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Light for Science

Automotive Research

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overview

To keep ahead of the competition the automotive industry needs to identify and realise innovative developments in chemistry, materials science and engineering. A deep understanding of fundamental processes such as catalysis and detailed knowledge of material properties on the molecular scale is vital to developing and maintaining competitive advantage and minimising impact on the environment.

Current knowledge of paints, fuels and motor oils all owe a debt to synchrotron radiation. Researchers have been able to probe more deeply into the structure of materials and predict their behaviour in a range of demanding conditions, allowing the development of more efficient fuel systems, stronger, lighter materials and reducing the failure rate of components.

Key Challenges

- **Improve Fuel Emissions**
  Understanding catalytic processes to optimise the operating conditions for converting harmful emissions such as carbon monoxide and nitrogen oxide to less harmful carbon dioxide and nitrogen gas
- **Stronger, Lighter Materials**
  Understanding the crystal structure of polymers to refine their properties and behaviour for specific purposes
- **Optimised use of additives**
  Analysing particle size and distribution allows performance characteristics to be determined to optimise operating performance
- **Processes in Realistic Environments**
  Understanding what happens to materials undergoing extreme stresses and strains – for example during injection moulding

The Synchrotron Solution

The high intensity of synchrotron X-rays enables more information to be gathered and analysed than traditional laboratory techniques, and the time scale for experiments is also dramatically reduced.

Techniques

X-ray Absorption Fine Structure (XAFS) and small and wide-angle x-ray scattering (SAXS and WAXS) allow the collection of data from fast industrial processes down to a ms timescale in purpose built environmental chambers.

Beamlines: I07 Surface and Interface Diffraction, I12 Joint Engineering, Environment and Processing (JEEP), I18 Microfocus Spectroscopy, I20 X-Ray Spectroscopy, I22 Non-Crystalline Diffraction

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case studies

Strong and Light

In deciding on materials for use in the automotive industry there is continual trade-off between weight and strength. A solution to this is the use of low density Metal Matrix Composites (MMC), metal-based materials interlaced with ceramic particles or fibres.

These materials have useful mechanical properties, but are limited by their propensity to crack or fracture under stress. Understanding the fracture mechanism requires knowledge of the process both at the metal/ceramic interface and the behaviour of the bulk material.

Existing techniques require sectioning the material to examine the effect on the bulk, a process which is both time-consuming and destructive. Through using phase contrast imaging on a synchrotron however, it is possible to investigate fracture damage mechanisms in a non-destructive way.

Experiments carried out at the European Synchrotron Radiation Facility (ESRF) in Grenoble showed that cracking occurs in greater intensity in the bulk material. This demonstrated the necessity of incorporating the bulk material response when investigating MMCs for industrial applications. Use of the synchrotron provided a considerable improvement on existing techniques and surface analysis.

Source: ESRF
Website: www.esrf.fr

Refining Catalysis

The amount of harmful hydrocarbons emitted from fossil fuel car engines is subject to stringent regulations. Since the 1970s catalytic converters have played a role in converting toxic substances such as carbon monoxide to less harmful emissions.

A key part of the catalytic process is the use of cerium oxide (ceria) as a buffer material, which absorbs or releases oxygen depending on the state of the engine. This ensures that the overall operating performance of the converter is optimised.

At the National Synchrotron Light Source in the United States experiments have been carried out looking at the performance of nanoparticles in place of bulk ceria. Using nanoparticles would reduce the amount of ceria needed, reducing cost and improving the overall efficiency of the converter, leading to cleaner air.

Ultrashort bursts of high intensity synchrotron X-rays allowed researchers to examine the “active phase” of catalytic conversion, where carbon monoxide and water combine to produce carbon dioxide and hydrogen gas. This will be hugely significant in the realisation of a hydrogen fuel economy.

Researcher Jose Rodriguez explains, “This kind of knowledge eventually will lead to a rational design of even more effective catalysts.”

Source: NSLS
Website: www.nsls.bnl.gov