Introduction to Exploratory Projects – Ongoing

In addition to deep research into high-risk, high-impact fundamental science and technology, GCEP also funds smaller exploratory efforts. These exploratory projects can be funded for up to one year, and have budget limits of up to $100,000 each. The goal of these projects is to quickly evaluate the feasibility of a novel concept. If such an investigation proves successful, the investigators may apply for regular GCEP funding.

Three exploratory projects are currently being funded.

Professor Hongjie Dai is working on ultra-fast rechargeable nickel/zinc batteries. Since starting this project, the synthesis of β-phase $Ni(OH)_2$ and Al, Co co-doped α-phase $Ni(OH)_2$ (NiAlCo) nanoplates covalently attached onto oxidized few-walled carbon nanotubes (β-$Ni(OH)_2$/CNT and NiAlCo/CNT) has been explored. These hybrid materials were investigated as the cathode material of rechargeable Ni/Zn batteries. They exhibited high specific capacity of ~220 and ~350 mAh/g for β-$Ni(OH)_2$/CNT and NiAlCo/CNT respectively, and long cycling stability with <20% capacity loss after 1,000 charge-discharge cycles. Future work will involve the use of the synthesized materials to develop fully rechargeable Ni/Zn batteries with an ultrahigh power density and fast charging and discharging time in seconds.

Professor Chris Edwards is exploring how combined restrained and unrestrained reactions can be used to realize high-efficiency (>70%) engines. The proposed system seeks to marry the internal combustion engine with fuel cells in a way that is beneficial to both. By operating some of the cylinders of an IC engine upstream of the fuel cell at a very rich equivalence ratio, the engine can serve as a fuel reformer to generate hydrogen from hydrocarbon molecules found in typical fuels. Work is underway to determine the operating conditions for each of the devices in the system, as well as the type of fuel cell that lends itself best to this application. Some preliminary experimental data has also been generated in exploring the use of an IC engine as a fuel reformer.

Professor Harold Hwang is focused on solar water splitting and trying to atomically engineer oxide heterostructures for this purpose. In this project, the emphasis is on using atomic scale controlled epitaxial oxide heterostructures as the platform to study and develop fundamental concepts in improving the efficiency of solar water splitting catalysts. For this exploratory project, the work focuses on: (1) identifying the role of the space charge region in the photocarrier separation process by systematically controlling the thickness and doping density in epitaxial thin films, (2) fabrication of atomic scale surface dipole layers to tune the energy band alignments at the electrolyte/oxide interface, and (3) basic characterization of intrinsic carrier transport properties of visible light harvesting photocatalysts.