Effects of Polishing Damage on β-Ga_2O_3 Schottky Diodes Electrical Properties

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Beta gallium oxide (β-Ga_2O_3) is one of the most attractive ultra-wide bandgap semiconductors for power applications because of its outstanding intrinsic properties such as a high breakdown field of about 8 MV/cm and the commercially available large size substrates [1]. Nowadays, the achievement of electronic grade β-Ga_2O_3 substrates with low defects density is still a very important issue. β-Ga_2O_3 crystals are grown by various methods, including Floating zone (FZ) method that allow a better control of doping density and reduction defects density [1]. On the other hand, the implementation of β-Ga_2O_3 devices required a substrate polishing step that may induce surface and sub-surface defects as shown on Figure 1. Thus far, the effects of such substrate polishing damages on β-Ga_2O_3 devices have not been investigated yet.

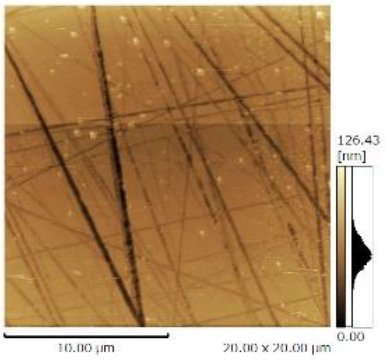

Fig. 1: AFM image of CMP surface damage on FZ β-Ga_2O_3 substrate

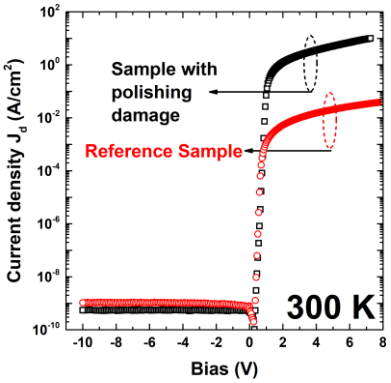

Fig. 2: Current-voltage characteristics of Schottky diodes fabricated on surface damage FZ β-Ga_2O_3 substrate and reference substrate

In this work, the effect of chemical-mechanical polishing (CMP) damage on vertical β-Ga_2O_3 Schottky diodes electrical properties are discussed. Basic Schottky diodes have been fabricated on FZ β-Ga_2O_3 substrates. The detailed growth process of FZ β-Ga_2O_3 substrates are reported in Ref. [1]. The substrates growth was followed by a CMP polishing that induced surface damage as shown on Figure 1. Titanium/gold (Ti/Au) metallic stack was deposited on substrates backside by electron-beam evaporation and annealed at 450 °C (20 min) to form ohmic contacts. Different Schottky metals, Aluminium (Al), Platinum (Pt), and Ruthenium (Ru) with Gold (Au) cap-layers were then deposited (on front side to achieve vertical Schottky diode). Figure 2 shows the typical current-voltage characteristics of Pt/Au Schottky contacts fabricated on damaged FZ β-Ga_2O_3 substrates. The fabricated Schottky diodes exhibited good rectification behaviours even at high temperature. A rectification ratio of about 9 order of magnitudes was measured from a bias ranging from –10 to 10 V. The typical Schottky barrier height and ideality factor are 1.22 eV and 1.3, respectively. It has been found that (Pt/Au) and (Ru/Au) contacts showed a Schottky behaviour whereas (Al/Au) contacts were ohmic. Moreover, basic Schottky diodes have been fabricated on a commercially available surface defects-free substrate [2] (reference sample) and compared to those fabricated on FZ β-Ga_2O_3 substrates (see Fig. 2). Very similar electrical properties were achieved for devices fabricated on both substrates. The transport mechanism, the device reproducibility, and the effects of Schottky metals on diodes electrical performance will be discussed.

[1] T. Ito *et al*, Jpn. J. Appl. Phys. 58, 110908 (2019),

[2] https://www.novelcrystal.co.jp/