NanoWestern

Western Science

Issue 2 2020

Dear Western Nanofabrication Users,

In a few weeks, we will turn the page of 2020, a difficult year for all of us, that has affected all our families, students, and ongoing research projects.

Since June 15th, we have reopened the Facility keeping a safe environment despite reducing our training capacity in the first months of the reopening. Since then, we have created and shared with you a series of tutorials, video and reference documentation that you can access through OWL. These multimedia supports are important for new users to consult or for existing users as a refresher prior to instrument booking. They do not replace hands-on training on the most complex instrumentation which has been resumed on a one-to-one basis. We will continue to develop and improve these training videos to improve our training capabilities. In parallel, we have enhanced our service capability and our team is available for sample characterization and nanoscale fabrication projects.

A NSERC-RTI grant obtained in the spring 2020 will enable the modernization of a second electron-beam evaporator to deposit a variety of high-quality thin films. We have also modernized our Ellipsometer with a computer and software upgrade. We are striving to continue providing you a privilege access to all nanofabrication and characterization instrumentation in the safest environment. Your input and needs about the available tools and service are therefore very important to us for future grant applications and developments of your research projects.

Please contact us for any question related to your sample nanoscale characterization and fabrication.

With our best wishes,

Francois Lagugne-Labarthet,

Scientific Director, Western Nanofabrication Facility.

Using the Focused Ion Beam to Reveal Corrosion Product Morphology

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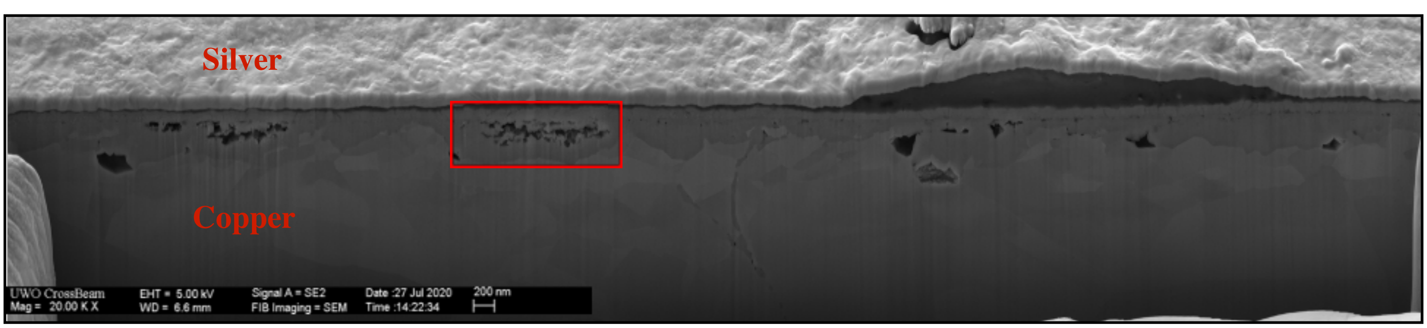
In Canada, approximately 2.9 million fuel bundles require long term disposal [1]. The fuel bundles are currently being stored in wet and dry storage. A long-term storage solution is needed to safely contain the used nuclear fuel (UNF), as the chemical toxicity persists for hundreds of thousands of years. As per international consensus on the best practice for managing UNF, the Nuclear Waste Management Organization (NWMO) plan is to isolate and contain UNF within a multiple-barrier system, underground in a deep geological repository (DGR). In the proposed design, used fuel bundles will be sealed in copper-coated carbon steel used fuel containers (UFC), encased in blocks of highly compacted bentonite clay, and emplaced ~500 m below ground in the DGR [2].

Due to bentonite's small pore size, high swelling pressures, and cation exchange properties, the bentonite will significantly limit the transport of active species to and, in the case of a UFC failure, from the UFCs [3, 4]. The high swelling pressure can suppress potential UFC corrosion induced by sulphate reducing bacteria (SRB), which produce sulphide as a metabolite, by decreasing the clay pore space and lowering water activity necessary for their metabolic activity [5-7]. My project investigates the effect of bentonite dry density, oxygen availability, and the evolution of conditions on the corrosion of copper in contact with bentonite, in addition to SRB viability as a function of water composition and bentonite dry density. To evaluate this, copper coupons are embedded in compacted bentonite material and pressurized to 10 Mpa with Type-1 water for varying durations.

After exposure, copper specimens are analysed using various microscopy and spectroscopy techniques, including Focused Ion Beam (FIB) cutting at the Western Nanofab. Silver was electrodeposited on a small area of the copper coupons surface to prevent any curtaining effects, and the FIB cut was taken in this area. FIB cutting is used to cross-sect a small area of the surface to be analyzed using scanning electron microscopy (SEM) for the corrosion product's morphology.



The FIB cut of a cold-spray copper coupon that was embedded in bentonite clay (compacted to a dry density of 1.1 g/cm³) for three months is shown above.

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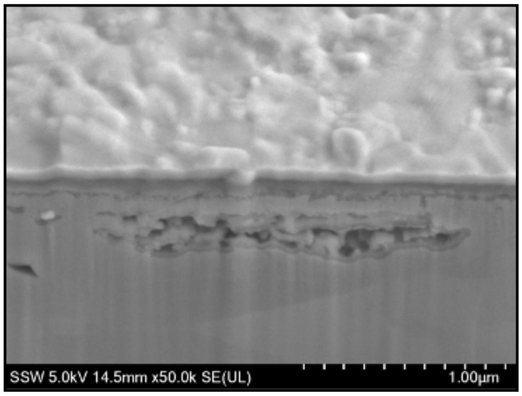
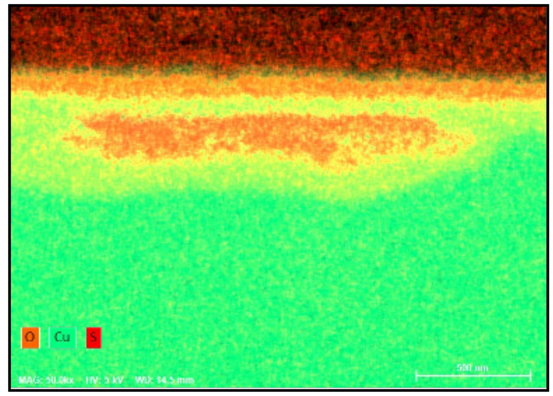
FIB reveals the corrosion product beneath the surface that would otherwise not be observed when using top-down analysis methods. Here, we can see a uniform layer across the sample with areas of damage reaching further into the bulk. When coupled with energy dispersive X-ray spectroscopy (EDX), elemental distribution can be determined. Examples of this technique coupling are shown below:





References:

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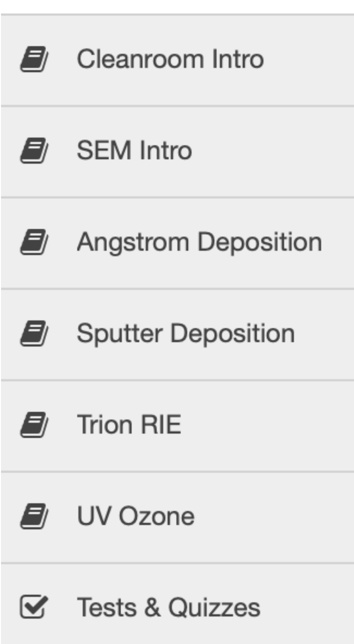
2. J. Noronha, Deep Geological Repository Conceptual Design Report Crystalline/Sedimentary Rock Environment, NWMO, Canada, APM-REP-00440-0015 R001, 2014.
3. A. Seiphoori, Thermo-hydro-mechanical characterisation and modelling of Wyoming granular bentonite, EPFL, TR 15-05, 2015.
4. D. Dixon, Review of the T-H-M-C Properties of MX-80 Bentonite, NWMO, Canada, TR-2019-07, 2019.
5. S. Stroes-Gascoyne, C.J. Hamon, D. Priyanto, D. Jalique, C. Kohle, W. Evergen, A. Grigoryan, D. K. Kober, Microbial Analysis of a Highly Compacted Wyoming MX-80 Bentonite Plug Infused Under Pressure with Distilled Deionised Water over a Period of Almost Eight Years, NWMO, Canada, TR-2014-20, 2014.
6. C. J. Hamon, S. Stroes-Gascoyne, P. Maak, S. Russell, Applied Clay Science 2010, 47 (12), 155-162.
7. A. Brown, Microbial water stress physiology. John Wiley & Sons: Chichester, UK, 1990.

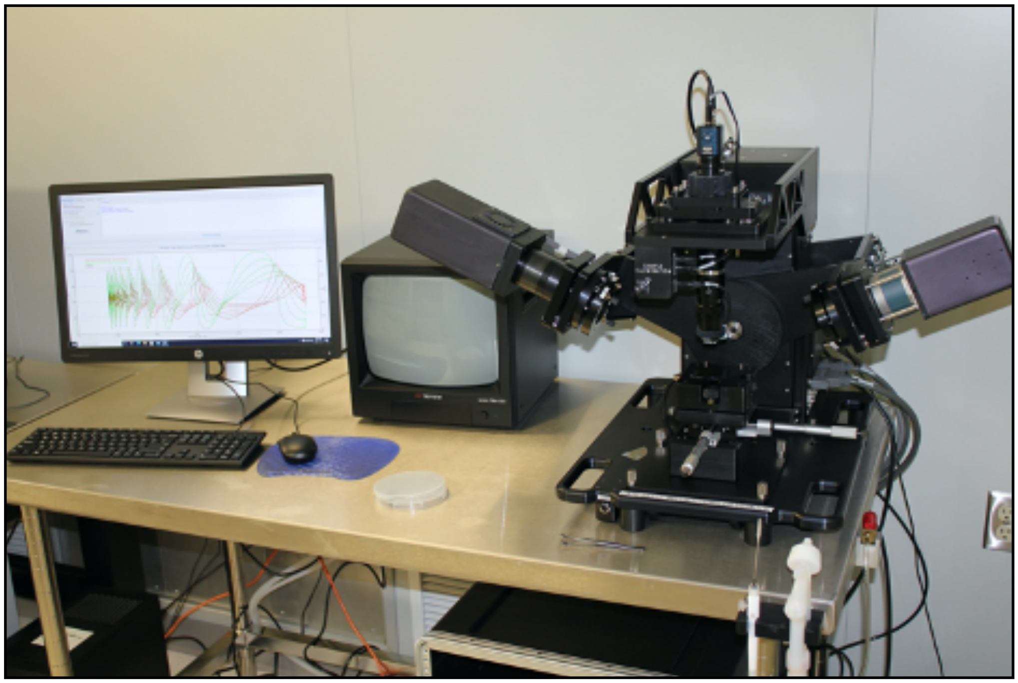


Training Videos Are Now Available on OWL

We are pleased to announce the creation of a series of instructional videos and procedures for instruments at the Nanofab. The videos and procedures are now posted on OWL. They are available for all users of the Nanofab as well as PI's. When you log into OWL, you will now see a "Western Nanofabrication Facility" site has been added to your available content. Our goal is to have online video tutorials and operating procedures available for all of the instruments in the cleanroom and wet lab.

Instrument Updates at the Western Nanofabrication Facility

Ellipsometer



The J.A. Woolam M-2000 Variable Angle Spectroscopic Ellipsometer (VASE) was purchased in 2007 and although the instrument itself continues to work well, the associated computer (still running Windows XP) was in need of replacing with a new Windows 10 PC. We have taken this opportunity to also update the analysis software to J.A. Woolam's CompleteEASE package which provides a more user-friendly interface for new or occasional users than the prior WVASE package.

HOSER Experimental e-beam Evaporator

Thanks to a successful NSERC RTI (Research Tools and Instruments) grant, we will be able to replace the ancient deposition hearth, power supply and control electronics in this workhorse system.

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