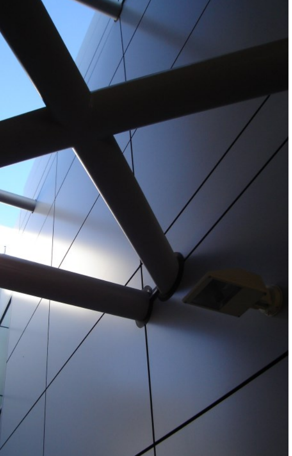

MECHANICAL ENGINEERING

The Department of Mechanical Engineering presents:

The Ph.D. Dissertation Defense of

Ozgul Yasar-Inceoglu

Tuesday, June 9, 2015, 1PM
in Bourns Hall A341

Synthesis and Surface Modification of Group IV Nanoparticles Using Non-thermal Plasmas

Doctor of Philosophy, Graduate Program in Mechanical Engineering
University of California, Riverside, June 2015
Dr. Lorenzo Mangolini, Chairperson

The rapidly increasing interest in silicon nanostructures is motivated by important advantages of this material compared to other semiconductors commonly investigated in the broad field of nanotechnology. Silicon nanoparticles are promising materials for many applications such as photovoltaics, transistors, light emitting devices, and energy storage devices.

Commonly used nanoparticle synthesis techniques have many challenges such as high cost, long processing time, and wide particle size distribution. In this dissertation, non-thermal plasma technique is used to overcome these challenges. In this study, in order to produce high quality nanoparticles, the direct comparison of the use of a chlorinated and hydrogenated precursor and its consequences on both the process parameters and material properties are initially investigated. The analysis results show that the chlorinated precursor yields nanoparticles vulnerable against oxidation in air compared to the hydrogenated precursor. In addition, it is found that in the chlorinated precursor case the gas composition needs to be modified and hydrogen needs to be added to the mixture to enable the nucleation and growth of the powder. Silicon nanocrystals with sizes between 5 and 10 nm have been produced in a non-thermal plasma reactor using chlorinated precursor.

The properties of the silicon nanoparticles can be tuned through post-processing steps to optimize for targeted applications. In particular surface modification is generally necessary to both tune dispersibility of the particles in desired solvents to achieve optimal coating conditions, and to interface the particles with other materials to realize functional heterostructures. In this contribution a non-thermal plasma-based process for the synthesis of silicon nanoparticles and their in-flight coating with a plasma polymerized shell (silicon/polymer core/shell) has been developed. It is found that it is possible to tune the chemistry of the shell by modifying the gas-phase composition during the polymerization step.

These nanoparticles are used as an anode material for lithium-ion batteries. The coating of the silicon particle with a polymer shell offers a way to uniformly disperse the particles into a carbon matrix after high-temperature treatment, which provides an improvement in the stability of an anode for lithium-ion batteries, compared to the case of uncoated silicon particles.

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