Topcon SEM and SEM image of fracture surface in irradiated Mo-Re alloy.

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Physical Properties Analysis

Physical, thermal, and electrical properties can also be measured. A partial listing of equipment and capabilities includes:

- *Four-point probe electrical resistivity*: The measurement of electrical resistivity allows for non-destructive evaluation of changes in microstructure as well as information on radiation-induced changes on electrical and thermal properties.
- *Mitutoyo automated microhardness*: Either Vickers or Knoop can be measured automatically using 10 g to 2.5 kg loads.
- *Density measurement*: Density can be accurately measured using density gradient columns for densities up to 3.2 g/cc with accuracy to 1 mg/cc (0.1% error). Immersion density can be used on microtensile or other specimens larger than 3 mm diameter with accuracy to < 0.4% error.

Other Instrumentation and capabilities

- *Scanning electron microscope*: X-ray capability and digital data acquisition and analysis provide key information on fracture mode. An in-vacuo tensile testing stage with digital movie image capture allows for unique testing configurations.
- *Optical microscopy*: In addition to SEM analysis, optical microscopy and digital data acquisition capabilities are also available.
- *Furnaces*: Several furnaces are available for heat treating radioactive specimens.
    - Air furnace: Capable of 1200°C.
    - Vacuum furnace: Capable of 1000°C in vacuum of 10^{-6} torr.
    - High Vacuum furnace: Capable of 2500°C in vacuum of 10^{-7} torr.
- *Metallography*: Slicing and polishing facilities are available for preparing ceramic and metallic samples of various sizes. Disc punches are also used to create transmission electron microscopy specimens.

Low Activation Materials Development and Analysis Laboratory

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

UT-BATTELLE

History of the LAMDA Facility

The Low Activation Materials Development and Analysis (LAMDA) facility was originally created as a laboratory for plutonium studies. With the increased interest in graphite for high temperature gas cooled reactors in the 1960's, the emphasis of this laboratory shifted to the measurement of thermophysical properties in graphite irradiated at various US fission reactors. The irradiated graphite research effort decreased in the 1980's due to dwindling funding. Over the past ten years, several key programs have increased their emphasis on the basics of radiation effects and the development of so-called "low activation" materials. As a result, the materials to be studied were of lower radiological threat, allowing materials to be evaluated in a less restrictive environment than the hot-cells typically used for the previous nuclear programs. For this reason the LAMDA facility became a primary facility for materials evaluation. This laboratory is now actively used by many different programs covering a wide range of testing, sample designs, and materials.

View of the LAMDA Laboratory

Description of the LAMDA facility

The LAMDA facility is a set of multipurpose laboratories for evaluation of materials with low radiological threat. As a guideline, samples must have gamma/beta activity corresponding to a dose of less than 60 mR/hr (at one foot). A low level of alpha contamination is acceptable. Alpha containing samples are considered non-routine and handled on a case-by-case basis. All materials to be observed in the facility are accepted from one of the ORNL hot-cells (predominantly 3025E, 3525, and 3047), with the radiological hazards previously identified. Once in LAMDA samples undergo a further radiological screening and decontamination. At this point the materials are catalogued and stored in the lead-lined storage vault within the facility.

The most commonly conducted work includes mechanical testing, optical and scanning electron microscopy, densitometry, metallography, thermal and electrical conductivity. A list of equipment is provided below. Other activities not previously conducted are possible with the appropriate planning and interface with health physics and the ES&H organization. It is routine for customers outside of the lab to visit during testing to inspect activities. Longer-term visitors can be trained to conduct testing within LAMDA.

LAMDA Testing Capabilities

There is an extensive set of equipment currently operating and permanently residing in LAMDA. Where appropriate all equipment is routinely calibrated to NIST traceable standards by Instrument and Controls Staff, meeting rigid quality assurance standards. Additional equipment can be moved in and out of LAMDA on a campaign basis.

MTS Testing System

Mechanical Properties Testing

A wide range of mechanical property tests can be performed, including tensile, compression, and fracture toughness. Four machines are currently available. All systems have digital data acquisition systems.

- *Refractory Element Test Stand (UTS)*: Primarily for tensile testing, this machine is capable of tensile testing in vacuum as low as 10^{-7} torr, load ranges from 25 to 1000 pounds. The molybdenum cage furnace is capable of temperature from ambient to 1300°C.
- *Refractory Element Test Stand (Instron)*: This instrument is used for tensile and fracture toughness testing in vacuum to low 10^{-6} torr at up to 1000ºC. Loads range from 25 to 500 pounds.
- *MTS Frame*: This 1000 lb frame is used in air or nitrogen cover gas with the testing temperature ranging from liquid nitrogen to 400°C.
- *MTS Frame:* This system has a 1000 lb frame for testing in air at room temperature or a clamshell furnace (800°C) under cover gas.