Abstract

The study of group-IV semiconductor nanocrystals is an attractive field of research because of their potential applications in CMOS compatible novel electronic and optoelectronic devices. In the dissertation, a systematic study on the synthesis and characterization of self assembled Ge nanocrystals on Si and embedded in dielectric matrix were carried out for light emission and as floating gates in MOS based nonvolatile memory.

Ge nanocrystals were synthesized in high-k hafnium and aluminum oxide matrices. It was found that the post deposition annealing temperature mainly determine the size and density of the nanocrystals. Quantitative stress state of the nanocrystals was determined by evaluating the Raman peak shift of the embedded nanocrystals with respect to the peak position of freestanding ones. Compared with the conventional floating gate memories, the nanocrystal memory devices had low operating voltage, fast write-erase speeds and good retention. An improved charge injection and a superior data retention was achieved in Ge nanocrystal memory device by using higk-k dielectrics as tunneling and capping oxides, instead of SiO_2, due to lower leakage current and lower electron barrier height of high-k dielectrics. Size dependent room temperature as well as low temperature visible photoluminescence of Ge nanocrystals embedded in different dielectric matrix was carried out to understand the origin of visible luminescence from indirect band gap group-IV materials. Quantum confined size dependent visible electroluminescence from Ge nanocrystals had been studied.

The growth of self-assembled Ge islands of different shapes and sizes on Si(100) substrates using molecular beam epitaxy was studied. The growth temperature and ex-situ annealing condition played important roles in photoluminescence characteristics from Ge(Si) islands. Infrared electroluminescence from Ge nanoislands MOS light emitting diode was achieved. Preferential ordering of Ge islands growth on pit pattern Si(100) substrates were studied. Improved infrared photoluminescence from circularly ordered Ge nanoislands had been observed due to lateral coupling.

Keywords: Germanium nanocrystals, floating gate, self-assembly, molecular beam epitaxy, photoluminescence.