Abstract

This work deals with the growth of $In_xGa_{1-x}As$ nanowires (NW) on Group IV substrates by metal organic chemical vapor deposition technique with silver (Ag) nanoparticles (NP) as catalysts with an objective to replace gold (Au) NP as catalysts having severe disadvantages for device application. Nanowires have been found to grow below the eutectic temperature of Ag/Group IV system by vapor-liquid-solid method. While optimizing the conditions for tapering free NWs with uniform composition along its length, the growth temperature has been found to play the deterministic role in controlling the growth mode of NWs. Multi-pronged NWs have been found to grow at 600 ^{0}C while at 500 ^{0}C growth of single pronged NWs have been found to occur which has been explained with the help of classical theory of heterogeneous nucleation of NWs. Tapering free NWs with perfect cylindrical morphology have been found to occur for a specific partial pressure maintained in the reactor during growth. This has also been explained with the help of classical nucleation theory combining conventional adsorption-induced model and diffusion-induced model. The size of the catalyst, interestingly, has been found to be the controlling factor for determining the direction of growth of NWs. Growth of vertical free standing NWs has been achieved for a specific size distribution of AgNPs on Ge (100) substrates without any surface treatments or nucleation steps. Besides, NPs have also been found to etch the Ge (100) surface which can be used for in situ nanopatterning of substrates. The dependence of NW growth direction on the size of the catalysts has been found to be due to the Gibbs-Thomson effect. Interface states density (D_{it}) in $In_xGa_{1-x}As$ NW/Si heterojunction has been determined by developing a model which is suitable for semiconductor-semiconductor heterojunction. The rectification characteristics of a single $In_xGa_{1-x}As$ NW/Si heterojunction have been demonstrated with standard waveforms of sinusoidal, square, triangular and sawtooth of two different frequencies of 1 Hz and 0.1 Hz. Using the nanoheterojunction as the rectifying element, a half-wave rectifier circuit has been designed which can be used for fabricating nanoscale power supply units on Si platform.