DEPARTMENT OF PHYSICS AND ASTRONOMY

COLLOQUIUM IN-PERSON ONLY EVENT

Multifunctional Nano Materials for Energy and Sensing Technologies: Graphene-based Hybrids and Semiconducting Oxides

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In this talk, I will present graphene-based functional hybrids for electrochemical energy conversion and storage systems and development of sensors based on nanostructured zinc oxide besides an overview of my research expertise and experience. Intense research in research in alternative sources of renewable and clean energy is stimulated by increasing global demand of electric energy. Electrochemical energy conversion/storage systems (super-/pseudocapacitors and batteries) represent the most efficient and environmentally benign technologies for sustainable advancements. There is an urgent need for engineered electrochemical electrodes to enable high-performance generation-II energy storage devices approaching industrially relevant specific energy and power densities while delivering electrical power on-demand. Among various nanocarbons, graphene showing quantum nature continues to promote extensive developments due to exceptionally rich surface chemistry and tunable physical-chemical properties. The ***first part*** will review potent synthetic strategies geared towards rational design of multifunctional graphene-based hybrids promoted by chemical hybridization and molecular bridging of 2D graphene nanosheets to 1D carbon nanotubes and 0D transition metal oxides and their performance was conducted using complementary analytical tools. Moreover, the fundamental insights into the dynamic physicochemical processes occurring at electrode-electrolyte interfaces was achieved using scanning electrochemical microscopy (SECM), that quantifies redox reaction kinetics (*i.e.,* heterogeneous electron transfer rate) and offers high spatial resolution imaging of electroactivity. The experimental findings complemented density functional theory signifying available density of states in the vicinity of Fermi level contributing to higher activity. This research opened new innovations for graphene related layered materials (*i.e.,* MoS_2) and emerging quantum materials for high current density electrocatalysts. The **second *part*** will discuss development of gas sensors based on hierarchical nanostructured ZnO due to growing interest in monitoring toxic, hazardous, and greenhouse gas (methane and carbon dioxide) emissions. Other than modern industries, the main contributor is agricultural livestock (*i.e.,* ruminants) as a byproduct of digestion and microbial fermentation. We synthesized sensing devices based on ZnO nanorod arrays and topological interconnected tetrapod network films on interdigitated electrodes and surface-catalyzed with palladium nanoparticles. The sensing performance was analyzed under combined thermal and UV light excitation and proposed sensing mechanisms based on space charge layer model and band-bending theory.

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