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Axially graded heteroepitaxy and Raman spectroscopic characterizations of $Si_{1-x}Ge_x$ nanowires

Jee-Eun Yang[1], Won-Hwa Park[2], Zee Hwan Kim[2], Moon-Ho Jo[1]

[1]Department of Materials Science and Engineering, Pohang University of Science and Technology (POSTECH), San 31, Hyoja-Dong, Nam-Gu, Pohang, Gyungbuk 790-784, Korea

[2]Department of Chemistry, Korea University, Anam-Dong, Seongbuk-Gu, Seoul 136-701, Korea

Group IV alloy semiconductors offer a continuously variable system with a wide range of crystal lattices and energy-band gaps, leading to various electrical and optical properties. $Si_{1-x}Ge_x$ ($0 \leq x \leq 1$) alloy semiconductors represent such an example, where Si and Ge form a continuous series of substitutional solid solutions with a fixed crystal structure over the entire compositional range. Indeed they serve as lattice-engineered platforms for strained Si carrier-channels with enhanced carrier-mobility in $Si/Si_{1-x}Ge_x$ heterostructures and photo-detectors in which the continuous variation in the energy band-gap is exploited in the long wavelength communication. In this contribution, we present our recent efforts to develop photonic components based on single-crystalline Si:Ge alloy nanowires, where the relative composition of Si and Ge is continuously modulated in a wide range along the individual nanowires. We first report the axially graded heteroepitaxy of $Si_{1-x}Ge_x$ nanowires, by the kinetic controls of the Au-catalytic decomposition of precursors during chemical vapor syntheses. Our transmission electron microscope studies demonstrate that the relative composition of Si and Ge is continuously graded along the uniformly nanowires, sharing the same crystal structures with the continuously varying lattices. We also employed a confocal Raman scattering imaging technique that the local variations in compositions can be spatially and spectrally resolved along the individual nanowires. The spatially-resolved spectra of the Raman phonon bands (n_{Si-Si}, n_{Si-Ge}, or n_{Ge-Ge}) allow us to optically estimate the local composition along the wire axis within the 500 nm spatial resolution.