Epitaxial III-V Semiconductors: Nanowires and Nanotubes

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Semiconductor nanowires have stimulated extensive interest in recent years because of their unique properties and potential applications as building blocks for nanoscale electronic and photonic devices. Realization of high quality, highly uniform, single-crystalline, reproducibly identical nanowires is a challenging task and one of the key hurdles for future development of nanotechnology. The significance of such controlled growth of nanowires would increase multifold if they were realized using a catalyst-free growth technique.

We report on the systematically controlled growth of InP nanowire arrays by catalyst-free selective area metalorganic vapor phase epitaxy on partially masked InP(111)A substrates. The length, diameter, shape and position of the nanowires were precisely controlled by optimization of the growth conditions and mask patterning. Manipulation of the growth conditions also enabled us to deliberately define the nanowire growth along either the axial or the radial direction, which has significant potential for the realization of novel nanostructures. Transmission electron microscopy studies revealed that the InP nanowires grown were single-crystalline with wurtzite crystal structure and the photoluminescence studies carried out at 4 K on InP nanowire arrays revealed a single intense emission peak with a significant blue-shift. The controlled fabrication thus enabled the nanowires to be realized in a highly uniform manner as reproducibly identical structures and with perfect positioning in predetermined configurations, making them highly suitable for practical integration into nano-devices.

Next, we report the realization of ordered arrays of single-crystalline InAs nanotubes by a simple pure-epitaxial approach. The process involved the fabrication of lattice-mismatched InP/InAs core-shell nanowires on InP (111)A substrates. The subsequent removal of the InP core resulted in vertically aligned InAs nanotubes which were highly uniform with well-defined features and controllable dimensions. Transmission electron microscopy studies confirmed that the nanotubes were single-crystalline with wurtzite crystal structure and temperature-dependent transport measurements revealed that they were conductive without any intentional doping. The realization of such conductive InAs nanotubes opens up new possibilities for both fundamental studies and future device applications.

Finally, we report the fabrication of InP/InAs/InP core-multishell nanowire arrays. Low temperature photoluminescence measurements indicate successful formation of *InAs quantum well tubes* with thicknesses of several mono-layers on InP nanowire sidewalls.

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