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Plasmas for controlling the synthesis of semiconductor nanocrystals

REBECCA ANTHONY, Department of Mechanical Engineering, Michigan State University

Recently, nonthermal plasma synthesis of opto-electronically active semiconductor nanomaterials has attracted interest. The plasma reactor is especially attractive for synthesis of some earth-abundant and nontoxic semiconductor nanocrystals (NCs), such as silicon and gallium nitride. These materials, with high melting temperatures, are more challenging to grow using the liquid-phase techniques that are successful for other materials, such as II-VI NCs. Here, plasma synthesis of high-quality NCs from these materials will be discussed, including investigations on controlling the NCs' light emission properties via physical changes in the NCs brought about by altering the plasma parameters. For example, nanoparticle crystallinity may be controlled by altering the power supplied to the plasma reactor, which has been revealed to influence both the density of atomic hydrogen and the ion density in the plasma. In addition, the surfaces of NCs (which have been shown to be crucial in determining NC luminescence properties) can be altered utilizing reactions that take place in the plasma after NC growth is finished. The features of the plasma reactor provide unique and selective control over the properties of NCs, and also allow for deposition of dense films of NCs directly from the gas-phase, in complete avoidance of liquid-phase methods. These features - crystallization of environmentally benign materials, capacity to control NC surfaces via plasma-intiated reactions, and direct deposition of these materials onto device substrates – unite in a method for "green" processing of nanomaterials. Future directions for utilizing plasma reactors for nanomaterials synthesis and processing will also be discussed.