Abstract

The fabrication of SiGe based nanostructures using strained layer hetero-epitaxy are attractive because of higher carrier mobilities and the potential for the realization of quantum confined optoelectronic devices compatible with Si CMOS technology. For this purpose, the growth of strained epitaxial Ge layer on relaxed SiGe or the growth of Ge islands on Si using Stranski-Krastanov growth mechanism are of immense interests for different kind of optoelectronic devices in near future. Also the Ge nanostructures, either quantum dot or nanowire can be very effective as an efficient source in near infrared (NIR) optical communication wavelength of 1.54 μm upon doping the nanostructures with rare earth elements like erbium (Er). In addition to optical sources, SiGe nanostructures with heterojunction kind of structure can be very useful for UV-Vis-NIR photodetection too. In this dissertation, growth and optical properties of compressively strained epitaxial Ge films on relaxed $Si_{0.5}Ge_{0.5}$ substrates have been studied. Direct band gap optical transition with the signature of heavy hole and light hole splitting in photoluminescence as well as electroluminescence in compressively strained Ge film has been achieved. The growth of self-assembled pseudomorphic Ge islands on Si (001) substrates using molecular beam epitaxy has been investigated. Photoluminescence properties have been correlated with the size distribution for different growth parameters. Ge island based metal-insulator-semiconductor light emitting diode as well as photodetector structure, emitting or detecting light in the wavelength range of 1.53 to 1.67 μm has been demonstrated. Ge quantum dots synthesized within silica matrix has been shown to be efficient sensitizers to Er^{3+} ions for improving 1.54 μm luminescence with Dexter like distance dependent interaction. We have also studied the photo-physics of Ge nanowires with Er doping for 1.54 μm luminescence applications. It has been shown that the Ge related oxygen deficiency centers present mostly at the interface have an important role in transferring energy to Er^{3+} ions. Apart from the optical emitters, Si/CdS nanowire radial heterojunctions have been fabricated on metal assisted chemical etched Si nanowire templates followed by the pulsed laser deposition of CdS. Photoconduction gain of more than 200% has been achieved from those radial heterojunction nanowires, with peak responsivity crossing 1 A/W. The results from the present investigation indicate that strained Ge films and nanostructures could be extremely useful for Ge based CMOS compatible photonic devices in near future.

Keywords: molecular beam epitaxy, Ge quantum dot, Er doped Ge nanowire, radial heterojunction, photoluminescence, electroluminescence, photodetector.