Effects of Sacrifice Oxidation on Characterization of Defects in High-Purity Semi-insulating 4H-SiC by Discharge Current Transient Spectroscopy

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Abstract. To determine the energy levels of intrinsic defects in high-purity semi-insulating 4H-SiC, we apply discharge current transient spectroscopy (DCTS) that is graphical peak analysis method based on the transient reverse current of a Schottky barrier diode, because transient capacitance methods such as deep level transient spectroscopy and isothermal capacitance transient spectroscopy are feasible only in low-resistivity semiconductors. The reverse current consists the reverse current through the balk and the surface leakage current of the diode. Therefore, it is elucidated that the sacrifice oxidation could dramatically reduce the surface currents of diodes in the case of high-purity semi-insulating 4H-SiC, suggesting that the densities and emission rates of traps in the bulk of SiC can be determined from the transient reverse current.

Discharge Current Transient Spectroscopy. The signal of DCTS is defined as

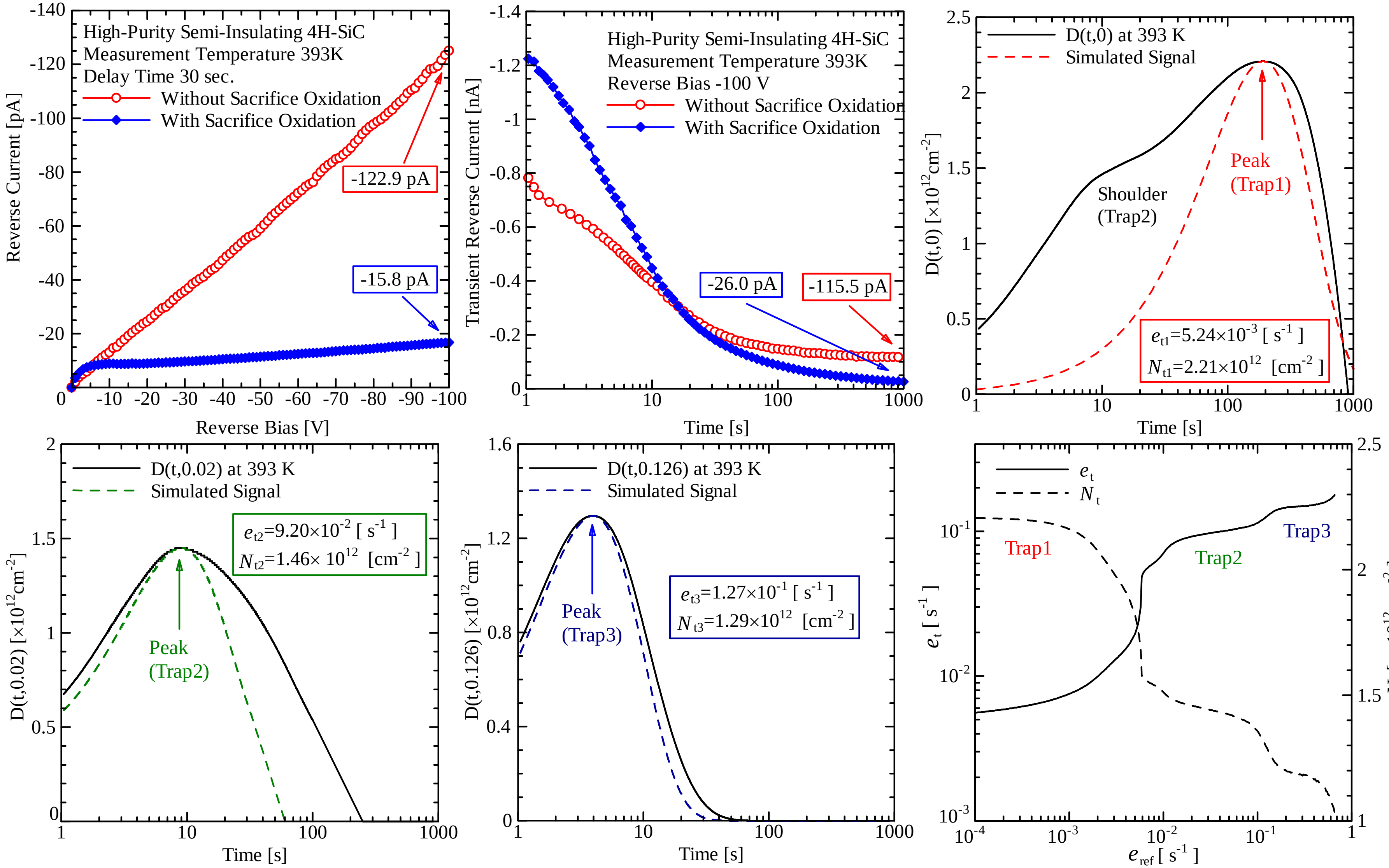
$$D(t, e_{\mathrm{ref}}) \equiv \frac{t}{qS}\left[I_{\mathrm{dis}}(t) - I_{\mathrm{S}}(V_{\mathrm{R}})\right]\exp(-e_{\mathrm{ref}}t + 1)$$

From the time and value of each peak, we can accurately determine the emission rate and sheet density of the corresponding defect as;

$$e_{\mathrm{t}i} = \frac{1}{t_{\mathrm{peak}i}} - e_{\mathrm{ref}} \qquad N_{\mathrm{t}i} = \frac{D(t_{\mathrm{peak}i}, e_{\mathrm{ref}})}{1 - e_{\mathrm{ref}}t_{\mathrm{peak}i}}$$

Experiment. A 0.374-mm-thick high-purity semi-insulating 4H-SiC wafer was purchased from Cree Inc., and was cut to a size of 5 mm×5 mm. Each side of the chip surface was oxidized in an O_2 atmosphere at 1273 K for 2 hours. After the sacrifice oxide layer on the chip was removed using HF, Ni electrodes with a radius of 1.25 mm were evaporated onto both sides of the chip. Since thermal treatment was not carried out, the diodes work as a back-to-back diode. The current-voltage () characteristics of the diodes were measured from 0 to -100 V by an increment of reverse bias using Keithley 236 source-measure unit (SMU236). We waited for 30 s, referred to as a delay time, to measure the reverse current at each bias after the bias was increased by -1 V [5]. After was measured at of -100 V at 373 K. The densities and emission rates of traps in semi-insulating 4H-SiC were determined by DCTS.

Results and Discussion



Summary. It is elucidated that the sacrifice oxidation could dramatically reduce the surface currents of diodes in the case of high-purity semi-insulating 4H-SiC, suggesting that the densities and emission rates of traps in the bulk of SiC can be determined from the transient reverse current. We applied DCTS to determine those of traps, and could characterize three types of traps with close emission rates.