Introduction to Advanced Materials and Catalysts

The development and advancement of materials is an overarching need in systems that extract, distribute, store or use energy. The performance of these systems depends on the properties of the materials: plastics, coatings, alloys and catalysts are some of the broad classes of materials used in current energy devices. Advancements in these materials optimize energy conversion processes, improve system efficiency, extend lifetime, and reduce CO_2 emissions. Although initially developed for a specific application, material properties may crosscut to other energy technologies or industries.

GCEP has several projects whose main focus is on materials development. Most of these are officially listed under their application area. Some projects have a materials component to their research. For example, research in the Hydrogen area includes studies of nanomaterials for hydrogen storage and NMR studies of fuel cell electrolytes. Studies in the CO_2 Separation and Capture area on advanced membrane reactors and development of innovative gas separation membranes involve development of materials with highly specific properties. The Solar area is replete with materials research for nanostructured photovoltaic cells. The studies listed above are all materials intensive investigations whose details can be found under their specific application areas in this report. The remainder of this section is dedicated to the two following investigation efforts:

Professors Christopher Chidsey, Daniel Stack, and Robert Waymouth are developing efficient catalysts for direct-hydrocarbon fuel cells. It is envisioned that these catalysts will be transition metal complexes mounted on carbon electrodes. Specifically, various configurations of late-metal multi-metallic catalyst complexes are being investigated for their role as electrooxidation catalysts, and biologically inspired mono- and multi-metallic copper complexes are being examined as electroreduction catalysts.

Professors Paul McIntyre and Shriram Ramanathan (Harvard University) are exploring new approaches for low-to-intermediate temperature solid oxide fuel cells (SOFCs) using nanoscale-engineered metal-oxide electrolytes manufactured by atomic layer deposition. They are also exploiting photo-excitation effects to reduce the activation energy of the reactions occurring at the membrane surface.