

New Surface Technology at the Nanofab

Our success in securing a NSERC-RTI grant has enabled the open-user Western Nanofab to enhance its training capacity offering access to a new Reactive Ion etching system. This was a Team effort that included 7 principal investigators from Western (Lagugn , P.Simpson, L.Goncharova, J. Yang, J.Sabarinathan, S. Mittler) and 2 from University of Windsor (S.Chowdhury, T. Carmichael).

The Trion Phantom III RIE is a state-of-the-art plasma etching tool utilizing fluorine and oxygen chemistry for isotropic or anisotropic etching of silicon, silicon dioxide and silicon nitride. The system also provides an excellent method for substrate cleaning and preparation using room temperature oxygen plasma.

We will continue to apply for grants in order to provide access to newer instrumentation and offer state-of-the-art technologies to all our users. In the meantime, please contact Nanofab staff if you wish to use or be trained on our new RIE system. Your successes are our successes so please let us know your needs.

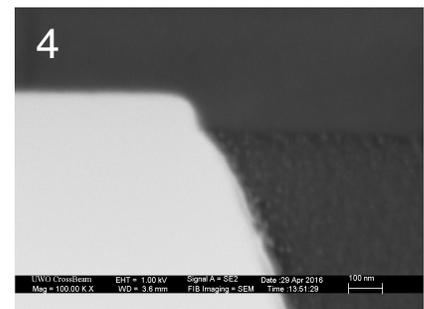
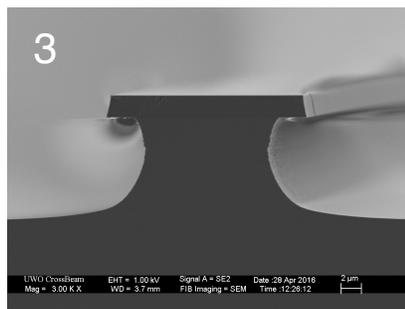
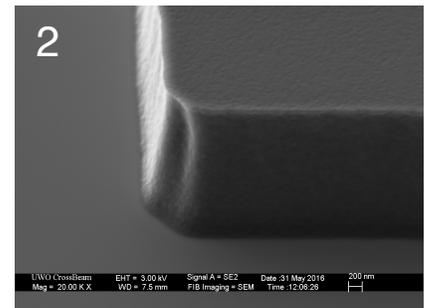
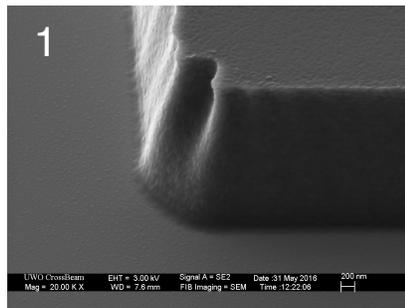


Image 1 : Patterned photoresist after development with no plasma treatment.

Image 2 : Patterned photoresist after room temperature oxygen plasma.

Image 3 : Isotropic Etching of a Silicon wafer.

Image 4 : Silicon Oxide etched using a CHF_3 and O_2 plasma.





The Long-Term Evolution of the Corrosion Products formed on Carbon Steel in Simulated Groundwater Solutions as Applied to the Design of Canadian Spent Nuclear Fuel Waste

Shannon Hill Prof. David W. Shoesmith

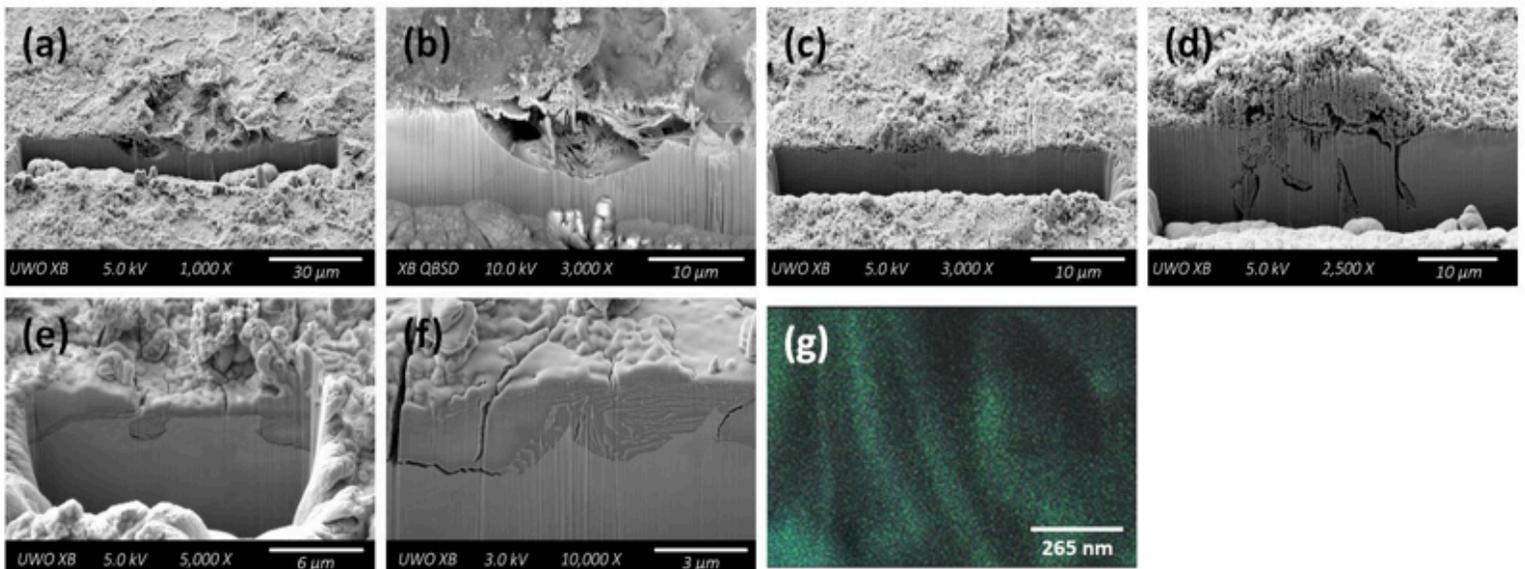
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It has been proposed that Canada's spent nuclear fuel waste be disposed of 500 m deep in either granitic rock or sedimentary clay deposits. Within the multi-barrier containment system, fuel wastes would be sealed in a metallic container consisting of a carbon steel vessel with or without an outer copper corrosion barrier. If container failure occurs, the surrounding groundwaters will come into contact with the fuel leading to its corrosion and the release of radionuclides. Our project is focused on the long-term evolution of the corrosion of carbon steel under anoxic groundwater conditions and investigates the effects of the moderate to extreme salinity expected at repository depths. A combination of Raman spectroscopy and SEM imaging of the surfaces and on and FIB cross-sections are being used to track the evolution of the corrosion product film over extended periods of time in solutions containing Cl⁻ at concentrations from 0.10 M to 4.77 M.

Steel coupons exposed to [Cl⁻]=4.77 M were shown to develop a Fe₃O₄ corrosion film more rapidly than those exposed to [Cl⁻]=0.10 M.

This can be observed in the FIB cross-sections where the sample exposed to [Cl⁻]=0.10 M shows a very thin film across the general surface (Fig. a-c) while the sample exposed to [Cl⁻]=4.77 M shows a film on the order of 3 μm thick (Fig. e-f). However, the damage experienced in the [Cl⁻]=4.77 M exposure appears to be more uniform while the sample exposed to [Cl⁻]=0.10 M shows locations in which damage has penetrated into the base metal in the form of either pits (Fig. b) or along single tracks associated with grain boundaries (Fig. d). Clearly the salinity has a significant influence on damage distribution. The bright lamellar structures seen within the oxide film for the sample exposed to [Cl⁻]=4.77 M (Fig. f) were analysed using EDX mapping (Fig. g) which highlights the locations of elemental iron (blue) and carbon (green). The coincidence of both the iron and carbon signals with these bright locations shows the cementite (Fe₃C) structure of the pearlite grains has been left behind after the preferential conversion of the α-Fe within the grain structure to Fe₃O₄. This would suggest a galvanic coupling between the α-Fe and Fe₃C of the pearlite grains.

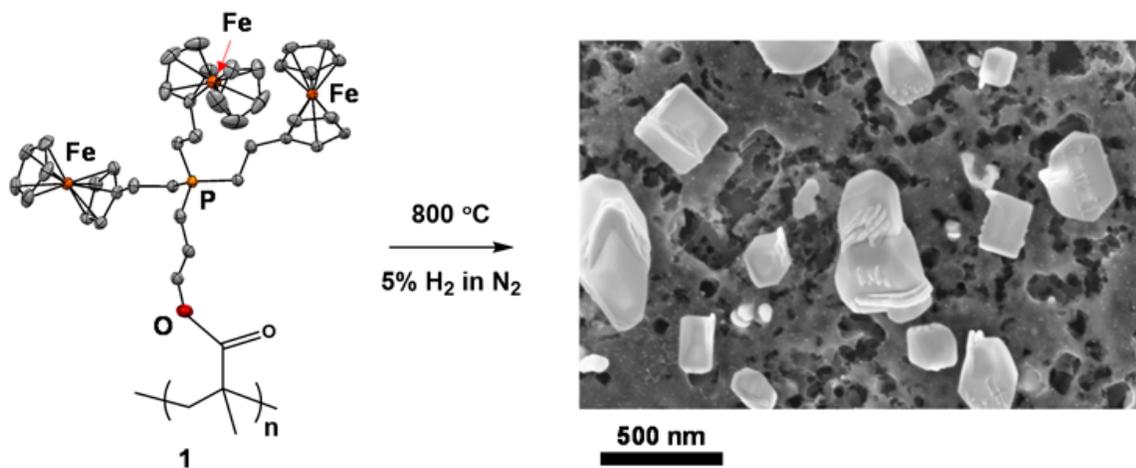


Synthesis of Metal-Rich Nanoparticles from Highly Metallized Phosphonium Polyelectrolytes



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Metal-containing polymers have emerged over the past two decades as a versatile new class of (multi)functional materials.¹ These materials combine the processability of polymers and the highly desirable properties (e.g., redox and catalytic activity, magnetic, light-absorbing) of transition metals and can be used as precursors to nano structured materials.² In this context, we have synthesized the first example of metal-containing phosphonium polyelectrolyte **1** and a thin film of this polyelectrolyte was prepared by spin coating of its solution onto a freshly cleaned silicon wafer. The film was later dried and under a steady flow of 5% H₂ in N₂ heated to 800 C and finally analyzed by scanning electron microscopy (SEM). The resulting images and elemental mapping/analysis experiments revealed a mixture of magnetite (Fe₃O₄) crystallites and a carbon-, phosphorus-, and oxygen-containing phase. Crucially, a significant quantity of the iron within the polyelectrolytes appears to be retained upon pyrolysis, illustrating the promise of this new class of highly metallized polyelectrolytes as precursors to functional metal-rich ceramics and/or nanoparticles.³ Building on this results, our future work will focus on the synthesis of mixed-metal containing polymers (metal = Fe, and Ru) and production of alloyed nanoparticles through pyrolysis and/or e-beam lithography.



1. G. R. Whittell, M. D. Hager, U. S. Schubert and I. Manners, *Nat. Mater.*, 2011, 10, 176–188.
2. L. Ren, J. Zhang, C. G. Hardy, S. Ma and C. Tang, *Macromol. Rapid Commun.*, 2012, 33, 510–516.
3. A. Rabiee Kenaree , B. M. Berven, P. J. Ragogna and J. B. Gilroy, *Chem. Commun.*, 2014, 50, 10714–10717.



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