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. Five exploratory projects are currently being funded.

Professor Wilcox has a project aimed at enhancing hydride thermodynamics through nanostructuring. This project targets hydrogen storage in nanostructured magnesium based hydrides and will investigate the reaction mechanism. Results so far demonstrate that bulk $Mg(AlH_4)_2$ can release hydrogen but its uptake reaction is unfavorable, and bulk $Mg(AlH_4)_2$ is metastable with respect to bulk MgH_2. However, in the cases of nanoparticle systems, hydrogen release and its recharging may be possible by controlling the particle size and temperature, which may facilitate experimental studies to determine the thermodynamically favored reaction pathways for the dehydrogenation and hydrogenation processes of $Mg(AlH_4)_2$ nanoparticles.

Professor Xiaolin Zheng is carrying out research aimed at new pathways towards high performance transparent conductive oxides. The proposed research will study how a composite microwire array and nanoparticle film structure and application of rapid high temperature flame doping method (the Sol-flame Method) can enhance the electrical conductivity of solution-processed transparent conductive oxides (TCOs). The goal is to expand the material choice for TCOs solar panels at decreased deposition costs. Since the start of the project, high density and uniform ZnO nanowires and ZnO nanowires coated with ZnO shell films as the base materials for TCO, have been prepared and the method to measure the sheet resistance of those films identified. As a next step, ZnO microwires will be grown and used as the epitaxial substrates for the ZnO film. Finally, the effect of flame doping on ZnO film on its electrical conductivity will be tested.

Professors McIntyre and Salleo have an interdisciplinary exploratory project entitled "Enabling Methods and Materials for Stackable Tandem Solar Cells with Polymer Electrolyte Interconnect". This project studies the use of liquid and solid-state electrolyte interconnects to create Schottky and tandem junction solar cells. This approach avoids the complex fabrication processes required to make tunnel junctions typically required for multijunction photovoltaics. Instead it relies on low temperature, easy to fabricate polymer layers, which can be optimized independently of the semiconductor junctions. In the 2015 funding year, three core studies were initiated: the first is to reproduce and surpass previous performance benchmarks using a liquid electrolyte Schottky junction with crystalline silicon; the second is to use the liquid electrolyte junction in a tandem architecture with amorphous silicon p-i-n junctions, and the third, is to develop and optimize a solid state polymer electrolyte layer to eventually replace the liquid electrolyte in Schottky and multijunction (tandem) architectures. Results to date can be found in the report.

Professor Spormann with graduate student Ann Lefsnefsky are working on a microbial platform for conversion of methane and syngas to biofuels and industrial chemicals. The exploratory research seeks to engineer a microbial platform that converts biologically produced methane or syngas to useful fuels and industrial precursor chemicals. If successful, this microbial fermentation technology, which relies on novel metabolic principles, will provide a means to remove net CO_2 from the atmosphere at considerable scale and to utilize syngas to fully replace petroleum hydrocarbons. These researchers have successfully overcome the first hurdle towards achieving this by demonstrating genetic experiments for engineering traits in *Methanosarcina acetivorans* can be done.

Professor Lindenberg and his research group have an exploratory project entitled, “Optimization of Carrier Transport Processes and Figure of Merit for an Intermediate Band Solar Cell”. This exploratory research work is focused on the use of ultrafast terahertz spectroscopy as an all-optical probe of the first steps in carrier transport processes in energy related materials. First experiments have been carried out probing these processes in intermediate band materials. Intermediate-band materials have the potential to be highly efficient solar cells and can be fabricated by incorporating ultrahigh concentrations of deep-level dopants. The researchers have used optical-pump/terahertz-probe measurements to study carrier recombination dynamics of chalcogen-hyperdoped silicon with sub-picosecond resolution. The recombination dynamics are described by two exponential decay time scales: a fast decay time scale ranges between 1 and 200 ps followed by a slow decay on the order of 1 ns. In contrast to the prior theoretical predictions, the carrier lifetime decreases with increasing dopant concentration up to and above the insulator-to-metal transition. Evaluating the material’s figure of merit reveals an optimum doping concentration for maximizing performance.