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(G) (POS-66) SiGe quantum dots in SiO2 produced by co-ion implantation: optical and structural properties

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Despite its outstanding electronic properties, silicon has limited light emission capabilities due to its indirect bandgap. However, Si quantum structures (Si-QSs) exhibit light emission through quantum confinement. In this project, we investigate the co-implantation of silicon and germanium to create SiGe quantum dots (QDs). The relative concentration of Ge has a direct influence on the optical properties since the bandgap depends on it. Silicon ions at 40 keV were implanted into a 1 µm thermally grown SiO_2 film on a Si (001) substrate to achieve a peak concentration of 17.5 at. % in relation to the matrix. The chosen energy placed the implanted peak 50 nm below the surface. Samples were subsequently implanted with 55 keV Ge^+ with 0.5, 1.0, 2.0, 4.0, and 7.5 peak at. %, and thermally annealed to promote cluster growth and crystallization. The Ge implantation energy was calculated to put the Ge ion range at the same position as the Si ion range. For a second set of samples, Ge^+ implantation was done after $1100\,^{\circ}C$ annealing, necessary for Si QDs growth. Therefore, we also studied the influence of annealing order on the properties of the samples. Structural properties were studied with Raman spectroscopy, and we observed a Ge-Si peak at $405\,cm^{-1}$ indicating the formation of Si-Ge bonds only for the second set of samples with 7.5 peak Ge at. %. The optical properties of these SiGe QDs were studied with photoluminescence in the visible and near-infrared, with emissions around 800 nm and 1000 nm for both sets. It was observed that PL intensity decreased in both sets of samples with increasing Ge content, and the samples with no annealing between implants exhibited more intense PL. The PL peak at 1000 nm shifts to a lower wavelength with higher Ge at. %, which provides evidence of Ge incorporation in Si QDs in both sets of samples. Finally, the emission was investigated using time-resolved photoluminescence (TR-PL), and it showed that the lifetime time decreases as the Ge concentration increases for both sets of samples.

Keyword-1

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Keyword-2

Ion implantation

Keyword-3

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