Commissioning of the Irradiated Materials Characterization Laboratory

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The Irradiated Materials Characterization Laboratory (IMCL) is a nuclear research user facility designed for the characterization of the microstructure and properties of high activity nuclear fuels and materials. The 1114 m^2 (12,000 ft^2) laboratory consists of a single bay and a support wing designed to provide a suitable environment for the operation of high resolution scientific instruments. The open laboratory bay allows shielded instrument installations to be reconfigured to adapt to advances in instrumentation over the expected 40+ year life of the facility. Installation of the initial suite of shielded instruments began in 2015 and will be completed in early 2019. IMCL operation began in 2017, balancing scientific exploration with construction activities.

IMCL Instruments and Equipment

Transfers and Sample Preparation. Materials to be examined in IMCL are typically transferred into the Shielded Sample Preparation Area (SSPA) using a transfer container with an internal volume of approximately 1,000 cm^3 shielded with 10 cm of lead, consistent with IMCL's focus on detailed characterization of smaller samples of material. The (SSPA) consists of three lead shielded compartments, an inert atmosphere glovebox, and an airflow hood containing sample preparation equipment and an optical microscope. Radiation dose rates from samples may be measured in the SSPA sample transfer cell. If dose rates can be reduced sufficiently by size reduction, samples may be prepared in the glovebox and transferred to instruments using the air hood and a lightly shielded container.

Instruments

Shielded instruments currently in service consist of a FEI Helios dual beam Plasma FIB (Focused Ion Beam), a FEI Quanta dual beam FIB, and a Cameca SX100 R shielded microprobe. Because IMCL is focused on the examination of irradiated nuclear fuel, sample materials typically contain significant amounts of alpha- and beta-bearing material as well as high energy gamma emitters. Shielding and contamination control (confinement) functions are distinctly separated for the purpose of allowing easy access to the instruments for maintenance and modifications (Figure 5). Shielding for each instrument is provided by a 21.6 cm (8.5 inch) thick steel wall with a height of 2.1 m (7 feet), designed to provide worker protection from samples with dose rates equivalent to 7.4×10^{10} Bq (2 Ci) of ^{60}Co. Confinement of alpha and beta contamination is provided by an inert atmosphere glovebox. The glovebox is mounted inside of the shielded room adjacent to the front shield wall.

Leaded glass windows installed in the front shield wall provide visibility of the inside of the glovebox, instrument loading device, and sample transfer port. Transfers of material into instrument gloveboxes are made through a rapid transfer port without breach of confinement. Samples to be examined are loaded from the glovebox to the instruments using custom sample transfer apparatus and telemanipulators. Each instrument station also contains a sputter coater.

A shielded cell dedicated to the measurement of thermal properties is currently being installed. This cell will include instruments for temperature dependent measurement of thermal diffusivity, heat capacity, and dilation; sample dimensions and mass; and direct measurement of thermal conductivity using surface reflectivity (Hurley et al., 2015). One additional space in IMCL is reserved for a future shielded instrument.

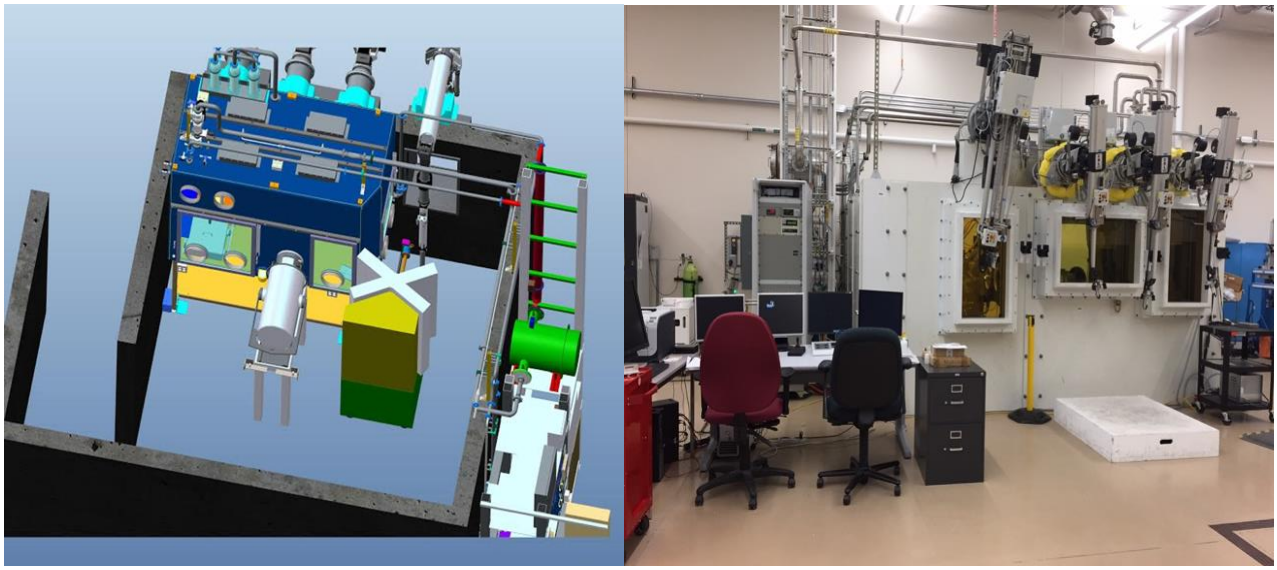

Figure 5: Left - Schematic of shielding and confinement system for IMCL scientific instruments. Gray denotes steel shield walls, blue denotes the confinement glovebox, and yellow/green an electron beam instrument. The IMCL shielded transfer container, depicted in silver, is attached to the center of the glovebox. Right - Photograph of the installed EPMA (Electron Probe MicroAnalysis) shielded cell.

In addition to the shielded instruments described above, IMCL houses an FEI Titan Themis 200 ChemiSTEM, Bruker D-8 micro XRD (X-Ray Diffraction) system, and a PANalytical Empyrean XRD.

Installations in progress include a JEOL 7600 FEG-SEM and a Quantum Design Physical Property Measurement system. A Zeiss Xradia micro computed tomography system will be installed in 2019.

Reference

Hurley, D. H., Schley, R. S., Khafizov, M., & Wendt, B. L. (2015). Local measurement of thermal conductivity and diffusivity. *Review of Scientific Instruments*, *86*(12), 123901.