Objective
GCEP provides funding for research activities of an exploratory nature that test the feasibility and application of potential step-out ideas. These activities focus on novel approaches and innovative concepts associated with technologies that may permit reductions in greenhouse gas emissions on a global scale. While exploratory activities are limited to $100K and a one-year performance period, the preliminary analysis results may support the submission of a detailed proposal.

Activities for 2007

Increasing Carbon Storage Within Soils by Controlling Key Microbial Respiration Processes
Scott Fendorf, Geological and Environmental Sciences, Stanford University; Shawn Benner, Geosciences, Boise State University

Integrating carbon sequestration objectives into traditional agricultural practices has the potential to provide dramatic short-term offsets in carbon emission. Managed wetlands, rice paddies in particular, represent a promising distributed carbon sink; if the average carbon content within the upper meter were increased by a few percent, the total annual carbon dioxide release from the burning of fossil fuels could be offset. It is conceivable that we could double the carbon content over a ten-year period, reaching an average total soil carbon content of 4-8%. This project will test the hypothesis that microbial methanogenesis can be minimized while simultaneously limiting carbon mineralization rates through control of water levels, periods of inundation, rates of both flooding and draining, and specific iron(III) mineral availability within rice paddies. The objectives of the exploratory study are: 1. to examine current organic carbon and iron mineral phase contents within existing wetlands under different historic management practices; and 2. to conduct a pilot study wherein the operative microbial metabolisms are controlled to limit carbon mineralization rates (relative to aerobic rates) while restricting methane production.

Nanowire-Nanocrystal Multiexciton Solar Cells
Yi Cui, Materials Science and Engineering, Stanford University

This project explores a novel photovoltaic cell architecture using a network of PbSe nanowires combined with PbS nanocrystals. The aim of this project is to use the proposed structure to achieve both high photon absorption through impact ionization processes in the nanocrystals, and efficient charge transport through both the nanowire network and the nanocrystal arrays filling the void space in the nanowire scaffold. This concept is a new approach to the realization of high-efficiency thin film photovoltaics, and will require the exploration of fundamental questions, many of which will also benefit other innovative thin film technologies.
Nanostructured ZnO as a Solution-Processable Transparent Electrode Material for Low-Cost Photovoltaics
Alberto Salleo, Materials Science and Engineering, Stanford University

This study explores innovative approaches for using zinc-based oxide materials as transparent conductive films in photovoltaic devices. The proposed strategy consists of depositing a planar network of doped ZnO nanowires from solution and annealing it by laser to form a continuous film. This approach promises better conductivity and transparency properties than in unannealed nanowire networks, in addition to the advantages associated with solution processing. Laser annealing of highly-doped ZnO nanowires is a novel technique that will be investigated for the first time in this project.

Plasma Activated Fuel Cells
Mark A. Cappelli, Mechanical Engineering, Stanford University

In this project, the effects of plasma injection on the operation of a fuel cell will be studied. A non-equilibrium plasma will be generated in the inlet gases of the fuel cell via dielectric barrier discharge. Ionized gas-phase species may alter the reaction pathways at the catalytic solid-gas interface in a way that affects significantly the activation losses. Through bench top experiments and systems-level modeling, this research will determine whether the resulting change in operational efficiency can overcome the power needed to generate the plasma. The applications of plasma to fuel cells extend beyond mere efficiency gains; plasma enhancement may also be used simultaneously for internal fuel reforming.

Feasibility of a Novel Photoelectrochemical Conversion Device
Fritz B. Prinz, Mechanical Engineering and Materials Science and Engineering, Stanford University

This project envisions solar conversion systems where light is converted to electricity via charge separation and transfer through a solid-state electrolyte. The latter occurs through an ultra-thin solid state electrolyte which is capable of conducting redox couples that carry both positive and negative charges without allowing them to recombine within the confinements of the film electrolyte.

To effectively screen feasible material alternatives for this project, efficient computational tools are needed for the down selection process. Therefore this project also aims to develop a computational tool to calculate the electronic structure including the band gap of nano-scale devices with practical computational resources. The simulation tool under development will use a tight binding method that is shown to be fast enough to evaluate relevant systems with reasonable accuracy.