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Nanostructured Materials for Energy Conversion and Storage

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The Team and Funding

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Capabilities

- Plasma Enhanced Chemical Vapor Deposition
- Atomic Layer Deposition of Oxides
- In-vacuo XPS and UPS
- Electrochemical Techniques
  - Voltammetry, Electrochemical Impedance Spectroscopy (EIS), Potential Transient Measurements (PTM), Incident Photon Conversion Efficiency (IPCE)
- Microfabrication ("MEMS") – with RTI
Micro-patterned CNTs
Vertically Aligned Graphene Nanosheets
Graphenated CNTs

A hybrid structure of graphene foliates along the length of aligned multi-walled CNTs.

Parker et al., Journal of Materials Research v27, p1046(2012)
High capacitance achieved through hybrid graphene-CNT structure.

Increased deposition time correlates with increased graphene foliate density and leads to higher capacitance for energy storage.
Hybrid Graphene-CNT Nanostructures: Enhanced Catalytic Activity

High catalytic activity achieved through hybrid graphene-CNT structure

C-V curves using the ferri-ferrocyanide couple to examine catalytic activity and electron transfer rates

CNT

g-CNT
Solar Fuels via Atomic Layer Deposition of Nanostructured Photoelectrodes

Self-Limiting Growth Process Enables Deposition of Conformal and Uniform Ultra-Thin Films

Porous Heterostructure Design Enhances Energy Conversion Efficiency

ALD Enables Optimization of Coating Thickness without Sacrificing Porosity
Solar Fuels via Atomic Layer Deposition of Nanostructured Photoelectrodes

Incident Photon to Current Conversion Efficiency (IPCE) comparison between our Heteronanostructure and TiO2 Nanowires

Schematic of Photoconversion Mechanism (above)
Expected from our Nanostructure (below)
Additional Energy Applications of Interest

- Miniature mass spectrometer for methane detection
- Electrochemical disinfection for energy neutral off-grid toilet for the developing world
Coded Aperture Miniature Mass Spectrometer
“The Ultimate Chemical Sensor”

Energy Applications:
*Detection of rogue methane at well heads and refinery perimeters*

Microfabrication Process
Aperture Coding: Results for Ethanol

Traditional Magnetic Sector Mass Spectrometry with a Single Slit

Magnetic Sector Mass Spectrometry with a Coded Aperture showing a >10x signal gain
Electrochemical disinfection of liquid waste

Energy Neutral Off-Grid Toilets for the Developing World
66% energy saving by using 10% duty cycle pulsed mode as opposed to continuous ON mode