Introduction to Advanced Materials and Catalysts

The performance of systems that extract, distribute, store and use energy is dependent on the properties of the materials from which those systems are built. Improvements in system performance and reductions in CO_2 emissions can be expected to result from the application of optimized materials to energy conversion processes. Although initially, material development may be targeted towards a specific application, the discovery of improved materials is often capable of impacting a wide array of energy technologies.

The molecular structure of a material determines its mechanical strength, surface area, permeability to fluids and chemical reactivity. Furthermore, the stability of that structure impacts the durability in the harsh environments of highly cyclic mechanical, thermal and chemical loading present in energy and resource processing devices. The structure and stability of a material affect its functionality, while the resources required to manufacture the material determine its economic feasibility.

Plastics, coatings, alloys and catalysts are some of the broad classes of materials used in current energy products. For example, the blades of a wind turbine are tailored to be strong and flexible (and are therefore made from a fiber-adhesive composite), while the blades in a gas turbine are designed to withstand extreme temperatures (and are made from thermally coated metal alloys). Two different applications demand entirely different materials solutions.

The materials discovery process has accelerated rapidly in recent years as automation and high-throughput screening techniques have matured. Furthermore materials that are structured at the nanometer scale have captured the interest of many researchers due to their unique and often surprising macroscopic characteristics.

GCEP has several projects whose main focus is material development, however, most of these are officially listed under their application area. Nanomaterials for Hydrogen Storage, NMR Studies of Fuel Cell Electrolytes, Micro and Nanoscale Electrochemistry of Fuel Cells (in the Hydrogen area), Advanced Membrane Reactors (in the CO_2 Separation and Capture area) and Nanostructured Photovoltaic Cells (in the Solar area) 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 Professor Chidsey's investigation of Electrocatalysts for Hydrocarbon Fuel Cells.