Hetero-Nanostructures:
Enabling Future Electrochemical Energy Harvesters

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The ever-increasing worldwide consumption of fossil fuels and its inevitable environmental impacts has driven the research toward the development of clean, cost-effective and more sustainable energy technologies for large-scale applications. In addition to that, efficient small-scale power generation is critical for a variety of portable applications such as mobile electronics, sensors and wearable/implantable health monitoring devices. The scalability of electrochemical energy conversion technologies makes them very attractive for both applications. However, the development of commercially viable electrochemical energy devices requires further enhancement in the performance of individual components of the electrochemical cell while reducing the manufacturing cost. Heterogeneous nanostructures (heteronanostructures) hold great promise for applications in energy conversion and photo/electro-catalysis due to the versatile morphology of nanomaterials, and their potential for high energy-conversion efficiency. In this talk, I will focus on the development of one-dimensional (1D) heteronanostructures for efficient photoelectrochemical (PEC) water splitting and micro-solid oxide fuel cells (micro-SOFCs).

The photoelectrochemical production of hydrogen is currently hampered by three fundamental limitations: low efficiency, short lifetime, and high cost of catalyst materials. TiO_2 nanotube arrays have been known as one of the most photochemically stable catalyst material systems but their large bandgap (~3 eV) prevents efficient light absorption. In the first part of my presentation, I will present a comprehensive investigation of doping mechanism of strontium into TiO_2 nanotube arrays while maintaining the nanotubular structure and discuss the resulting improvements in electronic, optical, and photoelectrochemical properties of the material for hydrogen evolution in PEC water splitting. In the second part of my talk, I will describe the hydrothermal synthesis of strontium titanate (STO) nanotube arrays on silicon substrates. Then, I will discuss the fabrication and characterization of coaxial nanotubular heteronanostructure of yttrium-stabilized zirconia (YSZ) on freestanding STO nanotubes as a platform for the electrolyte membrane of low temperature integrated micro-SOFCs. Finally, I will briefly discuss the development of bio-fuel cells to power miniaturized biomedical implants. This will include the design aspects for inorganic biocompatible electrode materials for non-enzymatic glucose-based biofuel cells.

Biography:

Hoda Amani Hamedani is currently a senior research associate in the department of Chemical and Biomolecular Engineering working on Breakthrough Electrolytes for Energy Storage (BEES) within the newly established EFRC. She received her Ph.D. degree from the School of Materials Science and Engineering at Georgia Tech in 2013. Her research at Georgia Tech has been focused on renewable energy and energy conversion particularly the design, fabrication and characterization of novel nanostructured materials for fuel cells and hydrogen production via photoelectrochemical water splitting. During her M.S. study, Hoda worked on the design, fabrication and microstructure modeling of functionally graded nanostructures for the cathode of solid oxide fuel cells (SOFCs). Her Ph.D. dissertation focused on the development of novel hetero-nanostructures and low-dimensional semiconductor nanostructures on the silicon substrates for energy harvesting in micro-devices.

Hoda's research on energy and biomaterials has resulted to publications in several high impact journals such as the Advanced Functional Materials. Her work on the design of novel photoelectrode materials for photoelectrochemical water splitting has won the Best Junior Researcher Award at TMS 2011. After her Ph.D., she expanded her scholarly interests into nanomaterials for implantable biomedical devices. During her post-graduate studies, she has been working on continuous power generation for implantable biomedical devices as a visiting scholar at Stanford University. She has also been a senior materials scientist at Nano Precision Medical Inc. working on the development of nanoporous materials for sub-dermally-implantable drug delivery devices.