Investigations On Some Photonic Devices Based On Group IV Semiconductor Materials

ABSTRACT

The high quality and advanced high-volume processing technology, high integration levels with nearly a billion transistor in a single chip and low cost have made silicon the sole material for electronics industry. To increase the speed and integration level, the length of the individual transistors is being downsized to nanometers. Extensive work is now being done to solve the related interconnection problem by incorporating Si based photonics. The indirect gap of Si, however, does not lead to any practical Si-based light-sources: either efficient light emitting diodes or a Si laser, and any electrically controlled modulator. In recent days, different approaches are made to make the material lasing by exploiting quantum confinement, alloying effects, or nano crystal formation. In the present thesis, the author has reported on some investigations of optoelectronic properties of Si and its alloys, both in bulk form and quantum wells, as well as on some studies of device applications using these materials. It is discussed that how the $\text{Ge}^{1-z}\text{C}_z/\text{Ge}^{1-x-y}\text{Si}_x\text{Sn}_y$, $\text{Ge}^{1-p}\text{Si}_p\text{C}_z/\text{Ge}^{1-x-y}\text{Si}_x\text{Sn}_y$ and $\text{Ge}^{1-p}\text{Sn}_p\text{C}_z/\text{Ge}^{1-x-y}\text{Si}_x\text{Sn}_y$ give rise to a direct band gap of around 0.8 eV and type I band alignment. The mid infrared SiGeSn based structures have been studied and the effective gains of those structures are then estimated. The performance of a front side illuminated Ge–GeSn–GeSn hetero phototransistor grown on a Si platform has been examined and predicted. The terminal currents are evaluated here by solving continuity equation in the base under optical generation. the performance of a N-SiGeSn/P-SiGeSn/N-SiGeSn HPT on a GeSn virtual substrate grown on Si is studied. There are ten GeSn/SiGeSn type I MQWs in which the GeSn wells show direct band gap nature. An empirical expression to reproduce the direct gap excitonic electroabsorption in Ge$_{0.992}$Sn$_{0.008}$ QW with Si$_{0.3}$Ge$_{0.61}$Sn$_{0.09}$ barrier has been used. GeSn/SiGeSn well-barrier-well heterostructure is studied under Franz-Keldysh effect.