Low-dimensional Germanium Structures for Electronic and Optoelectronic Devices

Abstract

The improved electronic and optical properties of group – IV semiconductor nanostructures make them attractive for numerous applications in devices and technology. In this dissertation, the growth and characterization of Ge nanocrystals embedded in different dielectric matrices, self-assembled Sn doped Ge quantum dots on Si substrates, and Ge/SiGe multiple quantum well structures grown on virtual substrates have been studied. The grown nanostructures have been explored for use in non-volatile floating gate memory, nanocrystal based photodetectors and light emitting devices. The study has demonstrated an enhanced memory window with superior retention characteristics, owing to the Coulomb blockade effect, due to the introduction of multi layer nanocrystals in the floating gate. The photoresponse of the fabricated metal-insulator-semiconductor photodetector is found to be broad and extended to the visible region with an external quantum efficiency of more than 100% under a proper biasing condition. No-phonon assisted transition in the optical communication wavelength range of 1.4-1.8 μm has been observed in $Ge_{1-x}Sn_x$ islands samples. Observed electroluminescence from the fabricated p-i-n structures on $Ge_{1-x}Sn_x$ sample above a threshold bias of 4V makes them attractive for the future Si based optical devices. Furthermore, the properties of Ge/SiGe multiple quantum well structures grown on virtual substrates have been studied to achieve the light emission near room temperature.

Keywords: Ge nanocrystals, floating gate memory, photodetectors, strained $Ge_{1-x}Sn_x$ islands, multiple quantum well, molecular beam epitaxy.