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Characterization of Etched and Grown GaN-GaN Schottky Diodes

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GaN-based devices are of much current interest for high-power electronics due to their superior physical and electrical properties, which include high electric breakdown field, high operation temperature, large band gap, and high electron velocity. GaN devices grown on GaN substrates have greatly reduced dislocation density ($<10^6$ cm^{-2}) compared to heteroepitaxial GaN (10^8-10^{10} cm^{-2}), which should assist in improving device performance for high-power applications as well as providing increased energy conversion efficiency [1]. The commercialization of GaN-based devices is also possible due to the wide availability of freestanding GaN substrates grown by hydride vapor phase epitaxy. In this study, GaN-on-GaN Schottky diodes have been examined for the presence of dislocations as well as any damage caused in *p*-GaN layers grown after chemical etching. Samples were grown homo-epitaxially on 2-inch *c*-plane *n*+ GaN substrates using metal-organic chemical vapor deposition [2]. Nine microns of unintentionally doped (UID) GaN was then grown on the GaN substrates for all samples. A reference sample labeled as NE was then grown with an additional 25nm UID GaN layer, whereas samples labeled E25 and E58 were etched using low-power inductively-coupled plasma (ICP) followed by growth of UID GaN with thicknesses of 25nm and 58nm, respectively. 500-nm of Mg-doped *p*-GaN was then deposited on all three samples. The doping concentrations in the *p*-GaN layers were 7 E+19 cm^{-3} of Mg, the UID GaN had 1.0E16 cm^{-3} of Si and *n*-GaN had 1.0E18 cm^{-3} of Si, as measured by secondary ion mass spectroscopy (SIMS). Samples suitable for transmission electron microscopy (TEM) were prepared using an FEI NOVA 200 dual-beam system, initially thinned at 30 keV and then finally at 5 keV. A Philips-FEI CM-200 microscope operated at 200 keV was mostly used for imaging.

Figures 1(a), 1(b) and 1(c) show schematics of the device structures for the Samples NE, E25 and N58, respectively, where the wavy lines signify that surface etching was carried out before initiation of the *p*-GaN growth. Figure 2(a) is a cross-sectional TEM image of Sample NE, which shows no visible sign of the presence of defects or precipitates. Figure 2(b) is a TEM image of Sample N25, and the presence of small precipitates in the *p*-GaN layer can be observed. Figure 2(c) is a TEM image of Sample N58. Precipitates are visible in the *p*-GaN material and the interface between *p*-GaN and UID layer is clearly visible. Figure 2(d) shows a higher-resolution image of the interface region. In the two etched samples, i.e. E25 and E58, no obvious etch damage is observed. Further investigations into the presence and nature of the precipitates in the *p*-GaN layers are ongoing [3].

References:

[1] K. Fujito et al., J. Cryst. Growth. **311** (2009), p. 3011-3014.
[2] Y. Zhang, A. Dadgar, T. Palacios, J. Phys. D. Appl. Phys. **51** (2018), p. 27.
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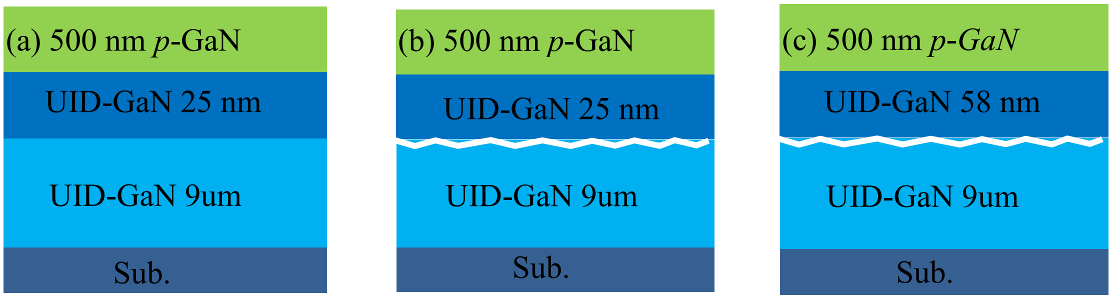

Figure 1. Schematics showing differences in nominal device structure: (a) NE; (b) E25; and (c) E58.

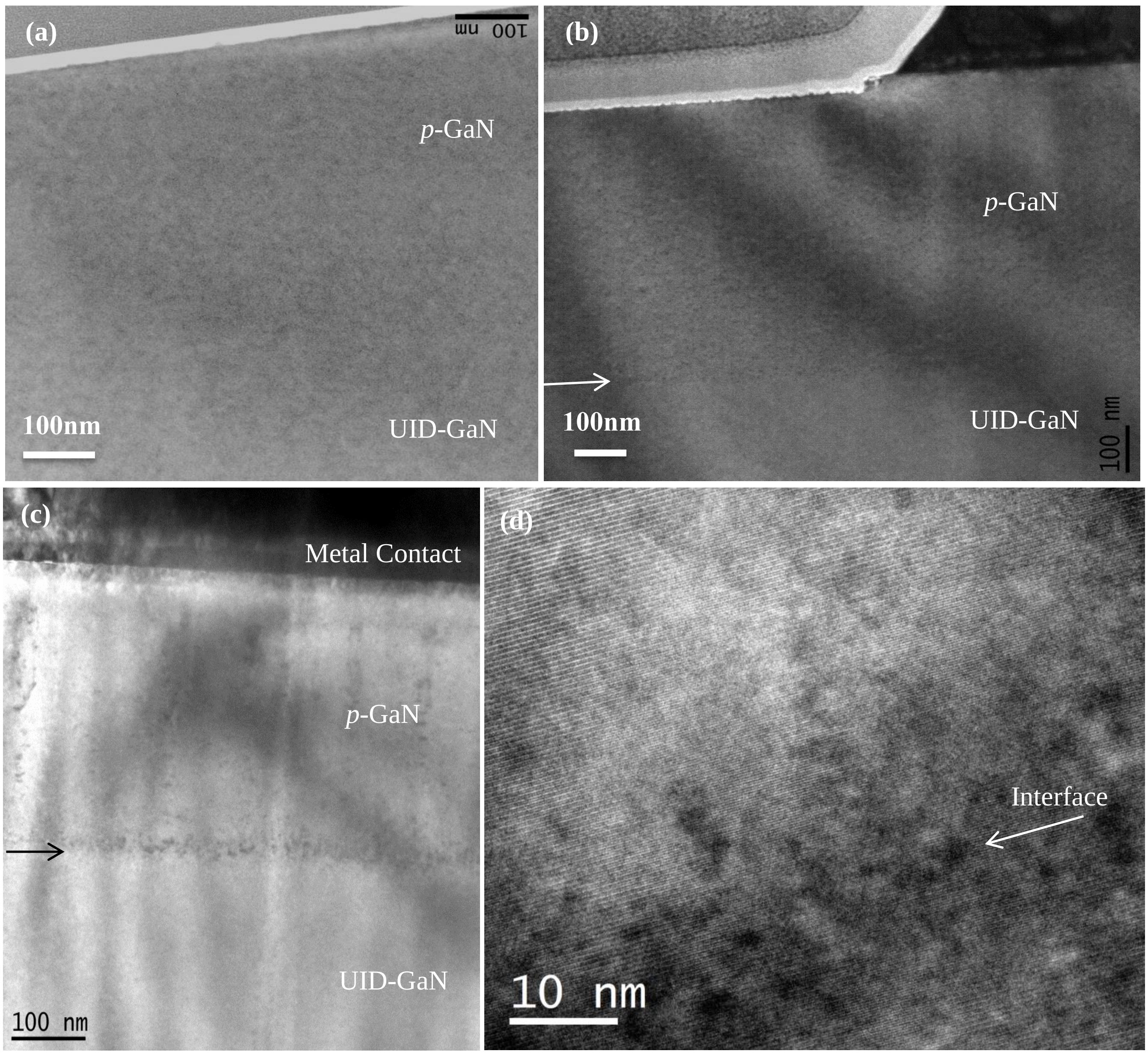

Figure 2. Cross-sectional TEM images of GaN-on-GaN Schottky diodes: (a) Sample NE showing no visible sign of GaN-GaN interface; (b) Sample E25 showing faint signs of small precipitates in *p*-GaN layer, (c) Sample E58 showing precipitates at GaN-GaN interface and also within the *p*-GaN layer, and (d) Higher magnification image showing interface region of Sample E58.

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