# The Fossil Report

Oak Ridge National Laboratory Fossil Energy Program January - February 2001

**Energy Technology for the Future...and for the World**

## ORNL Process Applied to Thermal Barrier Coatings

The Chemical Vapor Infiltration Process, developed on the Advanced Research Materials Program, makes possible the fabrication of fiber-reinforced ceramic composites with high fracture toughness and high strength.

Composites manufactured by this process retain all the high-temperature characteristics which make them exceptional choices for structural components of advanced fossil energy systems.

With this process, complex geometries can be fabricated, making the process valuable for potential applications in recuperators, solid oxide fuel cell components, heat exchangers, combustors, filtration systems, gas turbine components, and burner tubes.

Fossil Energy Program researchers, led by Ted Besmann of the Metals and Ceramics Division, are now focusing their efforts on the development of a chemical vapor deposition process for the fabrication of yttria-stabilized zirconia, or YSZ, for thermal and

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## A Word from the Editor

Recent articles in *The Fossil Report* lacked proper recognition of the DOE Office of Fossil Energy organizations which have generously supported our activities over the years. These omissions were entirely inadvertent, and the Editor sincerely apologizes.

If you have not read the articles listed below, please take a moment to click on the titles and read about some of the exciting work at Oak Ridge National Laboratory, sponsored by DOE Office of Fossil Energy organizations.

**Remote Sensing To Monitor Environmental Change**, November - December 2000. Work sponsored by the **DOE Office of Fossil Energy**, **National Petroleum Technology Office**.

**ORNL and Special Metals to Develop ODS Alloy for Heat Exchanger Tubing**, November - December 2000. Work sponsored by the **DOE Office of Fossil Energy**, **National Energy Technology Laboratory**.

**Ecological Risk Assessments Are Not Just Toxicity Tests Anymore**, September-October 2000. Work sponsored by the **DOE Office of Fossil Energy**, **National Petroleum Technology Office**.

**Hydrogen Separation Membranes Focus of New Project**, July-August 2000. Work sponsored by the **DOE Office of Fossil Energy**, **National Energy Technology Laboratory**.

**Carbon Credits Is Focus of ORNL Activity,** May-June 2000. Work sponsored by the **DOE Office of Fossil Energy**, **National Energy Technology Laboratory**.

**ORNL to Provide Support to Oil Spill Workshops**, May-June 2000. Work sponsored by the **DOE Office of Fossil Energy** .

**Molybdenum_Silicon_Boron Intermetallics Being Developed**, January-February 2000. Work sponsored by the **DOE Office of Fossil Energy**, **National Energy Technology Laboratory**.

**Click** for information on the Fifteenth Annual Conference on Fossil Energy Materials

*The Fossil Report* is published bimonthly by the Oak Ridge National Laboratory Fossil Energy Program.

Send comments to:

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environmental barrier applications.

Yttria-stabilized zirconia is especially suited for thermal barrier coating applications due to its low thermal conductivity and high thermal stability.

Current technology for thermal barrier coatings for high-performance turbine blades utilizes electron-beam-physical-vapor-deposition. The deposits resulting from this process are columnar in nature, resulting in excellent strain tolerance during thermal cycling.

The CVD process for fabrication of YSZ is envisioned as a replacement for the capital-intensive EBPVD process or as a supplement to EBPVD to coat regions that the EBPVD line-of-sight process cannot reach.

In addition, CVD YSZ may have important application as an environmental barrier coating over EBPVD layers.

It is envisioned that the chemical vapor deposition approach will result in a simpler and more advantageous means for depositing YSZ .

Moreover, the process is capable of depositing highly-columnar microstructures, reminiscent of the EBPVD grain structure and, thereby, has similar potential for accommodating thermal mismatch stresses and resistance to spallation.

This work is supported by the DOE National Energy Technology Laboratory, and by the DOE Office of Fossil Energy.

For more information on this work, contact Ted Besmann, Oak Ridge National Laboratory.

The reason people blame things on the previous generations is that there's only one other choice.

## Conference to Cover Wide Spectrum of Research

The Annual Conference on Fossil Energy Materials, the fifteenth in the series, will kick off on April 30, 2001, at the Hyatt Regency Hotel in Knoxville, Tennessee. Researchers from industry, universities, and government laboratories will meet to discuss and review research needs, critical to fossil energy technologies in the 21st century.

Mirroring the evolving face of fossil energy, the conference will cover research goals which address the needs of the Vision 21 concept. Vision 21 is an innovative Department of Energy Office of Fossil Energy concept, which envisions a virtually pollution-free energy plant of the future. The needs of such a plant require ambitious research efforts today.

Membranes for separation and purification, solid electrolyte systems, and novel activated carbon composites will lead the discussions on the first day.

The second day will begin with a session on coatings and protection of materials and continue with a session on advanced alloys in the afternoon. The session on advanced alloys will include materials needs for advanced steam cycle applications, development of oxide-dispersion-strengthened alloys, high-creep-strength alloys, and corrosion and mechanical properties of alloys in combustion and mixed-gas environments.

The Albany Research Center will host a session the morning of the third day on advanced metallurgical processes. Included in this session will be discussions of oxidation- and sulfidation-resistant alloys, oxidation in temperature gradients, erosive wear of materials, advanced titanium processing, microchannel devices, and refractory failures in fossil energy plants.

Ultrahigh performance materials will be the focus of an afternoon session on the third day. Chromium-based alloys, development of Mo-Si alloys, production of silicon carbide fibrils, and nondestructive testing techniques will be covered during this session.

In addition to oral presentations, posters will be on display at the conference, summarizing research on fuel cells, gas separation, gas cleaning, coatings and protection of materials, advanced alloys, oxide-dispersion-strengthened alloys, and ultrahigh performance materials.

For registration and additional conference information, contact Laverne Cash, Conference Coordinator, at 865-576-7270.

Conference information will also be available in the near future on the ORNL Fossil Energy Program Web site.

## Agreement Signed for Fabrication of Filter Elements

The Oak Ridge National Laboratory Fossil Energy Program, Bechtel-Jacobs Company, LLC's Inorganic Membrane Technology Laboratory, and Pall Corporation have signed a Cooperative Research and Development Agreement to explore and develop advanced manufacturing techniques to fabricate sintered iron-aluminide metal porous bodies used for gas filtration.

The objective of this effort is a reduction of production costs, while maintaining or improving performance in advanced coal gasification and combustion systems.

Removal of particles from the hot gases produced by coal gasification or combustion is vital to the successful operation of advanced energy systems...

Pall Corporation, located in East Hills, New York, is a specialty materials and engineering company with broad-based filtration and separations capabilities, and, in fact, is a world leader in filtration technology.

The Inorganic Membrane Technology Laboratory has considerable expertise in the production of porous materials. The facilities in the IMTL can produce porous objects in many shapes and sizes.

The ORNL Fossil Energy Program has been developing iron aluminide alloys for the past eighteen years, with particular interest in recent years in the manufacture, application, and testing of iron aluminides for gas filtration applications.

Removal of particles from the hot gases, produced by coal gasification or combustion, is vital to the successful operation of advanced energy systems at the high efficiency and low emission levels necessary to meet the Vision 21 goals of the Office of Fossil Energy. Hot-gas filtration is critical for these power systems, since the integrity and performance of downstream turbine and heat recovery components depend on durable and reliable hot-gas filters to prevent damage and expensive loss of service.

Materials used in hot-gas filters are required to withstand prolonged exposure to corrosive, high-temperature gaseous environments as well as to condensable vapors and solid species, some of which may have the potential for localized interaction with the filter material after extended times.

Iron aluminides are excellent candidates for such applications, because they offer reliability advantages over ceramic-based filters and typically have good-to-exceptional high-temperature corrosion resistance in a variety of sulfur-bearing environments relevant to coal-derived energy production systems.

*Artist's concept of a Vision 21 pollution-free energy plant - Courtesy U.S. Department of Energy*

Sintered metal filters have been fabricated from such alloys and have been exposed in a variety of test beds and are being used in actual particle filtration systems. Pall Corporation has recently developed and commercialized filter elements and systems made of iron aluminides; however, the cost of producing these filters is greater than that of comparable stainless steel ones.

Furthermore, the current manufacturing process for iron-aluminide filters is limited to production of short segments, which must be joined by welding to fabricate a typical filter element.

Pall Corporation currently uses an advanced manufacturing method to produce sintered metal filter tubes (stainless steel) of much greater length than can be achieved using Pall's traditional processing and fabrication procedures. This process, more economical than traditional processing, was developed in collaboration with the Inorganic Membrane Technology Laboratory (IMTL), based on the latter's expertise in membrane manufacturing techniques.

There appears, therefore, to be promise for the application of similar manufacturing approaches to iron aluminides. Such an achievement would provide a method of producing hot-gas filters more economically by reducing the number of processing steps and eliminating the need to fabricate segmented elements.

It is anticipated that the partnership of these three organizations will provide the stepping stones along the path to this important goal.

This work is supported by the DOE Office of Fossil Energy, National Energy Technology Laboratory.

For more information on this work, contact Peter Tortorelli, Oak Ridge National Laboratory.

## Vast Hydrate Formation Discovered Off Carolina Coast

Scientists aboard the **Ocean Drilling Program's** *JOIDES Resolution* have discovered a massive methane hydrate formation off the Carolina Coast in an area known as Blake Ridge.

This discovery can have significant implications to the nation's energy resources, especially in these times of increasing and gas prices.

The Ocean Drilling Program, an international partnership of scientists and research organizations has the charter to study the structure of the earth to gain an understanding of the earth's evolution and, as a result, of its future.

> ...this location alone could meet the natural gas needs of the United States for the next 105 years.

Over the more than fifteen years of voyages around the world's oceans, the ODP has amassed a extensive database of geological and environmental information from the substructure beneath the sea.

Charles Paull, then the chief scientist on the **expedition to Blake Ridge** and now with the Monterey Bay Aquarium Research Institute in California, predicts that the methane resources in this location alone could meet the natural gas needs of the United States for the next 105 years.

Located 2,800 feet below the surface of the Atlantic Ocean, the sediment which was extracted contained 40 liters of 99%-pure methane for each liter of sediment.

Paull estimates that there are 35 gigatons of methane carbon in the part of the Blake Ridge which was explored—representing about 7 percent of all carbon stored on land.

A future expedition of the *JOIDES Resolution*, planned for August 2002, will take scientists off the Oregon coast to what is suspected to be an even greater repository of gas hydrates.

The formation is appropriately named Hydrate Ridge.

Hydrate Ridge is significantly different from Blake Ridge in its geological structure. Hydrate Ridge is an accretionary complex.

Simply stated, this means that, in this geological region, the edge of one tectonic plate descends below another. In such situations, geologists know that hydrate-rich sediments are more likely to form.

*A nearly-pure piece of gas hydrate, 5 cm x 14 cm, white colored and coated with greenish-gray drilling slurry.* ***Courtesy Ocean Drilling Program***

In fact, sampling off the Oregon coast in 1996 revealed the presence of massive hydrate deposits.

The mechanisms of hydrate formation will be studied in two distinct sedimentary and tectonic formations during this expedition.

Explorations such as these represent the very early stages of research. The process of inventorying the world's gas hydrate reserves could easily last for many years.

Scientists and government officials alike agree, however, that, if gas and oil prices remain high, the schedule for commercialization and harvesting of this extraordinary energy storehouse far beneath the world's oceans could be just around the corner.

*The* ***JOIDES Resolution****, a marine research vessel unlike any other vessel in the world, is an integrated drilling platform and laboratory. JOIDES Resolution is 470 feet in length and has a drilling system which can handle 30,000 feet of drilling pipe. This capability allows this research to be carried out in 99.9% of the world's oceans.*

*With a computer-controlled stabilizer system and an acoustic beacon placed on the ocean floor near the drill site, the vessel is able to remain over the drill hole, in spite of rough seas and high winds, and to drill in waters up to 5 miles deep.*

*Courtesy* ***Ocean Drilling Program***