Synthesis and characterisation of silicon nanoclusters in alumina

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Si has been shown to display unique electrical and optical properties when its size is reduced to the material's Bohr exciton radius. Si nanoclusters (Si-NCs) embedded in dielectric materials have been the subject of intense research due to their potential applications in optical and optoelectronic devices. However, there is an incomplete understanding of the processes responsible for the properties of Si-NCs, particularly the mechanism by which Si-NCs luminescence.[1-3] Gaining an understanding of these processes would aid in the development of a Si-based light source, which is key to the development of high efficiency optical and optoelectronic devices. In our study, we synthesized Si-NCs embedded in Al_2O_3 and analyzed their optical properties. Al_2O_3 is used as the host medium because it has a band gap energy that is adequate for charge carrier confinement, and a high dielectric constant which makes it a promising candidate for charge storage devices.[4] In addition, the transparency of Al_2O_3 makes it suitable for the fabrication of transparent devices.

In our study, Si-NCs were produced by ion implantation of Al_2O_3 with Si ions followed by an annealing process. The amorphous Al_2O_3 films used were synthesized by anodization of Al foils, and crystalline samples were purchased from MTI Corporation and Valley Design Corporation. An in-depth analysis of the structure, composition and optical properties of these Si-NC/Al_2O_3 structures was conducted using particle induced x-ray emission (PIXE), Rutherford backscattering spectroscopy (RBS), photoluminescence (PL) spectroscopy, time-resolved PL (TRPL), cathodoluminescence (CL) spectroscopy, scanning electron microscopy (SEM), powder x-ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR) and x-ray absorption near edge spectroscopy (XANES). From these analyses we conclude that the luminescence of Si-NC/Al_2O_3 is heavily impacted by the presence of defects sites within the matrix and Si diffusion within the matrix is negatively impacted by the crystallinity of the Al_2O_3 matrix.

References

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