Nanomanufacturing Weekly

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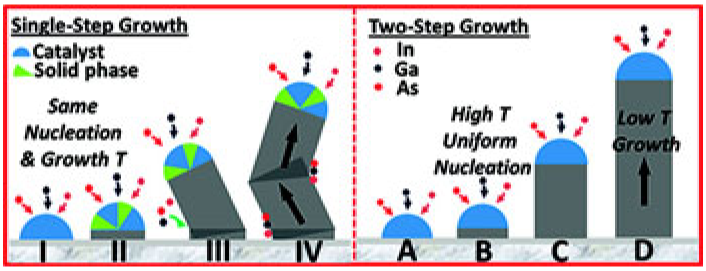
Two-Step Growth Method for InGaAs Nanowires for High-performance Electronic Devices



Indium arsenide (InAs) nanowires (NWs) have gained wide interest due to high carrier mobility and quantum confinement properties, making them excellent candidates for high-speed and high-frequency electronic devices. A drawback of InAs remains the narrow electronic bandgap, which results in excessive leakage currents for subsequent device applications. Approaches to resolving this have investigated complicated materials systems such as indium phosphide heterojunctions (InAs/InP) or segments of InAsP along the InAs-NW length. Indium gallium arsenide (InGaAs) is one potential material system that can be grown through continuous processes while controlling the electronic bandgap and mobility through composition. Growth of In-rich NWs still retains the superior electronic properties of InAs while reducing the leakage current.

The growth of InGaAs is typically achieved using a high temperature catalytic solid-source chemical vapor deposition (CVD) method. Using gold (Au) as the catalyst, Au nanoparticles are formed by thermal annealing a 0.5 nm film of gold coated on an oxidized silicon substrate at ~800°C, followed by NW growth as the precursor vapors are supplied from the heated solid source. Growth of InGaAs nanowires is plagued by defect and morphology issues during single step growth due to the similarity in temperatures between the catalyst anneal and the NW growth steps. As a result, the catalyst nanoparticle experiences a liquid-solid phase interface that leads to inhomogeneous NW growth, and a kinked NW morphology indicative of significant defects within the NW structures. Recently, Hou et. al. investigated a two-step growth process wherein the catalyst anneal was conducted at a high temperature, then the source and substrate zones were cooled to better control the reactant delivery and growth conditions of the NWs. The added nucleation step

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Nano for Business 2012: Building Toward a Sustainable Future prior to growth significantly reduced the kinked morphology, defect density, and previously observed surface coatings that formed around the NWs. The lower temperature growth conditions provide a more favorable mechanism resulting in straighter NWs having smoother surface. The mechanism is facilitated by eliminating the formation of a solid phase at the catalyst interface, thereby enabling uniform, preferential growth of NWs following the well-established vapor-liquid-solid (VLS) growth process.

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