ATR
National Scientific User Facility

The Energy of Collaboration

April 2011 Bimonthly Report

Accomplishments and Look Ahead

March 2011

- Hosted Raymond Cao from OSU as NSUF/CAES colloquium speaker. Dr. Cao made a presentation on "The Use of External Neutron Beam for Characterization and Testing of Materials for Nuclear Reactors."
- ATR-NSUF Industry Advisory Committee (ANIAC) meeting in Charlotte, NC.

April 2011

- ATR-NSUF hosted a workshop on irradiation testing at Student ANS meeting at Georgia Tech. Approximately 12 students attended and all were new to the NSUF.
- Participated in the National User Facility Organization (NUFO) exhibit to Congress. This inaugural exhibit hosted posters from all of the DOE User Facilities, including ATR NSUF. The exhibit was staffed by Todd Allen and Dr. Meimei Li of Argonne National Laboratory. According to NUFO organizers, the members of Congress who attended were very interested in what they saw and have asked for additional information.

May 2011

- UCSB-2 capsule planned for insertion.
- Host Klaus van Benthem from UC Davis as NSUF/CAES colloquium speaker May 9.
- Drexel static capsule insertion.

Noteworthy News

TMS Meeting Recap

The Minerals, Metals and Materials Society (TMS) 2011 Annual Meeting, February 28 – March 3, in San Diego, California turned out to be the perfect forum for promoting ATR NSUF to TMS members and students alike. ATR NSUF has staffed a booth at TMS meetings for several years and through the interactions, has found a unique audience for its capabilities. However, this year's meeting opened several other avenues for TMS members and students to learn about ATR NSUF.

Todd Allen Chaired a session titled "Material Science Advances Using Test Reactor Facilities" to help promote the idea of reactor testing research to interested meeting participants. A number of principal investigators presented research findings from their ATR NSUF experiments including: Dr. K. L. Murty, North Carolina State University; Dr. Kumar Sridharan, University of Wisconsin; and Dr. G. Robert Odette, University of California, Santa Barbara. Since many TMS faculty members and their students may not have considered nuclear energy as a research area these kinds of opportunities help promote the NSUF as a potential entryway into this exciting field.

ATR NSUF also sponsored awards for student oral- and poster presentations. These awards were announced at the "Microstructural Processes in Irradiated Materials Symposium." Six oral presentations and two poster presentations were awarded $500.00 for being judged as outstanding. Two oral presentations were awarded honorable mention. Please join us in congratulating the following students.

<u>Outstanding Oral Presentations:</u>

- Leland Barnard, University of Wisconsin, "Ab Initio-Based Rate Theory Modeling of Radiation Induced Segregation in Ni-Cr Alloys"
- Anne Campbell, University of Michigan, "Proton Irradiation-Induced Creep Effects in Pyrolytic Carbon and Graphite"
- Nicholas Cunningham, University of California, Santa Barbara, "On the Stability of Nanofeatures in Nanostructured Ferritic Alloys and the Effects of Long Term High Temperature Thermal Aging and Friction Stir Welding"
- Cem Topbasi, Pennsylvania State University, "In-situ Investigation of Microstructure Evolution in NF616 and HCM12A Alloys under Heavy Ion Irradiation"
- Cheng Xu, University of Michigan, "Stress, Temperature, and Dose Rate Dependence of Proton Irradiation Creep of Ferritic-Martensitic Steel T91"

ATR
National Scientific User Facility

- Bei Ye, University of Illinois, "The Influence of Temperature on the Evolution of Irradiation-Induced Defect Structure in CeO_2"

Honorable Mention Oral Presentations:

- Wei-Ying Chen, University of Illinois, "Stoichiometry Dependence of the Evolution of Irradiated-induced Defect Xlusters in $Ce_xLa_{1-x}O_2$
- Janelle Wharry, University of Michigan, "Application of Modified Inverse Kirkendall Model of Radiation-Induced Segregation to Ferritic-Martensitic Alloys"

Outstanding Poster Presentations:

- Akira Kuramoto, Tohoku University, "Effects of Irradiation Dose on Microstructural Evolution and Hardening of High- and Low-Cu Reactor Pressure Vessel Steels"
- Rannesh Lokesh, University of Illinois, "Microstructural Evolution of Cu based Complex Alloys Under Prolonged Particle Irradiation"

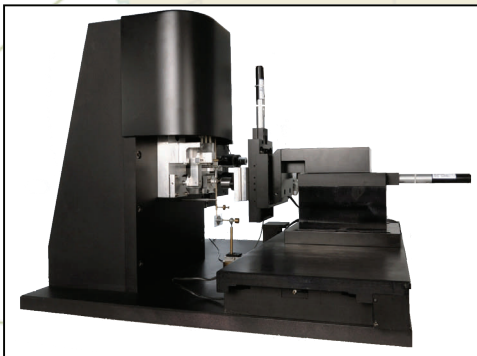
Two New Partner Facilities Join ATR NSUF

Workers refuel the HFIR at Oak Ridge National Laboratory, one of two new partner facilities to join the ATR NSUF.

We are pleased to welcome two new partner facilities to the ATR NSUF - Oak Ridge National Laboratory (ORNL) in Tennessee and the University of California, Berkeley. Partnerships like these increase access to national irradiation and testing capabilities and provide greater flexibility to respond to user needs. The user facility now includes eight partner facilities located throughout the United States.

"The ATR National Scientific User Facility gives university and industry scientists unprecedented access to the nation's most capable nuclear research facilities," said Todd Allen, the user facility's scientific director. "We're pleased to count Berkeley's and Oak Ridge's unique capabilities among those available to our users."

The new partnerships will make ORNL's High Flux Isotope Reactor (HFIR) and its associated capabilities available to the ATR NSUF users. The HFIR is a versatile, 85-megawatt isotope and test reactor that provides one of the highest steady-state neutron fluxes of any reactor in the world. Irradiation experiment facilities include a wide variety of test positions, a hydraulic shuttle and the capability for multiple instrumented target positions. Target fabrication, hot cell facilities for the examination of nuclear fuels and irradiated materials, the Radiochemical Engineering Development Center, and a set of special radiological laboratories at ORNL will also join the partnership. HFIR is operated by DOE, Basic Energy Sciences.



The nanoindentation system is one of several capabilities new partner facility UC Berkeley will bring to the ATR NSUF.

UC Berkeley also will bring several capabilities for examining irradiated material samples. Its facilities include a nano-indentation system for nano- and microscale hardness testing at ambient and elevated temperature and inert environments, positron annihilation spectroscopy, and warm sample preparation.

ATR
National Scientific User Facility

"We strongly believe in using existing capabilities across the United States to efficiently support the research and development needs of the NSUF customers," remarked Todd Allen. INL's ATR, its post-irradiation examination capabilities, and the partner facilities offer some of the most advanced nuclear fuels and materials testing and examination capabilities in the country. Congratulations to our two new partners! We look forward to working with you!

MIT Makes Progress on ATR NSUF-awarded UCB Hydride Fuel Irradiation Experiment

Gordon Kohse, Kurt Terrani, David Carpenter (l-r) assemble rodlets at MIT for the University of California, Berkeley Hydride-Fuel Irradiation ATR NSUF experiment.

The University of California, Berkeley (UCB) Hydride Fuel Irradiation (HYFI) experiment "Light Water Reactor Hydride-Fuel Irradiation," awarded by ATR NSUF in January 2010, is making progress in its research on the potential use of uranium-zirconium hydride fuel pellets with Zircaloy™ cladding in light water reactors. In mid-March, experimenters successfully inserted the UCB HYFI experiment into the MIT reactor core, performed the initial check of the instrumentation, and completed preparation for startup. Leading the experiment are UCB principal investigators Drs. Donald Olander and Mehdi Balooch. Collaborator Dr. Gordon Kohse of MIT explained the implications this project can have on the field of nuclear engineering. "This experiment looks into the possible advantages of hydride fuel over the current oxide fuel in commercial power reactors. In boiling water reactors, hydride fuel could lead to higher power density (more power from the same size core) and simplified fuel designs. Hydride fuel could improve the ability of both boiling and pressurized water reactors to burn plutonium," said Kohse.

Last December, Oak Ridge National Laboratory collaborator Kurt Terrani, Dr. Gordon Kohse, and post-doc David Carpenter assembled rodlets at the MIT Reactor (MITR) for the UCB Hydride Fuel Irradiation experiment.

MIT received five zircaloy-clad fuel rodlets with uranium-zirconium hydride fuel from UCB in August of 2010. Four of the rodlets were already filled with a lead-bismuth eutectic (LBE) bond (the fifth will use only a helium fill gas) and three had holes drilled into the center of the pellet stack for thermocouple insertion. Dr. Kohse explained that LBE was used in these rodlets because "it is a low melting point alloy that is compatible with both the fuel and the cladding and is used to enhance the heat transfer between the fuel and cladding, thus keeping fuel temperatures lower."

One of the rodlets was reserved for use with the new INL transient hot wire probe. This rodlet was transferred to a MITR hot work hood and, using the proposed probe dimensions, a hole was hand-tapped through the LBE. The 2.2 mm outside diameter (OD) hole tip is in a hollow channel in the central pellet with a larger OD upper section to accommodate the upper section of the probe. This rodlet was then re-sealed with a temporary flange until the probe is ready to be inserted in the rodlet.

The team loaded the other three bonded rodlets into a helium-filled glove box and removed their temporary flanges. They then cleaned and checked the stainless steel flanges, which already had a thermocouple in-

ATR
National Scientific User Facility

serted through their center and welded into place, for function and dimensions. Rodlets were matched with their flange based on the length of the thermocouple end and the depth to the central pellet. The flanges were then sealed with copper O-rings under the helium atmosphere (~0.2 psi), and the function of the thermocouples verified before returning the rodlets to storage pending insertion in their outer capsule. The helium atmosphere established in the rodlets by this procedure is necessary to avoid reactions of the fuel, bond and cladding material with oxygen during irradiation.

Rodlet as received at MIT with blank flange (thermocouple not yet installed) and protective shipping sleeve.

Two sample fuel rods have been irradiated in the MITR since March and a third fuel rod will be added in May. This third rod is scheduled to have a short exposure and will be removed later this year so the research team can gather information about changes to the fuel in the early part of its life. The other two samples will continue to be irradiated until approximately May 2012 and samples will be taken at various exposure levels throughout that irradiation period. After irradiation, the samples will be shipped to the Idaho National Laboratory for post-irradiation examination.

By doing research with the ATR NSUF, partner facilities such as the MITR are adding new capabilities to their own facilities. ATR NSUF funding was instrumental in the development of a new type of in-core experimental facility at the MITR that offers high temperature irradiation in an inert gas environment up to 900 °C. “This new type of irradiation facility is designed for temperatures ranging from 500 to 900°C and should appeal to those who conduct high temperature reactor materials and instrumentation testing,” said Dr. Lin-wen Hu, Associate Director of the MIT Nuclear Reactor Laboratory (NRL). Collaboration related to this facility is continuing, with INL-developed irradiation-resistant thermocouples being used and evaluated in an irradiation for another user. This is just one of many examples that shows the mutually beneficial relationship between the ATR NSUF and its partner institutions. While this UCB HYFI experiment is not directly related to the MITR new high temperature in-core irradiation facility, Dr. Kohse still commented on the benefits of working with the ATR NSUF. “This UCB HYFI experiment builds and improves on prior experience irradiating a novel fuel form in the MIT reactor,” he said.

Another great aspect of the ATR NSUF is the ongoing trajectory research can take. “ATR NSUF helps support training and education,” stated Dr. Hu. David Carpenter’s experience is a great example of the benefits students can receive working with the ATR NSUF, in particular the potential for future research opportunities. David started working with the ATR NSUF as a PhD candidate on Dr. Kazimi’s SiC project. He is now working as a post-doc on the UCB Hydride Irradiation project. “The ATR NSUF helped to fund the experiment that made my PhD possible at a time when experimental research projects were difficult to find,” said Carpenter. “I am now able to contribute to several ATR NSUF experiments in my professional work, and this has expanded my opportunities to work with other researchers and organizations.” Collaboration among students, researchers, universities, industry, and national laboratories, such as seen with David Carpenter, is one of the key benefits of the ATR NSUF.

Matt Mahowald (radiation protection), Kurt Terrani and David Carpenter preparing rodlets for thermocouple insertion in a fume hood at MIT.