Synthesizing Silicon Nanocrystals in Silicon Dioxide Matrix by Magnetron Sputtering Technique for Optical and Electrical Applications

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Charge storage and light emitting properties of Silicon (Si) nanocrystals embedded in silicon dioxide (SiO_2) matrix is of interest due to possible applications in nonvolatile memories and Si based optoelectronics. Floating nanocrystal based memory systems provide improved reliability with long retention time and higher density with low power consumption. It has been shown that Si nanocrystals can replace the classical floating gate electrode to improve Flash memory performance [1]. Photonic application of Si nanocrystals is based on the light emission generated by the Si nanocrystal as a result of the quantum size effect. This is expected to lead to the fabrication of Si based optoelectronic components such as Light Emitting Diodes (LED) [2].

Si nanocrystals can be synthesized by different techniques such as Ion Implantation [2], Chemical Vapor Deposition [3], Magnetron Sputtering [4], etc. Magnetron Sputtering is a superior in the synthesis of Si nanocrystals due to low process temperature, precise deposition control and good quality oxide production. Both floating Si nanocrystal non-volatile flash memory and Si nanocrystal based LED applications require good control over the material and device parameters such as the nanocrystal size uniformity, positioning nanocrystals in SiO_2 and the quality of SiO_2 matrix. With magnetron Sputtering technique, nanocrystal and matrix composition can easily be engineered, single and multilayer structures can be designed [5] and good quality thin SiO_2 layers can be achieved [6,7].

In this study, the effect of annealing temperature and time on the formation of Si nanocrystals in Si-rich SiO_2 layer prepared by Magnetron Sputtering have been studied systematically, shown in Fig. 1. The effect of post annealing under hydrogen and oxygen atmosphere are investigated with Photoluminescence Spectroscopy (PL), Fourier Transform Infrared Spectroscopy (FTIR), Capacitance-Voltage Characterization and Transmission Electron Microscopy (TEM). It is shown that the PL efficiency can be improved substantially with hydrogen annealing as a result of passivation of non-radiative transition centers. Post annealing under O_2 ambient has led to blue shift in the PL peak position, shown in Fig. 2, indicating size controlled light emission from Si nanocrystals.

References:

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Figures:

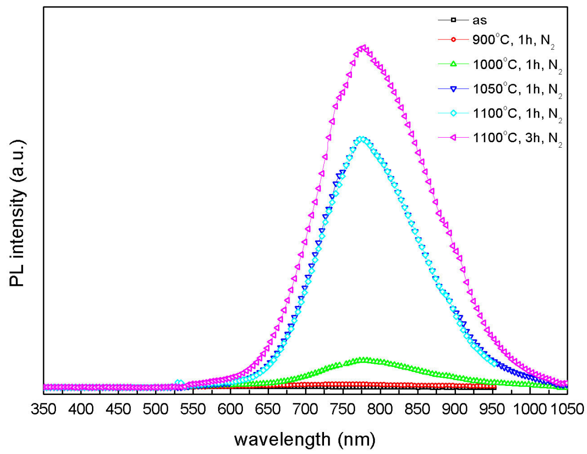

Fig.1. Photoluminescence spectra of Si reach SiO_2 layer for different annealing temperatures and annealing time

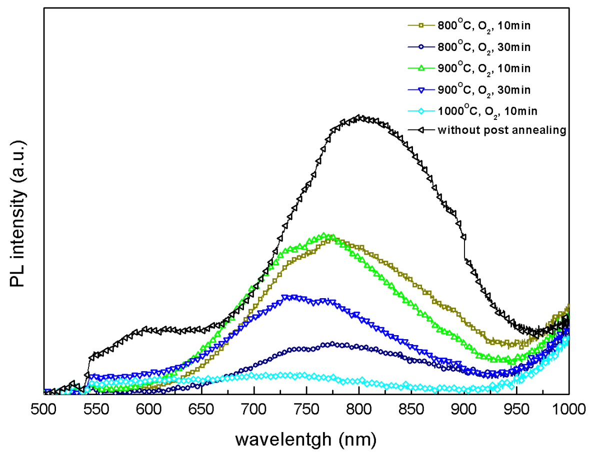

Fig. 2. Effect of post annealing under O_2 on Photoluminescence