes and the relative thicknesses of the layers with respect to one another are not necessarily reflected in the figures.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a process for preparing a support substrate 200 made of polycrystalline material. Said material is preferably silicon carbide (SiC) or aluminum nitride (AlN).

There exists a number of techniques for producing or growing disk-shaped polycrystalline materials intended to form substrates or wafers, in particular for the semiconductor industry. These techniques include in particular manufacture by sintering, by physical vapor transport (PVT), by chemical vapor deposition (CVD) or by high-temperature chemical vapor deposition (HTCVD), etc.
Manufacture by CVD has the advantage over sintering in particular of a dense disk having no porosity; another advantage is that the internal stresses of the disk after CVD growth are lower than those present in a disk produced by sintering.

The first step a) of the preparation process according to the invention is that of providing a raw disk 2 made of polycrystalline material and produced by one of the known techniques mentioned above. The raw disk 2 has two sides that extend substantially parallel to a main plane (x, y).

Step a) preferably involves a first substep a1) of chemical vapor deposition (CVD) of a layer 2' of polycrystalline material on a substrate referred to as a growth substrate 2'' (Figure 1a).

In the case where the polycrystalline material is SiC, this technique employs a gas mixture comprising at least one silicon precursor gas (such as a silane or a chlorosilane) and/or at least one carbon precursor gas (such as an alkane or an alkene) and/or at least one silicon and carbon precursor gas (such as methyltrichlorosilane, abbreviated MTCS), and, if necessary, at least one dopant gas. These gases may be diluted in a carrier gas, which may be a reducing gas such as hydrogen and/or an inert gas such as argon. The polycrystalline SiC layer 2' is formed from this gas mixture on the growth substrate 2''. The latter is preferably composed of fine-grained and purified isostatic graphite, so as to form a 3C-SiC

polytype. The reactor temperature during the CVD deposition of SiC should be between about 1000°C and about 1600°C. For example, the deposition can be carried out on a graphite disk having a diameter close to a nominal diameter of 150 mm and a thickness of greater than 2 mm, so as to ensure the assembly of growth substrate/p-SiC layers is sufficiently flat. The diameter and thickness of the graphite disk 2'' may of course vary, if it is desired to produce a support substrate having a diameter of 100 mm, 200 mm, or the like.

The following substep a2) corresponds to the removal of the growth substrate 2'' to obtain a raw disk 2 of polycrystalline material having two sides 2a, 2b (Figure 1a').

Returning to the previous example relating to SiC, the graphite growth substrate 2'' coated with the deposited p-SiC layer 2' is machined and then oxidized in air, typically at 900°C, to eliminate any graphite residue. It should be noted that the graphite 2'' could also be removed using purely mechanical machining techniques or even essentially by burning/oxidation. In practice, a raw p-SiC disk 2 is often obtained on either side of the growth substrate 2''.

For a diameter of 150 mm or 200 mm, the thickness of the raw disk 2 of polycrystalline material provided in step a) is typically between 700 µm and 3000 µm.

The process then comprises a step b) consisting of coarse grinding at least one of the sides 2a, 2b of the raw disk 2 with a grinding wheel suitable for a high degree of material removal.

As is known per se, a grinding wheel is a rotationally symmetrical tool composed of abrasive grains embedded in a binding matrix. The abrasive grains are for example diamond grains. To grind one side of the raw disk 2, the grinding wheel is rotated and gradually lowered to abrade the polycrystalline material and thus remove material above a certain thickness.

The grinding in step b) is described as "coarse" because it employs a grinding wheel having a large grain size.
In particular, the abrasive grains have an average size (or average diameter) of greater than or equal to 10 µm, typically of between 10 µm and 160 µm. Average size is understood as meaning the average of the sizes (diameters or equivalent diameters) of the abrasive grains that make up the grinding wheel.

In other words, the mesh or grit of the grinding wheel, the value of which varies inversely to the size of the abrasive grains, is less than or equal to 2000, typically between 100 and 2000.
The abrasive grains preferably have an average size of greater than or equal to 18 μm, typically of between 18 μm and 50 μm (i.e. a wheel mesh of between 350 and 1000), or even between 50 μm and 160 μm (i.e. a wheel mesh of between 100 and 350).

This coarse grinding causes the formation of a surface damaged region that can extend over several micrometers, several tens of micrometers, or even a few hundred micrometers (for example, between 15 μm and 600 μm).
The damaged region comprises two layers: a surface work-hardened layer 21 and an underlying stressed layer 22. The work-hardened layer 21 is characterized by the presence of significant scratching on the surface (giving rise in particular to high surface roughness) and the presence of cracks and stresses in the material. It has a typical thickness of between 0.5 μm and 50 μm, or even between 5 μm and 50 μm for the highest average sizes of abrasive grains.
The stressed layer 22 is, as its name suggests, characterized by stresses in the material, but without cracking. It is situated beneath the work-hardened layer 21 and has a typical thickness of between 10 μm and 500 μm.
The thicknesses of the work-hardened layer 21 and of the stressed layer 22 depend in particular on the size of the abrasive grains of the grinding wheel.

The damaged region with its two layers 21, 22 can be characterized in particular by transmission electron microscopy (TEM). The work-hardened layer 21 may also be identified by scanning electron microscopy (SEM): two examples are illustrated in Figures 3a and 3b, with a work-hardened layer 21 into which cracks can be seen to extend and having a thickness of the order of 4 μm and 10 μm respectively.

The coarse grinding is advantageously carried out on both sides 2a, 2b of the raw disk 2. This is because the raw disk 2 usually exhibits a high variation in thickness (TTV) and needs grinding on the side where growth (CVD) has taken place. In addition, the side initially in contact with the growth substrate 2'' has a nucleation zone with very small grains, a zone liable to create a stress differential with the other side (on which the grains have grown in size) and which should therefore preferably also be ground.

The coarse grinding preferably removes a thickness (referred to as first thickness) on one or both side(s) 2a, 2b of the raw disk 2 that is greater than or equal to 10 μm, greater than or equal to 50 μm, greater

than or equal to 150 μm, greater than or equal to 250 μm, greater than or equal to 500 μm or greater than or equal to 1 mm. The first thickness is advantageously between 100 μm and 300 μm, particularly when the raw disk 2 provided in step a) has been produced by a chemical vapor deposition (CVD) technique.

At the end of this step, a so-called ground disk 20 is obtained that has two sides 20a, 20b (Figure 1b).

After step c), a ground disk 20 with a diameter of 150 mm has a typical thickness of between 400 μm and 800 μm. For a ground disk 20 that is 200 mm in diameter, the typical thickness is between 550 μm and 900 μm.

The following step c) involves applying a heat treatment to the ground disk 20. The temperature and the duration of the heat treatment are defined so as to relieve all or some of the stresses present in the stressed layer 22 (said layer having been generated by the coarse grinding step b)). Only one stressed layer 22 is referred to here but, as can be seen in Figure 1b, the ground disk 20 may have two surface damaged regions (and therefore two stressed layers 22) on one side and on the other of its sides 20a, 20b, if both have undergone grinding in step b).

The heat treatment is carried out at a temperature above the growth/formation temperature of the raw disk 2 and below the melting point of the polycrystalline material.
In particular, the temperature applied in step c) is greater than or equal to 1500°C (for example in the case of p-AlN), or even greater than or equal to 1600°C (for example in the case of p-SiC), for a duration of greater than or equal to 10 min.

The heat treatment in step c) is preferably carried out at a temperature even greater than or equal to 1700°C, greater than or equal to 1800°C, greater than or equal to 1850°C or even greater than or equal to 2000°C. It is also preferable that the duration of the heat treatment is greater than or equal to 30 min, greater than or equal to 1 h or even greater than or equal to 2 h. The annealing atmosphere is advantageously neutral, for example argon-based. The heat treatment may advantageously be carried out under a pressure greater than atmospheric pressure.

At the end of this step, a so-called annealed disk 20’ is obtained (Figure 1c).

This heat treatment carried out after coarse grinding and prior to thinning by fine grinding (in the next step d)) permits a “repairing” of all or part of the stressed layer 22 and possibly even a partial repairing of the work-hardened layer 21 of the damaged region (of one or both sides 20a, 20b) of the ground disk 20. This repairing results in a rearrangement of the polycrystalline structure and a relieving of (and therefore a decrease in) the stresses present in the damaged region.

The annealed disk 20’ then comprises a first annealed layer 21’, formerly the work-hardened layer 21 of the ground disk 20. The first annealed layer 21’ extends over the same thickness as the work-hardened layer 21, but may benefit from a lower level of defectivity and stress by virtue of the heat treatment.

The annealed disk 20' also comprises a second annealed layer 22' situated beneath the first annealed layer 21', formerly the stressed layer 22 of the ground disk 20. The stress in the second annealed layer 22’ is fully or partly relieved, i.e. it is no longer liable (or less liable) to give rise to deformation of the disk during subsequent thinning or heat treatment steps. The second annealed layer 22’ extends over the same thickness as the stressed layer 22.

The process then comprises a step d) of thinning the annealed disk 20’ on the - at least one - side ground during step b). The aim of this step is to remove the first annealed layer 21’ while preserving at least part, and preferably all or most (more than 80%, or even more than 90%), of the second annealed layer 22’.

Step d) includes fine grinding with a grinding wheel, the abrasive grains of which have an average size (or average diameter) of less than or equal to 10 µm (i.e. a wheel mesh of greater than or equal to 2000). The average size of the abrasive grains is preferably less than or equal to 8 µm, 7 µm, 6 µm, 5 µm, 4 µm or even 3 µm (corresponding respectively to a wheel mesh of greater than or equal to about 2400, 2800, 3300, 4000, 5000 or 7000).

At the end of step e), the support substrate 200 is obtained (Figure 1d).

The heat treatment applied in step c) makes it possible for less material to be removed by fine grinding in this step d). According to the invention, the fine grinding aims to remove all of the first annealed layer 21’ or in any event most of it (typically more than 90% or even more than 95%), but does not remove the underlying second annealed layer 22’ or removes only a minor portion thereof (typically less than 20%,

less than 10% or even less than 5%), since the potential harm that the second annealed layer 22' could exert on the curvature is deactivated by step c).

The fine grinding advantageously removes a thickness (referred to as second thickness) on one or both side(s) 20a, 20b of the annealed disk 20' that is less than or equal to 50 µm, less than or equal to 20 µm, preferably between 5 µm and 20 µm.

For a diameter of 150 mm, the support substrate 200 after fine grinding typically has a thickness of between 110 µm and 400 µm; for a diameter of 200 mm, its typical thickness is between 110 µm and 600 µm.

Very fine-grain grinding wheels undergo significant and rapid wear with the thickness removed, so it is not economically advantageous to remove too much material with these grinding wheels. However, their advantage is that they provide very favorable preliminary surface finishes (low roughness and low thickness in the induced damaged region).
Because the thickness to be removed is small in step d), the application of the heat treatment directly after the coarse grinding makes it economically viable to carry out fine grinding with a grinding wheel having fine or even very fine abrasive grains, such as grains having an average size of less than or equal to 5 µm, less than or equal to 4 µm, or even less than or equal to 3 µm.

For example, step d) could be carried out on an annealed p-SiC disk 20' with a grinding wheel of mesh 4000, or even of mesh 8000, by applying a rotation of the head supporting the wheel ("spindle") of between 1000 and 2000 revolutions per minute (rpm) and a rotation of the plate supporting the annealed disk 20' of the order of 200 to 400 rpm, with a removal speed of between 0.1 µm/s and 0.5 µm/s, for example 0.15 µm/s.

After the fine grinding, step d) advantageously comprises a surface treatment including chemical-mechanical polishing, cleaning, annealing, chemical etching (wet or dry) and/or film deposition, so as to obtain a surface finish on the support substrate 200 that is compatible with direct joining to another substrate. Such a surface finish typically corresponds to a roughness of less than or equal to 1 nm RMS (measured by atomic force microscopy on scans of 20 µm x 20 µm. When carrying out fine grinding in step d) with a grinding wheel in which the abrasive grains have an average size of less than or equal to 3 µm, it should be noted that there is no need to add any mechanical or chemical-mechanical polishing

step; only cleaning (or a sequence of cleaning operations), film deposition, annealing and/or plasma activation are preferably carried out prior to joining the support substrate 200 to manufacture the composite structure 100. This is an important advantage because the polishing steps are costly and liable to differentially etch the grains of the polished side and this tends to degrade the surface quality, which is critical for joining.

Taking into account the successive application of steps (b), c), and d) without any other interposed step, the curvature of the p-SiC support substrate 200 remains within reasonable limits starting from a raw disk 2 of economically viable thickness and following a simple process that minimizes manufacturing costs.

The curvature can be measured using a confocal white-light sensor that scans a surface of the substrate, the latter being placed on a holder of the measuring tool. For a support substrate 200 having a diameter of 150 mm or 200 mm, the curvature is typically less than or equal to 150 µm, 100 µm or even 50 µm.

The sequence of steps b), c), and d) is also economically advantageous, because the coarse grinding is rapid and the associated grinding wheel withstands thick removal without prohibitive wear. Moreover, with step d) requiring low removal it is possible to use a high-mesh grinding wheel mesh, which facilitates the subsequent surface treatment aimed at obtaining a surface finish on the support substrate 200 that is compatible with direct joining.

The support substrate 200 thus prepared is intended for use in the manufacture of a composite structure 100. The process for manufacturing this structure 100 comprises the transfer of a thin layer 10 made of a single-crystal material to said support substrate 200. Although any known thin-layer transfer process may be used, it is possible in particular to employ the Smart Cut™ process based on the formation of a weakened plane buried in a donor substrate made of single-crystal material, through implantation of light ion species (for example H, He or a combination of these two species), and direct joining (by molecular adhesion) of said donor substrate and the support substrate. Detachment along the buried weakened plane then allows a thin single-crystal layer 10 to be transferred from the donor substrate to the support substrate 200 (Figure 2a), preserving the remainder of the donor substrate for subsequent reuse.

The thin single-crystal layer 10 may in particular be composed of silicon carbide, diamond, silicon, or II-VI or III-V semiconductor compounds (for example AlN, GaN, etc.), gallium oxide (Ga2O3), or any wide bandgap semiconductor material.

By way of example, the thin layer 10 of the composite structure 100 has a thickness of between a few tens of nm and a few hundred nm and for example between 50 nm and 800 nm. It will be seen hereafter that epitaxy steps can be executed on said thin layer 10 so as to thicken it (homoepitaxy), or to grow other materials (heteroepitaxy), for the requirements of the electronic components to be manufactured. The thin layer 10 has an electrical resistivity suitable for the target application and target components.

In the composite structure 100, the support substrate 200 has a thickness and a curvature as previously stated. The range of the curvature radius of the support substrate 200 makes said substrate perfectly compatible with the specifications of a composite structure 100 provided with a thin single-crystal layer 10, with the process for manufacturing such a structure 100, and with the subsequent production of microelectronic components on and/or in the thin layer 10. It should be noted that the curvature of the composite structure 100 remains close to the curvature of the support substrate 200.

The composite structure 100 may comprise a continuous or discontinuous intermediate layer 30 arranged between the thin layer 10 and the support substrate 200 and made of at least one metal or semiconductor material (Figure 2b). As is known per se in relation to a process for manufacturing the composite structure 100, the intermediate layer 30 may be formed on the thin layer 10 side, on the support substrate 200 side, or on both sides, prior to joining the donor substrate and the support substrate 200 along a bonding interface. The intermediate layer 30 may for example be made of silicon, silicon carbide, tungsten and/or titanium. Its thickness is typically between a few nm and a few hundred nm, preferably between 2 nm and 50 nm.

The composite structure 100 that is obtained is extremely robust in respect of the very high-temperature heat treatments that can be applied to improve the quality of the thin layer 10 or to manufacture components on and/or in said layer 10. The support substrate 200 in the composite structure 100 is stable and its curvature does not prohibitively increase during the high-temperature heat treatments applied to the composite structure 100 for the manufacture thereof and thereafter.

The composite structure 100 according to the invention is particularly suitable for the production of one (or more) electronic component(s), in particular high-voltage components, such as for example Schottky diodes, MOSFET or HEMT and/or high-frequency (RF) transistors, in and/or on the thin layer.

The invention is of course not limited to the described embodiments and examples and variant embodiments may be implemented without departing from the scope of the invention.

CLAIMS

1. **A process for preparing a support substrate (200)** made of polycrystalline material, the preparation process comprising the following steps:

   a) providing a raw disk (2) made of polycrystalline material, having two sides (2a, 2b);
   b) coarse grinding at least one of the sides (2a, 2b) of the raw disk (2) to obtain a ground disk (20) having at least one ground side (20a, 20b), the coarse grinding inducing, on said ground side (20a, 20b), the formation of a surface damaged region, the surface damaged region comprising a surface work-hardened layer (21) and an underlying stressed layer (22);
   c) applying a heat treatment to the ground disk (20), the temperature and duration of the heat treatment being defined so as to relieve the stresses present in the stressed layer (22), step c) affording an annealed disk (20') comprising on the - at least one - ground side (20a, 20b) a first surface annealed layer (21') in place of the work-hardened layer (21) and an underlying second annealed layer (22') in place of the stressed layer (22);
   d) thinning the annealed disk (20') on the - at least one - ground side (20a, 20b) to remove the first annealed layer (21'), step d) affording the support substrate (200) in which all or part of the second annealed layer (22') is preserved.

2. The preparation process as claimed in claim 1, wherein step a) comprises the following substeps:

   a1) the chemical vapor deposition of a layer formed from the polycrystalline material (2') on a growth substrate (2''),
   a2) removing the growth substrate (2'') to obtain the raw disk (2).

3. The preparation process as claimed in either of the preceding claims, wherein the polycrystalline material is silicon carbide (SiC) or aluminum nitride (AlN).

4. The preparation process as claimed in any of the preceding claims, wherein step b) is applied to both sides of the raw disk (2) and/or step d) is applied to both sides of the raw disk (2).

5. The preparation process as claimed in any of the preceding claims, wherein the coarse grinding is carried out with a grinding wheel, the abrasive grains of which have an average size of greater than or equal to 10 μm, or even greater than or equal to 18 μm.

6. The preparation process as claimed in any of the preceding claims, wherein the coarse grinding applied to one side and/or to the other side of the raw disk (2) removes a first thickness greater than or equal to 150 µm.

7. The preparation process as claimed in any of the preceding claims, wherein the heat treatment in step c) is carried out at a temperature greater than or equal to 1600°C, preferably greater than or equal to 1700°C, more preferably greater than or equal to 1800°C, more preferably greater than or equal to 1850°C, even more preferably greater than or equal to 2000°C.

8. The preparation process as claimed in any of the preceding claims, wherein the thinning in step d) includes fine grinding carried out with a grinding wheel, the abrasive grains of which have an average size of less than or equal to 5 µm, less than or equal to 4 µm, or even less than or equal to 3 µm.

9. The preparation process as claimed in claim 8, wherein the fine grinding applied to one side and/or to the other side of the annealed disk (20') removes a second thickness less than or equal to 50 µm.

10. The preparation process as claimed in claim 9, wherein the second thickness is less than or equal to 20 µm, preferably between 5 µm and 20 µm.

11. The preparation process as claimed in any of claims 8 to 10, wherein step d) comprises, after the fine grinding, a preparation of the surface comprising just cleaning, annealing, plasma activation and/or deposition of a film, so as to obtain a surface finish on the support substrate (200) that is compatible with direct joining to another substrate.

12. **A process for manufacturing a composite structure (100)** comprising:
    - preparing a support substrate (200) made of polycrystalline material in accordance with the process as claimed in any of the preceding claims, and
    - transferring a thin layer (10) of single-crystal material from a donor substrate (1) onto said support substrate (200).

13. The process for manufacturing a composite structure (100) as claimed in claim 12, wherein the polycrystalline material is silicon carbide (SiC) or aluminum nitride (AlN) and wherein the single-crystal material is selected from silicon carbide (SiC), gallium nitride (GaN), gallium oxide (Ga2O3), diamond, silicon, germanium, and indium phosphide (InP).

14. The manufacturing process as claimed in either of claims 12 and 13, also comprising the formation of electronic components in or on the thin layer (10).