Characteristics of Defects and Naoncrystallite Silicon
in Silicon Implanted Silicon Dioxide

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ABSTRACT

This thesis investigated the characteristics of defects and nanocrystallite silicon (nc-Si) in the silicon-ion-implanted dioxide (SiO_2:Si^+) and the semi-conducting properties of the SiO_2:Si^+ with 1 to 3-hrs furnace-annealing processes at 1100°C.

The pumping-intensity dependency of nc-Si related micro-photoluminescence (μ-PL) from the multi-recipe Si-implanted quartz is characterized. After annealing at 1100°C for three hours, the intensity of μ-PL at 724 nm contributed by nc-Si with a diameter of about 4 nm is the maximum. By increasing the pumping intensity from 10 kW/cm^2 to 300 kW/cm^2, the μ-PLs of 1-hr and 3-hr annealed Si-implanted quartz samples are red-shifted by <1.2 nm and 11 nm, respectively. The μ-PL of 3hr-annealed sample further red-shifts by 2.5 nm after pumping at 300 kW/cm^2 for one hour. Such a red-shift in PL is attributed to the anomalous quantum stark effect under strong illumination, which photo-ionizes the buried nc-Si and initiates an electric field beneath the surface of Si-implanted quartz. The measurement of accumulating charges and voltage drop during illumination primarily elucidate the correlation between red-shift in PL and the photo-ionized nc-Si induced surface electric-field. On the other hands, the Si-nanocrystal-enhanced photoconductivity of a metal-semiconductor-metal photodetector (MSM-PD) made on multi-recipe SiO_2:Si^+ substrate is reported. The result of the electrical characteristics show that the annealing-induced leakage current of the SiO_2:Si^+ material are strongly related to the nc-Si. The Al-SiO_2:Si^+ contact resistance, contact resistivity and the sheet resistance of SiO_2:Si^+ containing the nc-Si structure are determined as 9.1×10^8 Ω, 6.6×10^{10} Ω cm^2, and 3.4×10^{11} Ω/□, respectively. Different carrier transport models are employed to elucidate the nc-Si related current-voltage characteristics. The simulation reveals that the Schottky carrier transport predominated the carrier transport between metal–SiO_2:Si^+ interface. The reverse-saturation current (J_s) for the SiO_2:Si^+ based MSM-PD is 4.4 pA. The MSM-PD exhibits photocurrent gain of 3 and responsivity of 6.69 nA/W. Wavelength dependent photoconductivity is also observed a maximum photocurrent of 42.6 pA at wavelength of 745 nm.