Abstract

The realization of Silicon based photonic devices will enable much faster data transmission than is possible today using the current electronics based devices. Group IV alloys germanium tin (GeSn) and silicon germanium tin (SiGeSn) have the potential to form an direct bandgap material and thus, they are promising candidates to develop a Si compatible light source and advance the field of silicon photonics. However, the growth of the alloys is challenging as it requires low temperature growth and proper strain management in the films during growth to prevent tin segregation. In order to satisfy these criteria, various research groups have developed novel chemical vapor deposition (CVD) reactors to deposit the films. While these reactors have been highly successful in depositing high crystal quality high Sn concentration films, they are generally expensive set-ups which utilize several turbomolecular/cryogenic pumps and/or load-lock systems. An more economical process than the state-of-the-art to grow group IV materials will be highly valuable. Thus, the work presented in this dissertation was focused on deposition of group IV semiconductor thin films using simplified plasma enhanced CVD (PECVD) reactors.

Two different in-house assembled PECVD reactor systems, namely Reactor No. 1 and 2, were utilized to deposit Ge, GeSn and SiGeSn thin films. PECVD technique was used as plasma assistance allows for potentially depositing the films at growth temperatures lower than those of conventional CVD. Germane (GeH4) and Digermane (Ge2H6) were used as the Ge precursor while Disilane (Si2H6) and tin chloride (SnCl4) were used as the precursors for Si and Sn respectively. The growth conditions such as growth temperature, precursor flow rates, precursor partial pressures, and chamber pressure were varied in a wide range to optimize the growth conditions for the films. Polycrystalline Ge films and SiGeSn films with an Sn content upto 8% were deposited using Reactor No. 1 and 2. Development of epitaxial Ge buffers and GeSn films was accomplished using a modified Reactor No. 2 at temperatures <400oC without the aid of ultra-high vacuum conditions or a high temperature substrate pre-deposition bake thereby leading to a low economic and thermal budget for the deposition process.