Room Temperature Photo- and Electroluminescence from Ion Implanted Silicon-Germanium

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In recent years, III-V quantum-size structures have become common for IR generation and detection, while Si structures with effects of size quantization are still subject of investigation. Ion beam implantation (IBI) followed by high temperature annealing is one of the promising methods for Silicon compatible nanostructure fabrication.

In this article, we are reporting the results of measuring the properties of Ge quantum-sized clusters made by ion beam implantation of Ge+ ions into the wafers of crystalline Si. Implantation doses varied from 10^{14} cm^{-2} to 10^{17} cm^{-2}, ion energies ranged from 50 keV to 150 keV, current density J being equal to 5 μA/cm^2. Thus, a single germanium 10 nm to 30 nm buried layer was implanted and Ge self-organized clusters were formed after 30-minute annealing at temperature of 950°C in argon environment. All samples were further examined with atomic force microscopy (AFM), X-ray fluorescence microscopy (XRF), Scanning electron microscopy (SEM) and then photo- and electro-excited in order to study composition, structure and optical properties of Ge implanted layer.

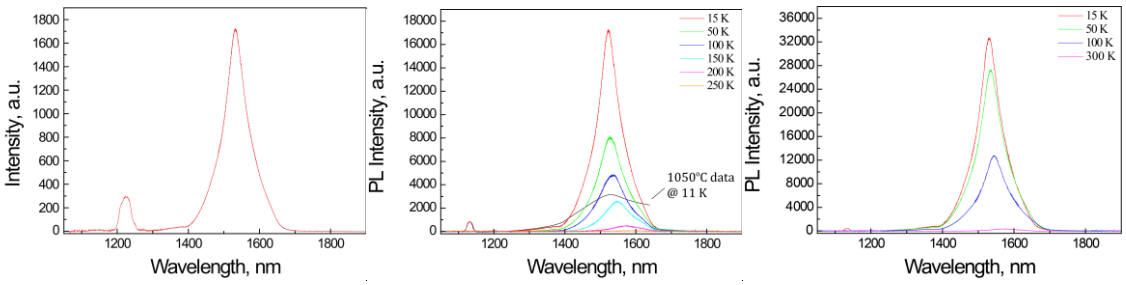

Fig.1 Measured electroluminescence at 300 K and two lasing emission spectrums respectively exited by He-Ne laser and by Ar laser.

To measure electroluminescence, we fabricated series of ring shaped p-i-n diodes in center doped by Ge ions. Electroluminescence was measured within temperature range of 225 to 303 K using Peltier element, photoluminescence was measured within temperature range of 15 to 300 K with a He–Ne laser (632.8 nm wavelength) and a Ar (488 nm) with up to 20 mW powers. Corresponding spectrums presented at Fig.1.

In conclusion, we have demonstrated room temperature photo- and electro- IR luminescence and low temperature CW lasing (in the range 1.2 to 1.6 μm) from ion implanted Ge QDs in Si and we have reported the role of implantation dose and annealing regime on Ge nanosized clusters formation.