Diamond P-type Lateral Schottky Barrier Diodes with High Breakdown Voltage (>4.6kV)

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1. Introduction

Diamond p-type lateral Schottky barrier diodes (SBDs) with a 2-µm-thick drift layer are fabricated with and without Al_2O_3 field plates. Their forward and reverse bias characteristics are studied in detail. Both SBDs, with and without Al_2O_3 field plates, exhibit rectifying ratios larger than 10^7 at room temperature, and a peak current density of 5.39 mA/mm under 40V forward bias at 200°C. The leakage current density at room temperature is stable at approximately 0.01 mA/mm for both diodes. The SBD without the Al_2O_3 field plate exhibited a breakdown voltage of ~1.2kV, while the SBD with the Al_2O_3 field plate is stable under a reverse voltage of ~4.6kV, which is one of the highest so far among p-type diamond Schottky diodes.

2. Methodology

Figure 1 shows the epitaxy (by microwave plasma enhanced chemical vapor deposition (MPCVD)) and cleanroom microfabrication process flow of diamond p-type lateral SBDs. The growth of the 2 µm p^- drift layer on a 3×3 mm^2 Type Ib (100) high pressure high temperature (HPHT) diamond substrate was followed by the selective growth of 200 nm p^+ diamond. Ohmic contacts, Al_2O_3 field plates, and Schottky contacts are deposited using e-beam evaporation and a standard lift-off process.

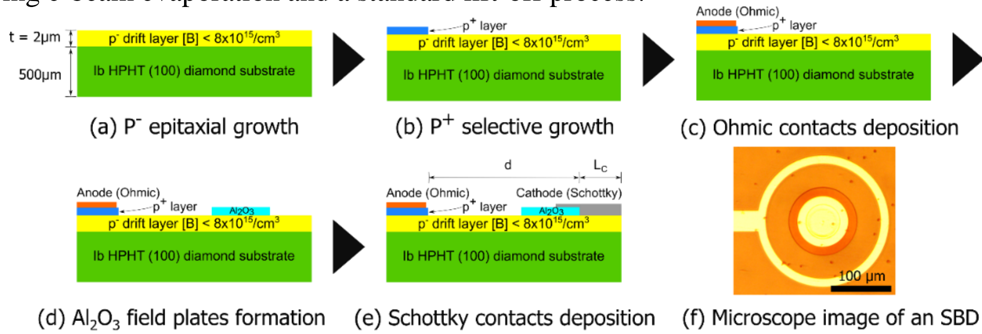

FIG. 1. Epitaxy and cleanroom microfabrication steps for diamond lateral SBDs.

3. Results

The forward characteristics of the fabricated SBDs with and without the Al_2O_3 field plate at room temperature and 200 °C are shown below in Figure 2 (a) and (b). The room temperature reverse characteristics is shown in Figure 2 (c). SBDs without the field plate has the same Schottky to ohmic distance d=80 µm, and the Schottky contact radius is the same as the inner radius of the Al_2O_3 field plate. Both diodes exhibit a rectifying ratio of 10^7. The lateral SBD without the field plate broke down at ~1.2kV, while the SBD with the field plate exhibited stable leakage current up to 4.6kV, which is the limit of the experimental setup.

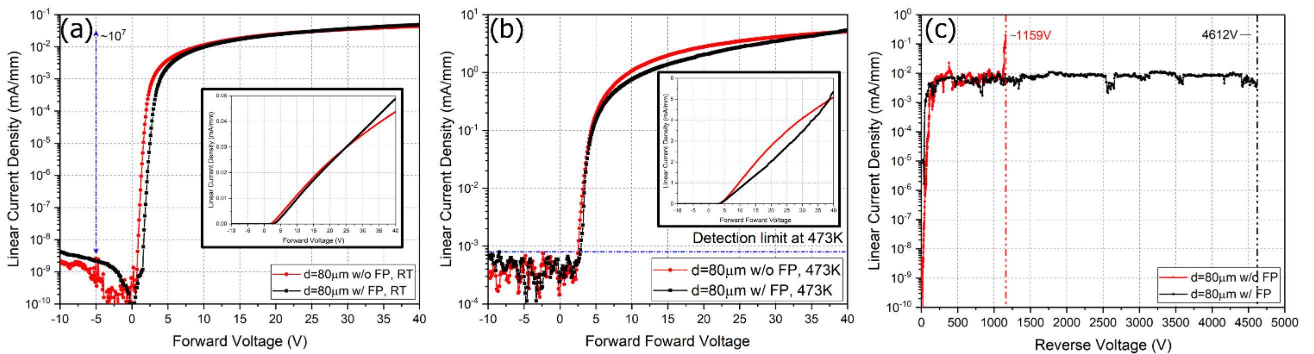

FIG. 2. (a) Forward *J-V* characteristics of diamond lateral SBDs with and without the field plate in semi-logarithmic and (inset) linear scales; (b) Forward *J-V* characteristics of diamond lateral SBDs with and without the FP in semi-logarithmic and (inset) linear scales at 200°C; (c) Reverse leakage *J-V* characteristics of diamond lateral SBDs with and without the field plate.