1300 V low on-resistance GaN HEMTs on Si

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Current GaN power devices are mostly rated at 650 volts and have been widely used in consumer products. However, the demands from photovoltaic and electric vehicle applications have prompted the pursuit of 1200 V devices, which enable low current topologies. Although higher off-state breakdown voltage can be achieved by increasing the spacing between the gate and drain electrodes, the substrate leakage current, determined by the vertical layer structure, must also be kept low under high-voltage operation. This work aims to design a buffer layer structure, concerning its thickness, strain balance, carbon doping level, and superlattice structure for this purpose.

The GaN HEMT structures were grown on 150 mm low-resistivity silicon substrates using metal-organic chemical vapor deposition. A total of four types of 6.5 μm-thick buffer layers were prepared in this study through a combination of carbon-doped GaN with different doping levels and superlattice structures of different pairs. An AlN insertion layer was also used to increase the thickness of the GaN layer to sustain a higher voltage and provide a better strain balance to avoid film cracks. As a result, GaN HEMTs (LGS= 3 μm, LG= 3 μm, LGD= 15 μm, WG= 100 μm) with a breakdown voltage over 1300 V at Id= 1μA/mm (1600 V at Id= 1 mA/mm) and a specific on-resistance of 8.5 ohm-mm (2.0 mohm-cm2) were realized.