However, due to the difference in growth rates for mesa areas and trench areas, the substrate surface cannot be fully coalesced, and accordingly has gaps formed between mesa areas. As the area ratio of edge-to-mesa plays a very important role in the effectiveness of LCG techniques, the mesa area cannot be very large. However, the area of a typical multi-finger power device for hundreds of watts output power can reach several mm^2 or more, dimensions too large for LCG. Thus, application of LCG growth methods to GaN power electronics is problematic due to the large dimensions.

[0007] Thus, what is needed is GaN HEMT structures and fabrication techniques which can overcome drawbacks of current GaN HEMT structures and fabrication techniques. Furthermore, other desirable features and characteristics will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background of the disclosure.

SUMMARY

[0008] According to the Detailed Description, a GaN high electron mobility transistor (HEMT) structure is provided. The GaN HEMT structure includes a substrate, an AlGaN/GaN heterostructure grown on the substrate, and a normally-off GaN device fabricated on the AlGaN/GaN heterostructure. The AlGaN/GaN heterostructure includes a GaN buffer layer and an AlGaN barrier layer.

[0009] Also, a native-off III-nitride lateral diode structure is provided. The lateral diode structure includes a substrate, an AlGaN/GaN heterostructure grown on the substrate, and a normally-off GaN device fabricated on the AlGaN/GaN heterostructure.

[0010] Further, an integrated chip-level power system is provided. The integrated chip-level power system includes a substrate, an AlGaN/GaN heterostructure layer

grown on the substrate and a plurality of GaN devices. The AlGaN/GaN heterostructure layer includes a GaN buffer layer and an AlGaN barrier layer and is formed into mesa areas and valley areas. Each of the plurality of GaN devices are fabricated on a separate one of the mesa areas.

[0011] In addition, a method is provided for fabrication of a GaN structure. The method includes providing a substrate, growing a AlGaN/GaN heterostructure having a GaN buffer layer and a AlGaN barrier layer on the substrate, and fabricating a normally-off GaN device on the AlGaN/GaN heterostructure

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views and which together with the detailed description below are incorporated in and form part of the specification, serve to illustrate various embodiments and to explain various principles and advantages in accordance with a present invention.

[0013] FIG. 1, comprising FIGs. 1A, 1B and 1C, illustrates conventional III-nitride high electron mobility transistor (HEMT) structures and their properties, wherein FIG. 1A is a graph of trade-off characteristics between specific on-resistance (R_{on}) and off-state breakdown voltage (BV) of Si, SiC and GaN devices; FIG. 1B is a schematic view of a conventional normally-on AlGaN/GaN HEMT in both an ON state and an OFF state; and FIG. 1C is a schematic device structure of a p-n super junction Si laterally diffused metal oxide semiconductor (LDMOS) device.

[0014] FIG. 2 illustrates a schematic of a structure of a normally-off GaN HEMT in accordance with a first embodiment.

However, due to the difference in growth rates for mesa areas and trench areas, the substrate surface cannot be fully coalesced, and accordingly has gaps formed between mesa areas. As the area ratio of edge-to-mesa plays a very important role in the effectiveness of LCG techniques, the mesa area cannot be very large. However, the area of a typical multi-finger power device for hundreds of watts output power can reach several mm^2 or more, dimensions too large for LCG. Thus, application of LCG growth methods to GaN power electronics is problematic due to the large dimensions.

[0007] Thus, what is needed is GaN HEMT structures and fabrication techniques which can overcome drawbacks of current GaN HEMT structures and fabrication techniques. Furthermore, other desirable features and characteristics will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background of the disclosure.

SUMMARY

[0008] According to the Detailed Description, a GaN high electron mobility transistor (HEMT) structure is provided. The GaN HEMT structure includes a substrate, an AlGaN/GaN heterostructure grown on the substrate, and a normally-off GaN device fabricated from the AlGaN/GaN heterostructure. The AlGaN/GaN heterostructure includes a GaN buffer layer and a AlGaN barrier layer. The normally-off GaN III-nitride device is a device selected from the group comprising a normally-off vertical GaN III-nitride HEMT device, a self-aligned source ohmic contact and drain field plate (SSDF) III-nitride HEMT device, a surface state energy level modulated (SSEM) III-nitride HEMT device, and a lateral negative charge assisted super junction (NSJ) III-nitride HEMT device.

[0009] Also, a native-off III-nitride lateral diode structure is provided. The native-off III-nitride lateral diode structure includes a substrate, a AlGaN/GaN heterostructure grown on the substrate, and a normally-off GaN III-nitride device fabricated from the AlGaN/GaN heterostructure. The AlGaN/GaN heterostructure includes a GaN buffer layer and a AlGaN barrier layer and the normally-off GaN III-nitride device includes a surface passivation layer.

[0010] Further, an integrated chip-level power system is provided. The integrated chip-level power system includes a substrate, a AlGaN/GaN heterostructure layer

grown on the substrate, and a plurality of normally-off GaN III-nitride devices. The AlGaN/GaN heterostructure layer includes a GaN buffer layer and a AlGaN barrier layer and is formed into mesa areas and valley areas, each of the plurality of normally-off GaN III-nitride devices fabricated from a separate one of the mesa areas.

[0011] In addition, a method is provided for fabrication of a GaN structure. The method includes providing a substrate, growing a AlGaN/GaN heterostructure on the substrate, the AlGaN/GaN heterostructure comprising a GaN buffer layer and a AlGaN barrier layer; and fabricating a GaN device from the AlGaN/GaN heterostructure. The GaN device is selected from the group comprising a normally-off vertical GaN III-nitride HEMT device, a self-aligned source ohmic contact and drain field plate (SSDF) III-nitride HEMT device, a surface state energy level modulated (SSEM) III-nitride HEMT device, and a lateral negative charge assisted super junction (NSJ) III-nitride HEMT device.

[0011a] Further, a method for fabrication of a GaN III-nitride structure is provided. The method includes providing a substrate, growing a AlGaN/GaN heterostructure on the substrate, the AlGaN/GaN heterostructure comprising a GaN buffer layer and a AlGaN barrier layer, and fabricating a native-off III-nitride lateral diode structure from the AlGaN/GaN heterostructure. The native-off III-nitride lateral diode structure comprising a cathode ohmic contact.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views and which together with the detailed description below are incorporated in and form part of the

specification, serve to illustrate various embodiments and to explain various principles and advantages in accordance with a present invention.

[0013] FIG. 1, comprising FIGs. 1A, 1B and 1C, illustrates conventional III-nitride high electron mobility transistor (HEMT) structures and their properties, wherein FIG. 1A is a graph of trade-off characteristics between specific on-resistance (R_{on}) and off-state breakdown voltage (BV) of Si, SiC and GaN devices; FIG. 1B is a schematic view of a conventional normally-on AlGaN/GaN HEMT in both an ON state and an OFF state; and FIG. 1C is a schematic device structure of a p-n super junction Si laterally diffused metal oxide semiconductor (LDMOS) device.

[0014] FIG. 2 illustrates a schematic of a structure of a normally-off GaN HEMT in accordance with a first embodiment.