

**TITLE: Removable semiconductor substrate made of polycrystalline silicon
carbide**

DESCRIPTION

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FIELD OF THE INVENTION

The invention relates to manufacturing semiconductor substrates, and more specifically to manufacturing polycrystalline silicon carbide support layers to be used in high-performance substrates.

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PRIOR ART

In the field of power electronics, wide-band semiconductor materials are known to be used. These materials have a wider bandgap than semiconductor materials such as silicon, which gives them electrical insulation properties between those of semiconductors and insulating materials. Notably, wide-band semiconductors have the advantage of tolerating higher temperatures than conventional semiconductors are able to withstand. In addition, these materials have a higher power density than conventional semiconductors, allowing volume and weight savings in the electronic systems incorporating them.

A frequently used wide-band semiconductor material is silicon carbide (SiC). In order to produce power electronic components, and in particular metal-oxide-semiconductor field-effect transistors (or MOSFETs), SiC substrates with a certain thickness need to be provided, generally of the order of 300 micrometres, providing them with mechanical strength that enables front-end processes to be carried out, i.e., the formation of electronic functions on the semiconductor substrate. The semiconductor substrates thus obtained are then placed on a metal support, notably made of copper, which has a Young's modulus and a thermal expansion coefficient different from those of the semiconductor substrate. Mechanical stresses therefore can be generated in the semiconductor substrate during the thermal cycles it experiences on the metal support. One way of overcoming this problem is to reduce the thickness of the SiC layer, which is only possible after carrying out the front-end processes.

To this end, a SiC substrate with a given thickness, close to 300 micrometres, can be formed before mechanically etching a portion thereof in order to reduce the thickness thereof, and therefore reduce the mechanical stresses imposed on the metal support or on any soldering joints between it and the SiC substrate during the use and the thermal cycling of the electronic component. In addition, reducing the thickness of the SiC substrate in this way allows its ON resistance and thermal resistance to be reduced, resulting in better electrical

performance capabilities, and allows the Young's modulus and the thermal expansion coefficient of the SiC substrate to be brought closer to those of the metal substrate.

However, mechanical etching is relatively expensive and difficult to implement due to the hardness of SiC, and the remaining part of the substrate may not be perfectly flat. Therefore, methods need to be established for obtaining a thin semiconductor substrate with even flatness, while reducing the costs and the time required to implement such methods.

DISCLOSURE OF THE INVENTION

An aim of the invention is to overcome the aforementioned disadvantages.

To this end, according to a first aspect of the invention, an intermediate substrate for manufacturing a semiconductor substrate is proposed, successively comprising:

- a. a first semiconductive layer;
- b. a first thermal barrier layer;
- c. a support comprising an absorption layer configured to absorb laser radiation in a determined wavelength range, with the temperature of the absorption layer increasing during absorption, and a separation zone adjacent to the absorption layer and configured to thermally degrade under the effect of the increase in temperature of the absorption layer, so as to separate at least part of the support from the rest of the intermediate substrate.

Thus, once the front-end processes have been completed, the invention allows the semiconductor substrate to be separated into two distinct parts without mechanical etching, so that only the desired thickness of the semiconductive layer remains before it is integrated into the metal support without compromising the flatness of the semiconductive layer. Using a laser to divide the semiconductor substrate into two parts, and thus isolate the desired thickness of this substrate, allows it to be obtained more quickly and at a lower cost than by mechanical etching. Using a thermal barrier layer limits the propagation of heat to the rest of the substrate and therefore promotes the separation with reduced laser power and/or exposure time.

According to one embodiment, the support comprises:

- a. a separation assembly comprising:
 - i. the absorption layer; and

- ii. a separation layer adjacent to the absorption layer and comprising the separation zone, with degradation of the separation zone occurring when the absorption layer reaches a threshold temperature;

- b. a second thermal barrier layer;

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- c. a support layer;

with the second thermal barrier layer being located between the separation assembly and the support layer.

According to one embodiment, the support comprises:

- a. the absorption layer; and

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- b. a support layer further forming a second thermal barrier;
with the separation zone being included in the support layer.

According to one embodiment, the substrate further comprises a seed layer adapted for growing the first semiconductive layer, with the seed layer preferably comprising graphite, the first semiconductive layer being interposed between the seed layer and the first thermal barrier layer.

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According to one embodiment, the separation layer is made up of silicon nitride.

According to one embodiment, the absorption layer is made of a material selected from among β -SiC type polycrystalline silicon carbide, titanium nitride or zirconium.

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According to one embodiment, the substrate further comprises a monocrystalline semiconductive layer, preferably comprising silicon carbide or gallium nitride, with a first face of the monocrystalline semiconductive layer being adjacent to the first semiconductive layer.

According to one embodiment, the first semiconductive layer is made up of a wide-band semiconductor material, notably of a material selected from among silicon carbide, aluminium nitride and gallium nitride.

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According to one embodiment, the support layer is a second semiconductive layer of lower quality than the first semiconductive layer, preferably made up of a material selected from among silicon carbide and silicon nitride.

According to one embodiment, the thickness of the support layer ranges between 100 and 200 nanometres.

According to one embodiment, the first and/or the second thermal barrier layer have thermal conductivity of less than 25 W/mK, with the second thermal barrier layer preferably being made up of titanium dioxide or silicon nitride.

According to one embodiment, the substrate further comprises a monocrystalline semiconductive layer disposed on a surface region of the first semiconductive layer, with the first semiconductive layer being located between the first thermal barrier layer and the monocrystalline semiconductive layer.

Another aspect of the invention relates to a method for manufacturing an intermediate semiconductor substrate, successively comprising the following steps of:

- a. growing a first electrically semiconductive layer on a seed layer;
- b. growing a first thermal barrier layer on the first semiconductive layer;
- c. growing a support on the first thermal barrier layer comprising an absorption layer configured to absorb laser radiation in a determined wavelength range, with the temperature of the absorption layer increasing during absorption, the support further comprising a separation zone adjacent to the absorption layer and configured to thermally degrade under the effect of the increase in temperature of the absorption layer, so as to separate at least part of the support from the rest of the intermediate substrate;
- d. removing the seed layer;

with the growing steps notably being obtained by gas phase deposition onto the previously formed layers.

According to one implementation of the method, growing the support comprises successive steps of:

- a. growing a separation assembly made up of the absorption layer and of a separation layer, with the growth of the separation assembly comprising:
 - growing the absorption layer;
 - growing the separation layer, with the separation layer comprising the separation zone, the separation zone being adjacent to the absorption layer;
- b. growing a second thermal barrier layer on the separation assembly;
- c. growing a support layer on the second thermal barrier layer;

with the growing steps notably being obtained by gas phase deposition onto the previously formed layers.

According to one implementation of the method, growing the support comprises successive steps of:

- 5 a. growing the absorption layer on the first thermal barrier layer;
- b. growing a support layer on the absorption layer also acting as a second thermal barrier;
- with the separation zone being included in the support layer;

10 with the growing steps notably being obtained by gas phase deposition onto the previously formed layers.

Another aspect of the invention relates to a method for manufacturing a substrate comprising a monocrystalline semiconductive layer on a polycrystalline semiconductor substrate, comprising the implementation of the method for manufacturing an intermediate semiconductor substrate as defined above, with the first semiconductive layer being polycrystalline,

15 and further comprising successive steps of:

- a. forming a weakened zone in a semiconductor donor substrate by implanting species, so as to delimit a monocrystalline semiconductive layer to be transferred;
- 20 b. bonding the monocrystalline semiconductive layer to be transferred onto a surface region of the first semiconductive layer;
- c. detaching the donor substrate along the weakened zone in order to transfer the monocrystalline semiconductive layer onto the first semiconductive layer.

25 Another aspect of the invention relates to a method for manufacturing an electronic component, comprising successive steps of:

- a. implementing the method for manufacturing a substrate as defined above;
- b. performing front-end processes in the monocrystalline semiconductive layer in order to form said electronic component.

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According to one implementation, the method comprises, after completing said front-end processes, a step of applying laser radiation to the intermediate substrate in the determined wavelength range, so as to thermally degrade the separation zone and to separate at least part of the support from the rest of the intermediate substrate.

According to one implementation, the method comprises, after applying the laser radiation, a step of removing residual layers located on a face of the first semiconductive layer opposite the monocrystalline semiconductive layer, with the residual layers originating from the step of applying the laser radiation.

Another aspect of the invention relates to an intermediate substrate for manufacturing a semiconductor substrate, successively comprising:

- a first semiconductive layer made up of polycrystalline silicon carbide (pSiC);
- a first thermal barrier layer made up of titanium dioxide (TiO_2);
- an absorption layer made up of 3C type polycrystalline silicon carbide (3C-pSiC);
- a separation layer made up of silicon nitride (Si_3N_4);
- a second thermal barrier layer made up of titanium dioxide (TiO_2);
- a support layer made up of 4H type polycrystalline silicon carbide (4H-pSiC).

Another aspect of the invention relates to an intermediate substrate for manufacturing a semiconductor substrate, successively comprising:

- a first semiconductive layer made up of polycrystalline silicon carbide (pSiC);
- a first thermal barrier layer made up of titanium dioxide (TiO_2);
- an absorption layer made up of titanium nitride (TiN);
- a separation layer made up of silicon nitride (Si_3N_4);
- a second thermal barrier layer made up of titanium dioxide (TiO_2);
- a support layer made up of 4H type polycrystalline silicon carbide (4H-pSiC).

DESCRIPTION OF THE FIGURES

Further features, aims and advantages of the invention will become apparent from the following description, which is purely illustrative and non-limiting, and which should be read with reference to the drawings, in which:

[Figure 1], [Figure 2], [Figure 3] and [Figure 4] schematically illustrate intermediate substrates for manufacturing a semiconductor substrate, according to various embodiments of a first aspect of the invention;

[Figure 5], [Figure 6] and [Figure 7] illustrate methods for manufacturing an intermediate substrate for subsequently manufacturing a semiconductor substrate, according to various embodiments of a second aspect of the invention;

Figure 8 illustrates a method for manufacturing a substrate comprising a monocrystalline semiconductive layer on a polycrystalline semiconductor substrate, according to a third aspect of the invention;

Figure 9 illustrates a method for manufacturing an electronic component, according to a fourth aspect of the invention;

[Figure 10], [Figure 11] and [Figure 12] show the results of a simulation of the change in temperature of an intermediate substrate when applying laser radiation.

Throughout the figures, similar elements use identical reference signs.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

According to a first aspect of the invention, an intermediate substrate 10 is shown in figure 1. It comprises an arrangement of layers, which can be successively formed from a graphite seed layer 1. The formation of the various layers of the intermediate substrate 10 can involve successively injecting gases that allow condensation deposits to be carried out.

The first formed layer is a first “high quality” semiconductive layer 2, which is configured to support a layer from which components will be formed, notably with a view to manufacturing power electronic components. The first semiconductive layer 2 is intended to remain in the final electronic component. The first semiconductive layer 2 can be a polycrystalline silicon carbide layer, notably of the 4H or 3C type (also called β -pSiC). Alternatively, and depending on the applications, it can be made up of 4H-type monocrystalline silicon carbide. The first semiconductive layer 2 also can be made up of another wide-band semiconductor material, such as aluminium nitride (AlN) or gallium nitride (GaN).

In some embodiments, the first semiconductive layer 2 is further configured to conduct an electric current. In particular, the first semiconductive layer 2 is doped.

When the first semiconductive layer 2 is made up of silicon carbide, it can be highly nitrogen doped (N++ doping). N-type doping with phosphorus or P-type doping with gallium or aluminium also can be contemplated. This doping provides the first semiconductive layer 2 with very low electrical resistivity, as well as high thermal conductivity, close to that of solid silicon carbide. However, when the first semiconductive layer 2 is formed by other materials, other forms of doping can be contemplated: for example, for a first semiconductive layer 2 made up of gallium nitride (GaN), silicon or magnesium doping can be used. In order to minimise the electrical resistance of this first semiconductive layer 2, it is beneficial for the thickness thereof to range between 10 and 300 μm , preferably less than 100 μm .

However, the intermediate semiconductor substrate must have sufficient mechanical strength to withstand the front-end processes applied thereto. To this end, the intermediate substrate 10 comprises a support 13, the thickness of which is configured to provide the substrate 10 with a given mechanical strength, for example, ranging between approximately 100 and 400 μm .

According to conceivable variants, the first semiconductive layer 2 is also likely to be non-doped or even to be electrically insulating (for example, in the case of a silicon carbide layer, by vanadium doping).

The support 13 comprises an absorption layer 3, as well as a separation zone 8 adjacent thereto. The absorption layer 3 is configured to absorb laser radiation in a determined wavelength range so that its temperature increases.

The wavelength range for the laser radiation is selected so that the seed layer 1 and the first thermal barrier layer 5 (described below) are substantially transparent to this radiation, in order to ensure that a sufficient portion of the radiation reaches the absorption layer 3, and in order to prevent damage to these layers by the radiation.

The temperature increase caused by the absorption layer 3 absorbing laser radiation degrades the separation zone 8, thus allowing the intermediate substrate 10 to be separated into two parts. Thus, the intermediate substrate can be manufactured and then the front-end processes can be carried out from the semiconductive layer 2, with the total thickness of the intermediate substrate 10 providing it with sufficient mechanical strength so as not to be damaged by these processes, and, finally, a laser can be applied in the determined wavelength range so as to separate a thin part of the substrate that comprises the first semiconductive layer 2 from the rest of the substrate 10, without having to resort to mechanical polishing or grinding, which could damage the first semiconductive layer 2 and which would be longer and more expensive to implement.

The absorption layer 3 can be made up of a material selected from β -SiC type polycrystalline silicon nitride, titanium nitride (TiN) or zirconium (Zr). When it is made up of β -SiC, the absorption layer 3 can be configured to absorb laser radiation with a wavelength ranging between 380 and 410 nanometres. Titanium nitride has the advantage of being able to absorb a wider range of radiation wavelengths, so that when the absorption layer is made up of this material, it can be configured to absorb laser radiation with wavelengths ranging between 380 nanometres and 1.7 micrometres. Silicon carbide, for its part, has the advantage of being a material that can be used for manufacturing the first semiconductive layer 2, and therefore of not introducing any new chemical elements when manufacturing the intermediate substrate 10.

The intermediate substrate further comprises a first thermal barrier layer 5 interposed between the first semiconductive layer 2 and the support 13. This layer is configured to form a barrier to thermal conduction between the absorption layer 3 and the first semiconductive layer 2, so as to limit an increase in temperature of the first semiconductive layer as much as possible. Indeed, the first thermal barrier layer 5 is configured to have lower thermal conductivity than that of the first semiconductive layer 2, and the temperature of the first semiconductive layer 2 would therefore increase without the first thermal barrier layer 5. Despite this, the first semiconductive layer 2 must have a low absorption coefficient over the wavelength range intended for the laser radiation, for example, a wavelength ranging between 380 and 410 nanometres, so that it does not absorb the radiation intended to heat the absorption layer 3.

According to one embodiment, illustrated in figure 2, the support 13 comprises a separation assembly 12 comprising, on the one hand, the absorption layer 3 and, on the other hand, a separation layer, called sacrificial separation layer 4, adjacent to the absorption layer and comprising the separation zone 8. The separation layer 4 is configured so that degradation of the separation zone 8 occurs when the absorption layer 3 reaches a threshold temperature, so as to be able to precisely control the separation from the intermediate substrate 10. The separation assembly 12 is disposed between the first thermal barrier layer 5 and a second thermal barrier layer 6. Finally, the second thermal barrier layer 6 is adjacent, on the side thereof opposite the separation assembly, to a support layer 7. The two thermal barriers 5, 6 allow the temperature increase to be confined to the separation assembly so that only the separation assembly experiences a significant increase in temperature, allowing the substrate to be separated into two parts along the separation zone 8 without degrading the rest of the substrate 10.

When allowed by the absorption coefficient of the absorption layer 3 and of the separation layer 4 at the intended wavelengths for the laser radiation, the absorption layer 3 can be disposed, within the separation assembly 12, closer to the first thermal barrier layer 5, as shown in figure 2, or, alternatively, the separation layer 4 can be disposed closer to the first thermal barrier layer 5. In other words, the absorption coefficients of the absorption layer 3 and of the separation layer 4 must allow the absorption layer 3 to be heated and the separation zone 8 of the separation layer 4 to be degraded depending on the arrangement selected for these two layers 3, 4 in the separation assembly 12.

The wavelength range for the laser radiation is selected so that the second thermal barrier layer 6 and the support layer 7 are substantially transparent to this radiation, in order to prevent damage to these layers by the radiation.

Advantageously, the separation layer 4 is very thin, for example, less than 100 micrometres thick, so as not to weaken the intermediate substrate before separation. Providing a thin separation layer 4 also allows the cost of manufacturing this layer to be limited. A thick separation layer 4 does not need to be provided since it is not intended to contribute to the mechanical strength of the substrate. It can be made up of silicon nitride (formula Si_3N_4).

The thermal barrier layers 5, 6 can have thermal conductivity of less than 25 W/mK, preferably of less than 10 W/mK. Notably, they can be made up of titanium dioxide (TiO_2) or of silicon nitride (Si_3N_4).

The main function of the support layer 7 is to increase the thickness of the intermediate substrate 10 so as to provide it with suitable mechanical strength for the front-end processes. Notably, the semiconductive properties of this layer are not important. Therefore, it is advantageous to minimise the cost of this layer as much as possible. Therefore, the support layer 7 is preferably of lower quality than the first semiconductive layer 2: notably, the thermal resistivity and the electrical resistivity of the support layer 7 are higher than those of the first semiconductive layer 2. For example, the first semiconductive layer 2 has electrical resistivity of less than 5 mΩ/cm, while the support layer 7 has electrical resistivity of more than 5 mΩ/cm.

The support layer 7 can be made up of 4H-SiC type polycrystalline silicon carbide, or of silicon nitride (Si_3N_4). It can range between 100 and 200 nanometres thick. In addition, and like the first semiconductive layer 2, it is advantageous for the support layer 7 to have a low absorption coefficient over the wavelength range intended for the laser radiation, so that it does not absorb the radiation intended for heating the absorption layer 3.

Another embodiment is illustrated in figure 3. The intermediate substrate 10 according to this embodiment does not include a second thermal barrier 6. In this case, the support layer 7 is made up of a material with a low absorption coefficient at the wavelengths intended for the laser radiation (i.e., transparent to the laser wavelength that is used), as well as low thermal conductivity. This could be silicon nitride (Si_3N_4), for example. A second thermal barrier layer 6 then does not need to be present, as the support layer 7 does not risk being damaged by the radiation. In addition, silicon nitride has a thermal expansion coefficient that is substantially close to that of polycrystalline silicon carbide, so that no additional mechanical stresses are introduced compared with the previously described embodiments. This method has the advantage of being compatible with the method for manufacturing the layer 2 (silicon and nitrogen in the deposition reactor) and of simplifying layer stacking compared with the previously described embodiments.

According to one embodiment, illustrated in figure 4, the intermediate substrate 10 comprises a monocrystalline semiconductive layer 14, a first face of which is adjacent to the

first semiconductive layer 2 on the side thereof opposite the first thermal barrier layer 5. The monocrystalline semiconductive layer can comprise silicon carbide or gallium nitride (GaN).

A second aspect of the invention relates to a method for manufacturing an intermediate semiconductor substrate 10 as described above. The method comprises several phases of growing layers, preferably implemented by successive gas deposition onto the previously formed layers. However, other deposition methods known to a person skilled in the art fall within the scope of the invention: for example, liquid phase epitaxy, molecular jet epitaxy or cathode sputtering. Advantageously, all the successive layers can be deposited in the same enclosure using the same deposition method.

With reference to figure 5, the first step 101 involves growing a first high-quality semiconductive layer 2 on a seed support 1. The method then comprises growing 102 a first thermal barrier layer 5 on this first semiconductive layer 2, then growing 103 a support 13 on the first thermal barrier layer 5. Finally, once these three growth steps have been completed, the method comprises removing 104 the seed layer, notably by grinding or mechanical polishing. The substrate 13 comprises an absorption layer 3 and a separation zone 8 adjacent thereto. As described for the intermediate substrate 10 according to the first aspect of the invention, the absorption layer 3 is configured to absorb light radiation over a given wavelength range, with the temperature of the absorption layer 3 then increasing by radiation, and the separation zone 8 is configured to weaken and separate under the effect of the heating, and thus allow at least part of the support 13 to separate from the rest of the intermediate substrate 10.

According to one implementation of the method, shown in figure 6, the growth 103 of the support 13 is divided into a plurality of successive sub-steps. A first sub-step involves growing a separation assembly 12 comprising the absorption layer 3, as well as a separate adjacent separation layer 4, with the separation layer 4 comprising the separation zone 8, the separation layer 4 being configured such that the separation zone 8 degrades when the absorption layer 3 reaches a threshold temperature. This first sub-step comprises growing 1031 the absorption layer 3, then growing 1032 the separation layer 4. A second sub-step 1033 involves growing 1033 a second thermal barrier layer 6 on the separation assembly 12 thus formed, thus allowing the increase in temperature by irradiation to be contained between the two thermal barrier layers 5, 6, i.e., in the vicinity of the separation assembly 12, and therefore without compromising the quality of the first semiconductive layer 2. Finally, the step 103 of growing the support 13 comprises a third sub-step 1034 of growing a support layer 7 configured so that the thickness and the mechanical strength of the intermediate substrate 10 are suitable for carrying out front-end processes.

According to an alternative implementation to that described in the previous paragraph, and illustrated in figure 7, growing 103 the support 13 comprises a first step 1031 of growing the absorption layer 3 on the first thermal barrier layer 5, then a second step 1035 of growing a support layer 7 that comprises the separation zone 8. In this case, the support layer 7 is made up of a material with low thermal conductivity, and which is transparent to the wavelengths intended for the light radiation applied to the intermediate substrate 10 in order to separate the substrate 10 along the separation zone 8. The support layer 7 is of lower quality than the first semiconductive layer 2. For example, the support layer 7 has been deposited at a higher growth rate than that of the first semiconductive layer 2.

A third aspect of the invention relates to a method for manufacturing a high-performance substrate. This method, which is illustrated in figure 8, comprises a first step of implementing the method for manufacturing an intermediate substrate 10 according to the second aspect of the invention. The method then comprises forming 109 a weakened zone in a donor semiconductor substrate 9 by implanting species through a face of the donor substrate 9 so as to separate the donor substrate into two parts, with one part defining a monocrystalline semiconductive layer 14. This is followed by a step 110 of bonding the donor substrate 9, in the vicinity of the monocrystalline semiconductive layer 14, onto a surface region of the first semiconductive layer 2 and a step 111 of detaching the donor substrate along the weakened zone. This then results in a semiconductor substrate comprising a monocrystalline semiconductive layer 14 disposed on a semiconductive layer 2, which, for its part, can be monocrystalline or polycrystalline depending on the applications.

A fourth aspect of the invention relates to a method for manufacturing an electronic component, as shown in figure 9. This method comprises a first step of implementing the method for manufacturing a semiconductor-type substrate according to the third aspect of the invention, as described in the previous paragraph. The method then comprises a step 112 of carrying out front-end processes in the first layer in order to form the electronic component. "Front-end" processes are understood to mean the production of individual components, such as transistors, resistors, capacitors or other components, integrated into the monocrystalline semiconductive layer 14 of the substrate.

According to one implementation, the method can further comprise, after the front-end processes have been carried out 112, applying 113 laser radiation to the intermediate substrate 10 in a given wavelength range, thus increasing the temperature of the absorption layer 4 and allowing the separation zone 8 to be degraded once the temperature of the absorption layer 4 reaches a threshold, and thus allowing at least part of the support 13 to be

separated from the rest of the intermediate substrate 10. Notably, laser radiation can be applied 113 to the support layer 7.

According to one implementation, and after applying 113 laser radiation, the method can further comprise a step 114 of removing residual layers 15 located on a face of the first semiconductive layer 2 opposite the monocrystalline semiconductive layer. The residual layers 15 originate from the step 113 of applying laser radiation, and notably comprise the first thermal barrier layer 5, and optionally the absorption layer 3, as well as part of the separation layer 4.

Figure 10 illustrates the change in temperature in the intermediate substrate 10 during simulations of substrate irradiation using laser radiation at 50 Watts and with a diameter of 125 micrometres, with a wavelength of 404 nanometres. Three curves I, II and III are shown, respectively corresponding to an irradiation time of 47.2 milliseconds, 47.9 milliseconds and 50 milliseconds. The intermediate substrate 10 used for the simulation comprises two separate thermal barrier layers 5, 6, as well as a separation layer 4, and the laser radiation is applied to a free face of the support layer 7 opposite the other layers of the intermediate substrate 10. It can be seen that the temperature of the absorption layer exceeds 2,000 °C, while the temperatures of the first semiconductive layer 2 and of the support layer 7 increase to a maximum of approximately 800 °C.

Figure 11 shows a change in the maximum temperature in the separation layer 4 as a function of the diameter of the laser that is used, under the same simulation conditions as for figure 10. The three curves I, II and III respectively correspond to exposure times for the intermediate substrate 10 of 50, 100 and 200 microseconds. It can be seen that a small diameter needs to be provided for the laser radiation in order to obtain a sufficiently high temperature increase in the separation layer 4. To increase the temperature in the separation layer 4 above 2,000 °C, a laser beam with a diameter of less than 150 micrometres is required under these simulation conditions.

Figure 12 shows, for the same simulation conditions:

- the change in the maximum temperature in the separation layer 4, with said layer being shown by the curves denoted I to VI;
- the change in the surface temperature of the substrate, shown by the curve denoted VII for a laser beam with a diameter of 125 micrometres and an exposure time of 200 microseconds.

The diameter of the laser radiation can vary according to several factors, for example, according to the power of the laser or the materials present in the substrate. For the

maximum temperature values in the separation layer 4, the parameters of the laser that is used are listed, for each curve, in Table 1 below.

With respect to the surface temperature of the substrate, it can be seen that it reaches a maximum of approximately 200 °C, which is much lower than the temperatures obtained in the separation layer, which demonstrates the effectiveness of the thermal barrier layers 5, 6.

The changes in the surface temperature of the substrate observed during these simulations for the other parameters (i.e., the simulation parameters corresponding to curves I to V), which are not shown in figure 12, are similar.

[Table 1]

Curve	Substrate exposure time (μs)	Laser diameter (μm)
I	50	150
II	100	150
III	200	150
IV	50	125
V	100	125
VI	200	125

CLAIMS

1. Intermediate substrate (10) for manufacturing a semiconductor substrate, successively comprising:
 - 5 a. a first semiconductive layer (2);
 - b. a first thermal barrier layer (5);
 - c. a support (13) comprising:
 - 10 i. an absorption layer (3) configured to absorb laser radiation in a determined wavelength range, with the temperature of the absorption layer (3) increasing during absorption; and
 - ii. a separation layer (4) comprising a separation zone (8) adjacent to the absorption layer (3) and being configured to thermally degrade under the effect of the increase in temperature of the absorption layer, so as to separate at least part of the support (13) from the rest of the intermediate substrate (10), with the degradation of the separation zone (8) occurring when the absorption layer (3) reaches a threshold temperature;
 - 15 iii. a second thermal barrier layer (6); and
 - iv. a support layer (7), with the support layer (7) being a second semiconductive layer of lower quality than the first semiconductive layer (2).
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2. Intermediate substrate (10) according to Claim 1, further comprising a seed layer (1) adapted for growing the first semiconductive layer (2), the seed layer (1) preferably comprising graphite, the first semiconductive layer (2) being interposed between the seed layer (1) and the first thermal barrier layer (5).
- 25 3. Intermediate substrate according to any one of Claims 1 and 2, with the separation layer (4) being made up of silicon nitride.
- 30 4. Intermediate substrate according to any one of Claims 1 to 3, with the absorption layer (3) being made up of a material selected from among β -SiC type polycrystalline silicon carbide, titanium nitride or zirconium.
5. Intermediate substrate according to any one of Claims 1 to 4, further comprising a monocrystalline semiconductive layer (14), preferably comprising silicon carbide (SiC)

or gallium nitride (GaN), with a first face of the monocrystalline semiconductive layer (14) being adjacent to the first semiconductive layer (2).

6. Intermediate substrate according to any one of Claims 1 to 5, with the first semiconductive layer (2) being made up of a wide-band semiconductor material, notably of a material selected from among silicon carbide, aluminium nitride and gallium nitride.
7. Intermediate substrate according to any one of Claims 1 to 6, wherein the support layer (7) is made up of a material selected from among silicon carbide and silicon nitride.
8. Intermediate substrate according to any one of Claims 1 to 7, with the thickness of the support layer (7) ranging between 100 and 200 nanometres.
9. Intermediate substrate according to any one of Claims 1 to 8, with the first (5) and/or the second (6) thermal barrier layer having thermal conductivity of less than 25 W/mK, the second thermal barrier layer (6) preferably being made up of titanium dioxide or silicon nitride.
10. Intermediate substrate according to any one of Claims 1 or 3 to 9, further comprising a monocrystalline semiconductive layer (14) disposed on a surface region of the first semiconductive layer, with the first semiconductive layer (2) being located between the first thermal barrier layer (5) and the monocrystalline semiconductive layer (14).
11. Method for manufacturing an intermediate semiconductor substrate (10), successively comprising the following steps of:
 - a. growing (101) a first electrically semiconductive layer (2) on a seed layer (1);
 - b. growing (102) a first thermal barrier layer (5) on the first semiconductive layer (2);
 - c. growing (103) a support (13) on the first thermal barrier layer (5) comprising an absorption layer (3) configured to absorb laser radiation in a determined wavelength range, with the temperature of the absorption layer (3) increasing during absorption, the support (13) further comprising a separation zone (8) adjacent to the absorption layer (3) and configured to thermally degrade under the effect of the increase in temperature of the absorption layer, so as to separate at least part of the support (13) from the rest of the intermediate substrate (10);

d. removing (104) the seed layer (1);

with the growing steps being obtained by gas phase deposition onto the previously formed layers.

12. Method for manufacturing an intermediate semiconductor substrate (10) according to Claim 11, with the growth (103) of the support (13) comprising successive steps of:

a. growing a separation assembly (12) made up of the absorption layer (3) and of a separation layer (4), with the growth of the separation assembly (12) comprising:

- growing (1031) the absorption layer (3);
- growing (1032) the separation layer (4), with the separation layer (4) comprising the separation zone (8), the separation zone (8) being adjacent to the absorption layer (3);

b. growing (1033) a second thermal barrier layer (6) on the separation assembly (12);

c. growing (1034) a support layer (7) on the second thermal barrier layer (6);

with the growing steps notably being obtained by gas phase deposition onto the previously formed layers.

13. Method for manufacturing an intermediate semiconductor substrate (10) according to Claim 11, with the growth (103) of the support (13) comprising successive steps of:

- a. growing (1031) the absorption layer (3) on the first thermal barrier layer (5);
- b. growing (1035) a support layer (7) on the absorption layer (3) also acting as a second thermal barrier;

with the separation zone (8) being included in the support layer (7);

with the growing steps notably being obtained by gas phase deposition onto the previously formed layers.

14. Method for manufacturing a substrate comprising a monocrystalline semiconductive layer on a polycrystalline semiconductor substrate, comprising the implementation of the method for manufacturing an intermediate semiconductor substrate (10) according to any one of Claims 11 to 13, with the first semiconductive layer (2) being polycrystalline, and further comprising successive steps of:

- a. forming (109) a weakened zone in a semiconductor donor substrate (9) by implanting species, so as to delimit a monocrystalline semiconductive layer (14) to be transferred;
 - b. bonding (110) the monocrystalline semiconductive layer (14) to be transferred onto a surface region of the first semiconductive layer (2);
 - c. detaching (111) the donor substrate (9) along the weakened zone in order to transfer the monocrystalline semiconductive layer (14) onto the first semiconductive layer (2).
15. Method for manufacturing an electronic component, comprising successive steps of:
- a. implementing the method for manufacturing a substrate according to Claim 14;
 - b. performing (112) front-end processes in the monocrystalline semiconductive layer (14) in order to form said electronic component.
16. Method for manufacturing an electronic component according to Claim 15, comprising, after completing said front-end processes, a step (113) of applying laser radiation to the intermediate substrate (10) in the determined wavelength range, so as to thermally degrade the separation zone (8) and to separate at least part of the support (13) from the rest of the intermediate substrate (10).
17. Method for manufacturing an electronic component according to Claim 16, comprising, after applying the laser radiation, a step (114) of removing residual layers (15) located on a face of the first semiconductive layer (2) opposite the monocrystalline semiconductive layer (14), with the residual layers (15) originating from the step (113) of applying the laser radiation.