

WHAT IS CLAIMED IS:

- 1 1. A method of forming a p-type gallium nitride layer, the method
2 comprising:
3 providing a substrate structure including a gallium nitride layer;
4 sputtering a dopant source including magnesium onto the gallium nitride layer;
5 depositing a capping structure over the dopant source;
6 annealing the substrate structure to diffuse magnesium into the gallium nitride
7 layer;
8 removing the capping structure and the dopant source; and
9 activating the diffused magnesium to form the p-type gallium nitride layer.
- 1 2. The method of claim 1 wherein the dopant source comprises a layer of
2 magnesium fluoride having a thickness ranging from 20 nm to 50 nm.
- 1 3. The method of claim 1 wherein the dopant source comprises a layer of
2 an aluminum nitride magnesium composite material having a thickness ranging from 5 nm to
3 50 nm.
- 1 4. The method of claim 1 wherein the substrate structure comprises:
2 a polycrystalline ceramic core;
3 a barrier layer encapsulating the polycrystalline ceramic core;
4 a bonding layer coupled to the barrier layer; and
5 a substantially single crystalline layer coupled to the bonding layer.
- 1 5. A method of forming a doped gallium nitride layer, the method
2 comprising:
3 providing a substrate structure including a gallium nitride layer;
4 forming a dopant source layer over the gallium nitride layer;
5 depositing a capping structure over the dopant source layer;
6 annealing the substrate structure to diffuse dopants into the gallium nitride
7 layer;
8 removing the capping structure and the dopant source layer; and
9 activating the diffused dopants.

- 1 6. The method of claim 5 wherein forming the dopant source layer
2 comprises sputtering the dopant source layer over the gallium nitride layer.
- 1 7. The method of claim 5 further comprising, prior to forming the dopant
2 source layer, performing a surface preparation process.
- 1 8. The method of claim 7 wherein the surface preparation process
2 comprises an organic clean process.
- 3 9. The method of claim 7 wherein the surface preparation process
4 comprises a metallic clean process.
- 5 10. The method of claim 7 wherein the surface preparation process
6 comprises an oxide removal process.
- 7 11. The method of claim 7 wherein the surface preparation process
8 comprises an organic clean process, a metallic clean process, and an oxide removal process.
- 1 12. The method of claim 5 wherein the gallium nitride layer is undoped.
- 1 13. The method of claim 5 wherein the dopant source layer comprises
2 magnesium having a thickness ranging from 5 nm to 20 nm and the gallium nitride layer
3 comprises a p-type gallium nitride layer.
- 1 14. The method of claim 5 wherein the dopant source layer comprises
2 magnesium fluoride having a thickness ranging from 20 nm to 50 nm.
- 1 15. The method of claim 5 wherein the dopant source layer comprises an
2 aluminum nitride magnesium composite material having a thickness ranging from 5 nm to 50
3 nm.
- 1 16. The method of claim 15 wherein a magnesium concentration in the
2 aluminum nitride magnesium composite material ranges from $1 \times 10^{19} \text{ cm}^{-3}$ to 10%.
- 1 17. The method of claim 5 wherein annealing the substrate structure is
2 performed at a temperature ranging from about 1000 °C to about 1400 °C.
- 1 18. The method of claim 5 wherein the substrate structure comprises:

2 a polycrystalline ceramic core;
3 a barrier layer encapsulating the polycrystalline ceramic core;
4 a bonding layer coupled to the barrier layer; and
5 a substantially single crystalline layer coupled to the bonding layer.

1 19. The method of claim 5 wherein the capping structure is operable to
2 anneal magnesium implant damage in the substrate structure.

1 20. The method of claim 5 further comprising, prior to forming the dopant
2 source layer, forming a mask on the gallium nitride layer, wherein the mask exposes one or
3 more portions of a top surface of the gallium nitride layer.

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