Noble-metal and semiconductor core-shell structures for plasmonics, catalysis and photovoltaics

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Semiconductor nanostructures having 1-D orientation such as nanowires and nanotubes are potentially capable to transport the charge along the c-axis of the wire/tube. Such transport is considered to be competitive comparing with the transport in 3-D materials in view of the lower population of interfacial sites. For instance, during the operation of the classic semiconductor solar cell, which is composed of 10-16 μm thick layer consisting of 10-20nm nanoparticles, the exited electrons must travel through 10^3-10^6 nanoparticles to reach the electrode. The project aims to develop nanowires/nanotubes having core-shell structure to facilitate the charge transfer in semiconductor devices. The structures may be important for fundamental understanding of 1-D charge transfer in semiconductors not available for conventional nanowires/nanotubes. The systems may be competitive to classic particle-particle interactions used in conventional semiconductor devices. The use of core-shell nanostructures for the improved charge transfer along the c-axis of nanowire/nanotube may be of high interest in view of fundamental understanding issues. The heterostuctures of semiconductor with noble metal such as gold, platinum and silver are important in the fields of plasmonics, catalysis and photovoltaics. The CdSe is sensitizer in combination with TiO_2 in light harvesting systems. Optimization of the pathway for charge transport may significantly affect quantum yields for the devices. This concept is realized by using 1-D nanostructures and appears to have a great potential for light harvesting systems, batteries, light-emitting diodes, etc. If real 1-D charge transfer is obtained by using core-shell nanowires a significant increase of quantum efficiencies for semiconductor devices is expected.

The project targets to synthesize and study of three types of core-shell nanowires/nanotubes in the form of semiconductor/semiconductor (type I and type II), semiconductor/noble-metal and more advanced nanostructures where the noble-metal is in the form of nanodisks/nanorings separated by synthetic metal. The unique core-shell nanowire/nanotubes will be developed based on our findings of synthetic metals electrodeposition in TiO_2 nanotubes. The various configurations of CdSe/ZnS, TiO_2/CdSe, TiO_2/Au, TiO_2/Pt and TiO_2/Ag will be investigated in terms of charge transfer characteristics. The quantum efficiency for core-shell structures will be studied by means of photoluminescence, photo-electrochemistry of composite materials will be studied in terms of open circuit photo-voltage and short-circuit current in solar cell simulator. The size effects will be studied in terms of charge transfer characteristics for heterostructures.