Chapter 4

Summary

4.1 Summary

The pumping-intensity-dependent μ-PL from multi-recipe Si-implanted quartz with 0.8 % excess Si density has been characterized. After annealing for one hour, the weak oxygen-bond and E'_{δ} defects at 410 nm and 550 nm are eliminated, while the nc-Si with a diameter of 4 nm contributes to a strong μ-PL at central wavelength of 724 nm. The nc-Si-related μ-PL reaches a maximum after annealing at 1100^{o}C for three hours. As the pumping density is increased from 10 kW/cm^2 to 300 kW/cm^2, the μ-PL of the irradiative defects are associated with blue-shift phenomena governed by band-filling effect. In contrast, the μ-PL wavelength of Si-implanted quartz annealed for three hours is significantly red-shift from 724 nm to 735 nm. This phenomenon cannot be well explained by either the substrate heating or the quantum-well coupling reported previously. The dominant mechanism is the anomalous quantum Stark effect induced by the built-in electric field from the buried nc-Si to the surface of Si-implanted quartz under high-intensity or long-term optical pumping. Such a red-shift in μ-PL is strongly correlated with the positively charged nc-Si, which has been corroborated by the observations of gradually accumulated charges and enlarged electric field on the surface of Si-implanted quartz during high-power illumination.

On the other hand, the results of nc-Si enhanced photoconductive response of multi-recipe SiO_2:Si^+ are performed. For the electrical properties of SiO_2:Si^+, the gated current flow mechanisms and photoconductivity of an inter-digitized MSM-PD made on high-temperature annealed SiO_2:Si^+ substrate are reported. According to the TLM model, the resistance due to a single contact (R_c) is 9.1×10^8 Ω, the sheet resistance of the semiconductor material between the contacts (r_s) is 3.4×10^{11} Ω/□ and the specific contact resistivity (ρ_c) is 6.6×10^{10} Ω cm^2. However, the gated current flow mechanisms show that two main gated current flow mechanisms for the MOSOM are not satisfied with nc-Si structure but the simulation of the Schottky carrier transported model is proved that the nc-Si structure has the characteristic of semiconductor and the reverse-saturation current is 4.4 pA. The photoconductivity of MSM-PD shows that the gain of photocurrent is 3 and the responsivity is 6.69 nA/W for the nc-Si structure and by wavelength dependence the maximum value of photocurrent of the nc-Si MSM-PD is 42.6 pA at the wavelength of 745 nm. That explanation of the improved photocurrent response at nc-Si band gap is primarily attributed to larger absorption coefficient.