Optical and structural properties of ultrathin Si Nanowires grown by innovative induction plasma torch process

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We report here on the structural characteristics and optoelectronic properties of novel Si nanowires (SiNW) synthesized by means of an original and high throughput (~Kg/day) induction plasma torch based process. Energy Filtered TEM mapping, X-ray Energy Dispersive Spectroscopy and Cathodoluminescence were combined in order to achieve the most thorough and accurate nanoscale characterizations of the structure and composition of the SiNW and SiNS. The as-synthesized material consists of a mixture of Si nanospheres and SiNWs (in the 1-10 nm size range). We found that Si NWs formation comes from two competitive growth mechanisms, namely Vapor-Liquid-Solid mechanism and Oxide Assisted Growth (OAG). In detail, Si NWs grown by OAG present an intriguing structure formed both by a nanometric cylindrical and "pearl necklace" Si core covered by a SiO_2 shell. We performed various thermal annealing processes at high temperature in order to induce a full transition from the pearl necklace structure to the formation of spherical Si nanocrystals embedded in SiO_2 NW. This spheroidization mechanism, related to the so-called "Rayleigh instability", makes these nanostructures extremely interesting for optical applications. Indeed, an efficient photoluminescence PL emission, over all the 700-1000 nm range, is observed for all the Si nanostructures upon their excitation with a 405 nm and 532 nm laser. By analyzing the PL signal, we were able to establish a correlation between the PL of the Si nanocrystals and their size distribution, demonstrating thereby the occurrence of quantum confinement effects.

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