46e Nanowire Synthesis Using Low-Melting Metals

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The nanowire synthesis using low-melting point metals such as Ga occurs via vapor-liquid-solid (VLS) approach in a unique manner, i.e., multiple nanowires grow from larger size Ga droplets.[1-2] In this case, the nucleation plays a major role in determining the size of the resulting nanowires as the Ga droplet size does not constrain the crystal growth in one dimension. However, there are several questions that needs to be addressed for rationalizing this concept further: (a) does the nuclei (nanowire) size depend upon the surface saturation or bulk saturation; (b) how does the interfacial energy at the melt/solid interface affect the 1-D growth; and (c) the role of temperature (phase diagram) and its limits for nanowire synthesis.

So, two distinct materials systems (non-reactive and reactive) were used to understand the nucleation and growth mechanisms: the dissolution and precipitation of Ge and nitrogen through molten Ga. The nucleation results suggested that the diameter, length (or domain size) and nucleation density of the precipitation remain uniform on any given gallium droplet. The resulting crystal size (related to nuclei size) increased with molten metal droplet sizes suggesting that the nucleation occurs due to bulk saturation. The Ge synthesis at higher temperatures and using conditions to lower interfacial energy (higher wetting) resulted in thicker wires eventually leading to 2/3-D crystal growth and lower nucleation density.

In the case of Ge, high densities of sub-10 nm, single crystalline nanowires were synthesized at temperatures as low as 100 ^{o}C. These nanowires grown in <110> were around 5 nm in diameter and 1-5 μm in length. Raman studies using excitation at low energy density levels indicated a large phonon blue shift (up to 15 cm^{-1}) suggesting that the Ge nanowires are quantum confined. The shifts observed in the Raman spectra are analyzed using models that incorporate the laser heating, stress and the phonon confinement effects.

[1]M.K. Sunkara, S. Sharma, R. Miranda, G. Lian and E.C. Dickey, “Bulk synthesis of silicon nanowires using a low-temperature vapor-liquid-solid method”, *Appl. Phys. Lett.*, **79** (10) , 1546-1548 (2001)

[2]H. Chandrasekaran and M.K. Sunkara, “Growth of Gallium nitride textured films and nanowires on polycrystalline substrates at sub-atmospheric pressures”, *MRS Symposium Proceedings*, **693**, 159-164 (2001)