Selective growth of silicon–germanium nanocrystals on insulator via dewetting

Abstract:

In this work Silicon nanocrystals (Si NCs) and Silicon-Germanium nanocrystals (SiGe NCs) are selectively grown on insulator via solid state dewetting of silicon thin film on insulator. First we have studied the physical properties of pure Si nanocrystals (Si NCs) formed by conventional solid state dewetting of Si thin layer on SiO_2 (SOI) at high temperature in Ultra High Vacuum Molecular Beam Epitaxy (UHV-MBE) reactor. Second we have grown selectively Si and SiGe NCs on same substrate via solid state dewetting of SOI combined Ge deposition by MBE. In first step we perform a partial solid state dewetting of the SOI substrate to form the Si NCs. Second step and after the transformation a part of the Si thin film into Si NCs, we deposit 20 monolayers of germanium on the SOI substrate during the dewetting process to change the composition of the diffused matters on the sample surface to grown new SiGe NCs. The dewetting kinetic was also studied to control the amount of Si NCs and SiGe NCs. Several characterization techniques, such as Transmission Electronic Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Electronic Microscopy (SEM) and Micro-Raman are combined to probe the structural and morphological properties of these NCs. For pure Si NCs formed via conventional dewetting process, the density and seize of Si NCs depend only on the initial Si film thickness. When the end of the dewetting process is carried out under Ge deposition, we observe the formation of two families of NCs selectively grown on the same sample: Si NCs formed via dewetting of SOI before Ge deposition, and, all around them, SiGe NCs formed via dewetting of SOI during Ge deposition.

The Ge concentration in self-assembled SiGe NCs gradually decreases away from the interface between the two families towards the part of the undewetted film. These

experimental results provide unique insights into the ultimate developed dewetting processes of SOI thin films and are helpful to control the selective distribution and composition of the SiGe nanocrystals on insulator via solid state dewetting for advanced photonic and opto-electronic applications.

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