The Canadian Centre for Electron Microscopy provides world-class electron microscopy capabilities and expertise. We are the go-to provider of electron microscopy services to Canadian industry and researchers working in a broad range of fields. Located at McMaster University and operated by the Brockhouse Institute for Materials Research, the CCEM features state-of-the-art instrumentation and experienced, dedicated staff who are happy to work with you to find solutions to your materials research and development questions.

Nuclear

Materials in nuclear applications undergo unique stresses and degradation mechanisms, and their reliability is uniquely important. Electron microscopy at the CCEM can provide structural and analytical information from phase identification to grain boundary segregation and precipitate and oxide analysis. Our staff have the experience in nuclear materials research required to successfully investigate a wide range of physical and chemical degradation processes.

We can provide

- identification and analysis of oxides, corrosion products
- crack measurement and nanochemical analysis
- texture, orientation, misorientation
- grain and phase identification, size/volume analysis

> “[Atom Probe Tomography] can provide a sub-nanometer level spatial resolution and excellent elemental sensitivity for nano-scale volumes of material... to study the mixed metal and oxide microstructure of internally oxidized Alloy 600.”
>
> **Langelier** 2016

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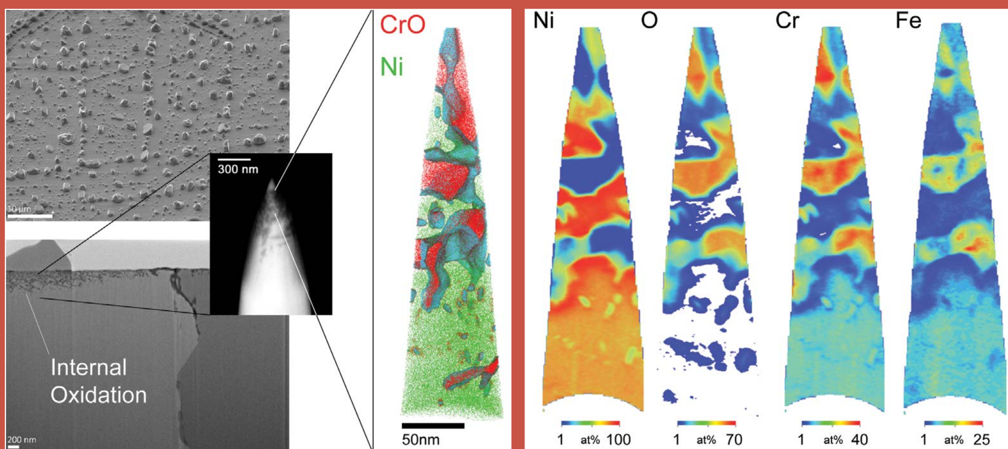
Investigating internal oxidation in Alloy 600 steam generator tubing

Under certain conditions, the oxidation of Ni Alloy 600 can occur internally by the inward diffusion of O, which reacts with the solute elements Cr and Fe, and expels Ni out from the surface. Atom probe tomography (APT) analysis of the internally-oxidized material in the sub-surface grains shows the resultant microstructure to consist of a nanoscale mixture of oxides and Ni-rich metal. Composition mapping reveals Cr-rich cores in the oxides, providing insight into their formation during internal oxidation. This result showcases the atom probe's unique ability to provide 3D data with a combination of high spatial and elemental resolution.

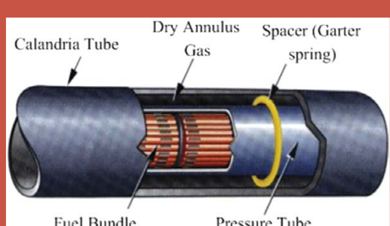


Atom probe tomography (APT) analysis of the internally-oxidized material in the sub-surface grains shows that the resultant microstructure consists of a nanoscale mixture of oxides and Ni-rich metal.

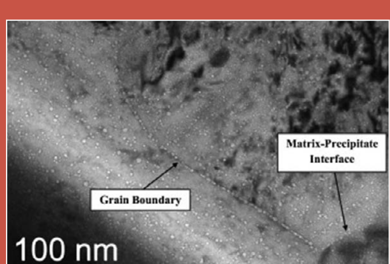
REFERENCE An atom probe tomography study of internal oxidation processes in Alloy 600, B. Langelier, S.Y. Persaud, R.C. Newman, G.A. Botton, Acta Materialia 109 (2016) 55-68

Investigating reduced ductility of Inconel after irradiation

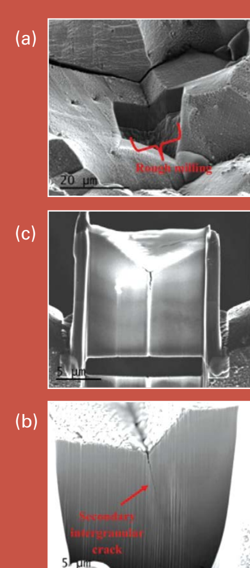
Inconel spacers have reduced ductility and load carrying capacity after irradiation, possibly due to helium bubbles that build up along grain boundaries. It has been suggested that the bubbles contribute to intergranular cracking. TEM imaging reveals helium bubbles in the matrix and at grain boundaries and careful manipulation of the imaging conditions by experienced CCEM staff allows measurement of their size. Intergranular fracture surfaces have been imaged, revealing features indicating that the decrease in strength of the grain boundaries is linked to the presence of the helium bubbles.



Cross section schematic of a fuel channel in a CANDU reactor.



TEM micrograph showing bubble alignment on grain boundaries and matrix–precipitate interface after irradiation.



TEM sample preparation from the intergranular fracture surface, (a) after rough ion beam milling, (b) higher magnification showing secondary intergranular crack, and (c) final TEM lamella.

REFERENCE Intergranular fracture in irradiated Inconel X-750 containing very high concentrations of helium and hydrogen, Colin D. Judge, Nicolas Gauquelin, Lori Walters, Mike Wright, James I. Cole, James Madden, Gianluigi A. Botton, Malcolm Griffiths, Journal of Nuclear Materials 457 (2015) 165–172