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Growth of SiGe/AlN Core/Shell Crystals by Aln Nanowire

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Extended Abstract

Si and Ge materials have indirect bandgaps in the natural cubic phase, but exhibit direct or quasi-direct bandgaps in the hexagonal (2H) phase, which offers great potential for fabricating optoelectronic devices and solar cells [1]. In particular, the growth of 2H-$Si_{1-x}Ge_x$ enables bandgap engineering through composition control, which offers greater application potential. Previous studies on the theoretical interpretation of direct bandgap structures and the growth of nanoscale 2H-$Si_{1-x}Ge_x$ have opened new horizons for the development of next-generation high-speed electronic and optoelectronic devices [2]. In this study, we report the growth of $Si_{1-x}Ge_x$/AlN core/shell crystals with 2H-phase cores in a single process by Plateau-Rayleigh instability (PRI) applied to AlN nanowires.

Unlike conventional template-based core/shell crystal growth methods, AlN nanowires were formed without the use of templates by employing a mixed-source hydride vapor-phase epitaxy (HVPE) method. Subsequently, equidistant elliptical Al membranes were formed on the AlN nanowires through PRI, and microscale 2H-Si_{1-x}/AlN core/shell crystals were grown via source adsorption on the elliptical Al membranes. The mixed-source HVPE method mixes the source corresponding to the core with Al and Ga sources in a graphite boat, and grows the crystal by supplying NH_3, HCl, and N_2 gas at a growth temperature of 1250 °C. Thus, the core reactants adsorb onto the elliptical Al membrane, forming droplets, and the AlN nanowires grow as an AlN shell. Then, the equidistant droplets supply the core material to the AlN shell, filling the core and enabling the growth of 2H-$Si_{1-x}Ge_x$/AlN core/shell crystals. The growth mechanism was analyzed using FE-SEM, and crystallinity was examined through HRTEM and Raman spectroscopy. It was confirmed that the grown core has a 2H characteristics, and the AlN shell exhibits the structural characteristics of wurtzite. Therefore, we propose a new approach to grow semiconductors from nanoscale to microscale through the unique phenomenon of nanomaterials.

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