Design and Fabrication of Gallium Oxide Junction Barrier Schottky Diode with High Bias Reliability

A junction barrier Schottky (JBS) diode is a class of vertical power diode that combines the low turn-on loss and fast switching of a Schottky barrier diode (SBD) with the improved blocking capabilities of a PN diode (PND). The lack of p-type doping in gallium oxide (Ga_2O_3) necessitates the heterogeneous integration of a p-type semiconductor such as nickel oxide (NiO) into pre-etched regions of Ga_2O_3. Plasma etching Ga_2O_3 damages the material and negatively impacts device performance.

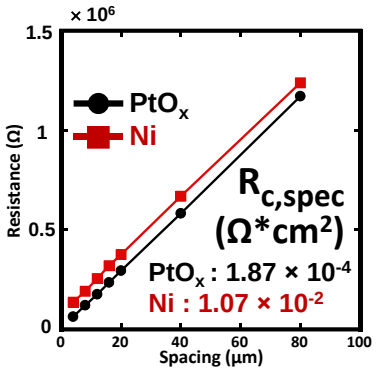

Fig.1. NiO LTLM data showing resistance as a function of contact spacing

In this work, JBS diodes were fabricated utilizing a Ga-flux, plasma-free etching in place of the high power BCl_3 RIE plasma. A bi-layer NiO edge termination structure was deposited using reactive sputtering in order to mitigate electric field crowding near the anode. Simulations using Silvaco TCAD were performed to show a reduction in the peak electric field underneath the anode when comparing the JBS and SBD diodes. Sputtered platinum oxide (PtO_x) contacts were deposited in order to increase the barrier height and reduce leakage current. PtO_x was also demonstrated to be a viable Ohmic contact to NiO in place of the tradition Ni metal (Fig. 1). Comparison of a PtO_x and Ni JBS diode show the increased turn-on voltage expected with the higher barrier height PtO_x while also resulting in lower differential specific on-resistance and increased current density. This signifies an improved Ohmic contact to NiO. Lastly, high voltage reliability testing was performed on the PtO_x JBS and SBDs in an attempt to quantify the Ga_2O_3 NiO heterojunction formed to the Ga flux etched regions. Devices were stressed up to 800 V for a cumulative stress time of 2000 s (Fig. 2). During the reliability testing, the devices were periodically turned on and the forward I-V characteristics were analyzed. As the Schottky regime of the JBS diode was turned on, no turn-on degradation or variation was observed. This signifies that no side-wall trapping was present between the Ga_2O_3 NiO heterojunction, a result of the plasma free Ga flux etching.

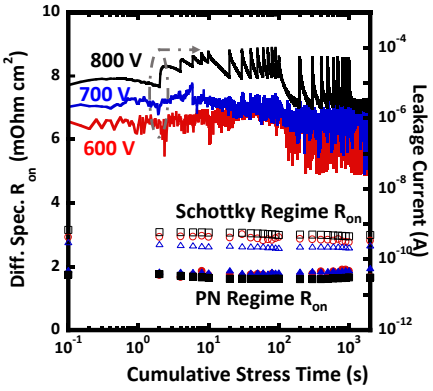

Fig. 2. Differential specific on-resistance and leakage current as a function of voltage and stress time measured at 600, 700, and 800 V

We demonstrate a kilovolt class Ga_2O_3 NiO JBS diode utilizing Ga flux etching and PtO_x anode. A reliability evaluation by means of a high voltage stress testing approach is demonstrated for a Ga_2O_3 device for the first time.