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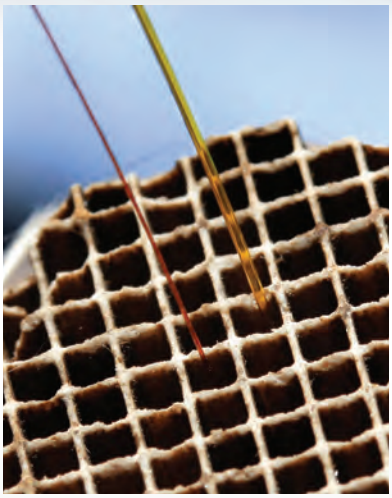
SpaciMS reveals details of vehicle engines and exhaust systems

Clean diesels and other advanced engines can contribute to reducing petroleum consumption and managing the environmental impacts of transportation. However, they require highly effective exhaust treatment technologies to meet more and more stringent emissions regulations.

SpaciMS (spatially resolved capillary input mass spectrometry) is a diagnostic tool developed in a DOE-funded collaborative effort between ORNL and Cummins, Inc., that provides unprecedented insight into catalytic devices, aftertreatment systems, and engine performance. It measures local changes in the chemical composition of gases in confined chemical reactors such as transportation catalysts. Using gas sampling capillaries positioned inside catalyst channels, SpaciMS pinpoints, measures, and maps concentrations of transient emissions such as nitrogen and carbon compounds. ORNL researchers are also using microscopy and computer modeling to predict the lifetimes of catalysts and filters for exhaust systems and developing advanced diesel combustion strategies to reduce emissions.

Technology Achievements

- Exhaust gas characterization—SpaciMS uses gas sampling capillaries positioned inside catalyst channels in exhaust aftertreatment devices to rapidly pinpoint and measure pollutants in the channels and enable detailed study of their chemistry. It is far more advanced than measurements provided by other techniques.
- Lifetime prediction—Computer modeling and images provided by aberration-corrected scanning transmission electron microscopy provide data to predict the lifetimes of particulate filters and of catalytic materials.
- Advanced combustion regimes—High-efficiency clean combustion (HECC) uses exhaust gas recirculation to reduce nitrogen oxide emissions. ORNL was the first DOE lab to demonstrate low-temperature diesel combustion in a multi-cylinder engine, an HECC forerunner.



Key Accomplishments

- Cummins used SpaciMS to develop and calibrate the 6.7 liter diesel engine and nitrogen oxide aftertreatment system used in Chrysler's 2007 Dodge Ram pickup, enabling it to meet 2010 emissions standards three years ahead of schedule.
- Hiden Analytical, a maker of scientific instruments, commercialized SpaciMS technology for determining intra-catalyst reactor chemistry to offer the first commercially available instrument of its kind.
- Researchers at ORNL's High Temperature Materials Laboratory used a combination of computer modeling and advanced microscopy to predict the lifetime of Corning's cordierite material for diesel exhaust aftertreatment.
- ORNL is a partner in research into advanced combustion regimes being conducted by individual engine and auto manufacturers.

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