# Transportation Systems

## Thermal Barrier Coatings for Diesel Components

DOE is sponsoring cost-shared programs with Caterpillar, Incorporated and the Cummins Engine Company, Incorporated to develop reliable and durable thermal barrier coatings. These coatings have significant potential for improving heavy-duty diesel engine fuel economy and vehicle performance and reducing emissions. An extensive data base was instrumental in the development of successful coatings for diesel engines. Caterpillar and Cummins are working to further develop and transfer coating technology to future diesel engines designs. Engine tests during this program have advanced the production and application of reliable thermal barrier coatings for diesel engines. Engine performance modeling indicates that the level of insulation provided by these coatings will yield a direct fuel economy benefit of nearly 4 percent for an advanced turbocharged and turbocompound diesel engine.

## Transformation-Toughened Ceramics Data Base

Transformation-toughened ceramics, such as partially stabilized zirconia, tetragonal zirconia polytypes, and zirconia-toughened alumina, offer important options for advanced engines because of their high strength and toughness, high coefficient of thermal expansion (similar to cast iron), and good thermal insulation properties. Ceramics are highly complex materials and early experiments found that satisfactory performance in engines was unpredictable. Under the Advanced Materials Development program, a comprehensive data base of mechanical and physical properties as a function of time, temperature, stress, relative humidity, and thermal history was developed. Over 25 different materials were characterized at four different laboratories. The data from this research have been compiled in a computerized data base and have been released to industry where the information aids designers in the development of advanced engines for commercialization. The Data Base for Transformation-Toughened Ceramics is a part of the second phase of the DOE Advanced Materials Development program, focusing on initiating contacts with industry to integrate new information on ceramics into engine design research.

## Whisker-Toughened Ceramic

Engine components made of ceramics are more durable and lighter (thus, more energy efficient) than those composed of metal. In addition, they are corrosion resistant and can be manufactured from low-cost, non-strategic materials. Past application of ceramics in engine construction was limited by the brittleness of the material. Following successful research by the ECUT program, the DOE Advanced Materials Development program developed a silicon nitride matrix with a silicon carbide whisker composite, known as whisker-toughened ceramic. This new material is 40 percent tougher and 25 percent stronger than conventional, nonreinforced ceramics. Whisker-toughened ceramic materials will be used by GTE in the production of auto parts.

## Tensile Testing System for Ceramics

A major thrust of the Advanced Materials Development program has been to produce uniaxial tension test data on structural ceramics for use in advanced engines. For tension testing data to be useful to engine designers, the testing system must be able to apply pure uniaxial loads to the testpiece, but the high modulus and brittle nature of ceramics make this very difficult. Many past attempts had limited success or were abandoned because of the high cost of performing the test or the questionable results ob-