Introduction to Exploratory Projects – Completed

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. Two exploratory projects have been completed this year.

Professor Hongjie Dai's exploratory research focussed on ultra-fast rechargeable nickel/zinc batteries. Since starting this project, NiAlCo layered double hydroxide (LDH) nanoplates attached to few-walled carbon nanotubes (NiAlCo/CNT) as the cathode material of rechargeable NiZn battery in aqueous alkaline electrolytes have been synthesized. The □-phase metalhydroxide with ultrathin morphology and strong coupling to nanotubes afforded a cathode with a high capacity of ~ 354 mAh/g and ~278 mAh/g at current densities of 6.7 A/g and 66.7 A/g, respectively. Al and Co co-doping is unique in stabilizing □-phase nickel hydroxide with only a small capacity loss of ~6% over 2000 charge and discharge cycles at 66.7 A/g. Rechargeable ultra-fast NiZn batteries with NiAlCo/CNT cathode and a zinc anode can deliver a cell voltage ~1.75 V, energy density ~ 274 Wh/kg and power density ~ 16 kW/kg (based on active materials) with < 1 minute charging time. These results open the possibility of ultrafast and safe batteries with high energy density.

Professor Chris Edwards' research explored how combined restrained and unrestrained reactions can be used to realize high-efficiency (>70%) engines. In the exploratory phase of this research, systems-level modeling was used to determine what is possible in configuring a fuel cell/ICE combined cycle. How well each technology can be adapted for our purpose and the complications that might arise from interfacing these devices was determined. Rich combustion of methanol, ethanol, and gasoline were explored and the resulting syngas levels up to the point of combustion stability or noticeable soot emissions were measured. A high-temperature (iron-chrome based catalyst) water-gas-shift reactor was designed and built to reduce exhaust gas CO and allow for fuel cell testing of actual shifted engine exhaust gas. A high temperature PEM (HTPEM) fuel cell of the type produced by BASF was designed and is being implemented for testing with the shifted rich engine exhaust gas and to demonstrate a completely coupled system – engine through shift reactor to fuel cell.