vapor phase epitaxy GaN substrates, J. Vac. Sci. Technol. B., 23, 1190 (2005)), however, it is expected that higher levels of beryllium doping impurities will eventually cause a deterioration of the GaN crystal quality.

SUMMARY OF THE INVENTION

In accordance with the present disclosure, a High Electron Mobility Transistor structure is provided, comprising: a substrate; a GaN buffer layer disposed on the substrate; a doped GaN layer disposed on, and in direct contact with, the GaN buffer layer, the doped GaN layer being doped with more than one different dopants, where one of the dopants is beryllium, and the beryllium doping is 5×10^{16} to 3×10^{19} atoms/cm^3; wherein one of the dopants is carbon, and the carbon doping is less than the beryllium doping but higher than 1×10^{16} atoms/cm^3; and wherein the doped GaN layer has a thickness between 10 and 300 nm; an unintentionally doped (UID) GaN channel layer on, and in direct contact with, the doped GaN layer, the UID GaN channel layer having a two-dimensional electron gas (2DEG) channel therein, wherein the UID GaN channel layer has a thickness of less than 200 nm.

In one embodiment; a barrier layer is disposed on, and in direct contact with, the UID GaN channel layer.

In one embodiment, a High Electron Mobility Transistor structure is provided comprising: a substrate; a high-resistivity GaN buffer layer disposed on the substrate; a doped GaN layer disposed on, and in direct contact with, the buffer layer, the doped GaN layer being doped with beryllium and carbon, wherein the beryllium doping is 5×10^{16} to 3×10^{19} atoms/cm^3, and wherein the carbon doping is less than the beryllium doping but higher than 1×10^{16} atoms/cm^3; and an unintentionally doped (UID) GaN channel layer disposed on, and in direct contact with, the doped GaN layer, the UID GaN channel layer having a two-dimensional electron gas (2DEG) channel therein, wherein the UID GaN channel layer has a thickness of less than 200 nm.

In one embodiment, the doped GaN layer has a thickness of 10-300 nm.

In one embodiment, the buffer layer has a resistivity of greater than 2.2×10^3 ohm*cm.

In molecular beam epitaxy (MBE) methods, while carbon is a highly-effective compensating dopant with a number of near-mid-gap states that can drastically reduce DC

WHAT IS CLAIMED IS:

1. A High Electron Mobility Transistor structure, comprising:

a substrate;

a GaN buffer layer disposed on the substrate;

a doped GaN layer disposed on, and in direct contact with, the GaN buffer layer, the doped GaN layer being doped with multiple different dopants where one of the dopants is beryllium, and the beryllium doping is 5×10^{16} to 3×10^{19} atoms/cm^3; wherein one of the dopants is carbon, and the carbon doping is less than the beryllium doping but higher than 1×10^{16} atoms/cm^3; and wherein the doped GaN layer has a thickness between 10 and 300 nm; and

an unintentionally doped (UID) GaN channel layer on, and in direct contact with, the doped GaN layer, the UID GaN channel layer having a two-dimensional electron gas (2DEG) channel therein, wherein the UID GaN channel layer has a thickness of less than 200 nm.

2. The structure recited in claim 1 including a barrier layer on, and in direct contact with, the UID GaN channel layer.

3. The structure recited in claim 1 including a nucleation layer disposed on the substrate.

4. A High Electron Mobility Transistor structure, comprising:

a substrate;

a GaN buffer layer disposed on the substrate;

a doped GaN layer disposed on, and in direct contact with, the buffer layer, the doped GaN layer being doped with beryllium and carbon, wherein the beryllium doping is 5×10^{16} to 3×10^{19} atoms/cm^3, and wherein the carbon doping is less than the beryllium doping but higher than 1×10^{16} atoms/cm^3; and

an unintentionally doped (UID) GaN channel layer on, and in direct contact with, the doped GaN layer, the UID GaN channel layer having a two-dimensional

electron gas (2DEG) channel therein, wherein the UID GaN channel layer has a thickness of less than 200 nm.

5. The structure recited in claim 4 wherein the doped GaN layer has a thickness of 10-300 nm.

6. The structure recited in claim 4 including a barrier layer on, and in direct contact with, the UID GaN channel layer.