use of intense lasers, with wavelengths which have energies exceeding the bandgap of the wide-bandgap semiconductors being used.

Based on the described problems, embodiments~~it is the object~~ of the present invention seek to provide high-quality epitaxial layers for optoelectronics, which avoid the disadvantages of the methods known in the prior art.

According to an embodiment~~The object~~ of the invention ~~is achieved by~~, there is provided a method for producing a semiconductor structure, comprising the provision of a 3C-SiC semiconductor layer structure containing a monocrystalline 3C-SiC layer, generated by implantation of carbon in silicon, on a first silicon substrate and application of an epitaxial layer of a nitride compound semiconductor, suitable for the generation of optoelectronic components, onto the 3C-SiC semiconductor layer structure, characterized in that the epitaxial layer of a nitride compound semiconductor is transferred onto a second substrate by bonding the nitride layer onto the surface of the second substrate and mechanically or chemically removing the layers of the 3C-SiC semiconductor layer structure which contain silicon and SiC, the second substrate being a metal alloy with a high reflectivity of greater than or equal to 80% or a substantially transparent substrate.

According to an aspect of the invention, there is provided a method for producing a semiconductor structure, comprising: a) providing a 3C-SiC semiconductor layer structure containing an exposed, monocrystalline 3C-SiC layer generated by implantation of carbon in silicon on a silicon substrate, b) applying an epitaxial layer of a gallium nitride compound semiconductor suitable for the generation of optoelectronic components onto the 3C-SiC semiconductor layer structure, c) depositing an electrically conductive reflective metal film directly onto the gallium nitride compound semiconductor epitaxial layer to form a metal reflective film coated gallium nitride layer, d) removing the silicon substrate and 3C-SiC layer; and e)

bonding the surface of the gallium nitride layer which formerly was in contact with the 3C-SiC layer onto a second substrate comprising a metal or metal alloy with a reflectivity greater than 80%, or onto a transparent or partially transparent substrate.

The Inventors have discovered that the silicon or the poly-SiC substrate also have detrimental properties in the case of SiC structures epitaxially grown for example with GaN, since even in this case with a light-emitting diode (LED) produced in the GaN layer, a part of the emitted radiation is absorbed by the substrate and the efficiency is therefore reduced.

Among the various available methods for generating silicon carbide layers, ion beam synthesis is used since the epitaxial layers generated on 3C-SiC have particularly good properties and the production is comparatively favorable. For instance,

Patent Claims

1. A method for producing a semiconductor structure, comprising the provision of a 3C-SiC semiconductor layer structure containing a monocrystalline 3C-SiC layer, generated by implantation of carbon in silicon, on a first silicon substrate and application of an epitaxial layer of a nitride compound semiconductor, suitable for the generation of optoelectronic components, onto the 3C-SiC semiconductor layer structure, characterized in that the epitaxial layer of a nitride compound semiconductor is transferred onto a second substrate by bonding the nitride layer onto the surface of the second substrate and mechanically or chemically removing the layers of the 3C-SiC semiconductor layer structure which contain silicon and SiC, the second substrate being a metal alloy with a high reflectivity of greater than or equal to 80% or a substantially transparent substrate.

2. The method as claimed in claim 1, characterized in that the silicon substrate is a wafer of float zone-grown silicon material.

3. The method as claimed in claim 1, characterized in that the silicon substrate is a wafer of Czochralski-grown silicon material.

4. The method as claimed in one of claims 1 to 3, characterized in that the 3C-SiC semiconductor layer is generated by heat treatment of the silicon substrate after implantation of carbon ions to a particular depth in it, so that a buried monocrystalline layer of 3C-SiC is formed at a particular depth in the silicon wafer, subsequent removal of the layers lying above the buried 3C-SiC layer until the 3C-SiC layer is exposed, and subsequent

chemical-mechanical polishing of the exposed surface of the monocrystalline 3C-SiC layer.

5. The method as claimed in claim 4, characterized in that the exposed 3C-SiC layer is smoothed to a surface roughness of 0.05-0.5 nm RMS by the polishing.

6. The method as claimed in one of claims 1 to 5, characterized in that the nitride compound semiconductor deposited on the 3C-SiC layer is selected from a group consisting of aluminum nitride, gallium nitride, indium nitride, gallium-aluminum nitride and gallium-indium nitride.

7. The method as claimed in one of claims 1 to 6, characterized in that the second substrate consists of a metal or a metal alloy.

8. The method as claimed in claim 7, characterized in that the second substrate consists of a copper alloy.

9. The method as claimed in one of claims 1 to 6, characterized in that the second substrate is a glass substrate.

10. The method as claimed in one of claims 1 to 9, characterized in that a carrier wafer or a film is adhesively bonded onto the epitaxial layer of the 3C-SiC layer structure before removal of the layers of the epitaxial 3C-SiC layer structure which contain silicon and silicon carbide, the material used for the fastening being one which can readily be dissolved after bonding of the epitaxial layer onto the second substrate in order to remove the carrier wafer or the film from the epitaxial layer.

11. The method as claimed in claim 10, characterized in that the removal of the silicon and layers containing silicon carbide of the 3C-SiC layer structure is carried out by mechanical processes such as grinding, lapping or polishing or by wet and dry chemical etching processes or by a combination of mechanical and chemical removal.

Patent Claims

1. A method for producing a semiconductor structure, comprising:

a) providing a 3C—SiC semiconductor layer structure containing an exposed, monocrystalline 3C—SiC layer generated by implantation of carbon in silicon on a silicon substrate,

b) applying an epitaxial layer of a gallium nitride compound semiconductor suitable for the generation of optoelectronic components onto the 3C—SiC semiconductor layer structure,

c) depositing an electrically conductive reflective metal film directly onto the gallium nitride compound semiconductor epitaxial layer to form a metal reflective film coated gallium nitride layer,

d) removing the silicon substrate and 3C—SiC layer; and

e) bonding the surface of the gallium nitride layer which formerly was in contact with the 3C—SiC layer onto a second substrate comprising a metal or metal alloy with a reflectivity greater than 80%, or onto a transparent or partially transparent substrate.

2. The method of claim 1, further comprising adhesively bonding the reflective metal film coated gallium nitride layer to a carrier prior to removing the silicon substrate and 3C—SiC layer.

3. The method of claim 2, wherein the carrier comprises a carrier wafer or carrier film.

4. The method of claim 2, wherein the step of adhesively bonding employs an adhesive composition comprising a wax or a solvent-soluble resin.

5. The method of claim 2, further comprising removing the adhesively bonded carrier wafer after step e).

6. The method of claim 1, wherein the 3C—SiC semiconductor layer is generated by heat treatment of the silicon substrate after implantation of carbon ions to a depth in the silicon substrate, so that a buried monocrystalline layer of 3C—SiC is formed at a depth in the silicon wafer, subsequently removing the layers lying above the buried 3C—SiC layer until the 3C—SiC layer is exposed, and subsequently chemical-mechanical polishing the exposed surface of the monocrystalline 3C—SiC layer.

7. The method of claim 6, wherein the exposed 3C—SiC layer is smoothed to a surface roughness of 0.05-0.5 nm RMS by the polishing.

8. The method of claim 1, wherein the second substrate consists of a metal or a metal alloy.

9. The method of claim 8, wherein the second substrate consists of a copper alloy.

10. The method of claim 1, wherein the second substrate is a glass substrate.

11. The method of claim 1, wherein the removal of the silicon and layers containing silicon carbide of the 3C—SiC layer structure is carried out by grinding, lapping, or polishing, by wet or dry chemical etching processes, or by a combination of mechanical and chemical removal.

12. The method of claim 1, wherein the silicon substrate is a wafer of float zone-grown silicon material.

13. The method of claim 1, wherein the silicon substrate is a wafer of Czochralski-grown silicon material.

14. The method of claim 1, wherein the second substrate is transparent or partially transparent, with a transmission coefficient greater than 50%.

15. The method of claim 1, wherein prior to adhesively bonding, the electrically conductive metal reflective layer is coated with a carbon layer film.