NanoWestern

Western Science

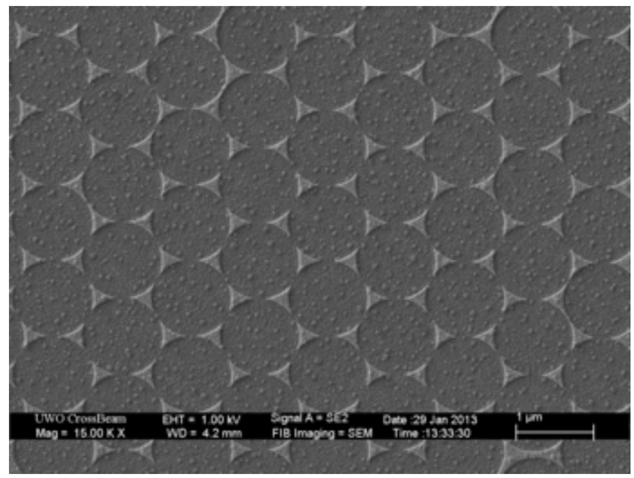
Issue 2 2013

Fabrication of new Nanostructures for High Sensitivity Raman Spectroscopy

Marion Bouchet *Supervisor: Prof. François Lagugné-Labarthet, Department of Chemistry, Western University, London, ON, Canada*

When a metal surface is irradiated with an electromagnetic field, the strong interaction between the light and the free electrons of the metal, induce a collective oscillation of the electron-waves that propagate along the interface. This phenomenon is called surface Plasmon polariton (SPP). When isolated metal nanostructures are irradiated, the field is confined in the vicinity of the nanostructure yielding an accumulation of charges near the sharp metal nanostructure. Such effect is known as localized surface plasmon resonance (LSPR) and is responsible for the colors of metallic nanostructures. Noticeably, it is possible to change the optical properties of the metallic particles by designing nanostructures with different geometries and sizes in order to tune the frequency of the electronic waves leading to a variety of potential applications. More specifically, this effect can be applied to detect small amounts of molecules through an enhancement of the electromagnetic effect mediated by a plasmonic effect. This can lead to the development of ultra-sensitive biosensors.

Using the Western Nanofabrication Facility, we fabricated new multilayered nanostructures for applications in Raman spectroscopy. On gold mirrors, 30 nm of silicon dioxide was sputtered. Next, a monolayer of polystyrene nanospheres was deposited followed by the evaporation of 3 nm of titanium and 30 nm of gold onto the compact monolayer of nanopsheres. After the removal of the nanospheres by sonication, the nanostructures were functionalized with thiolated molecules and probed under a Raman microscope. We have demonstrated that the new nanostructure improve the Raman sensitivity of a monolayer of 4-NTP.



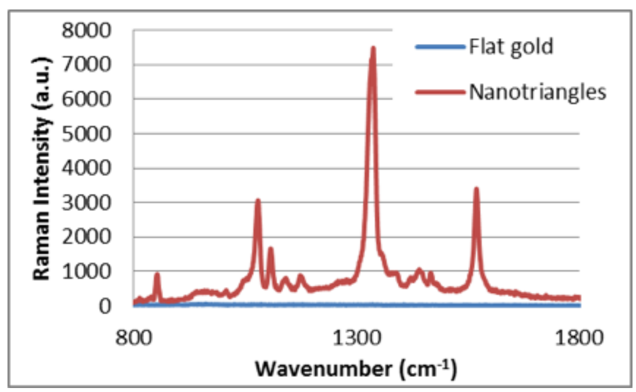
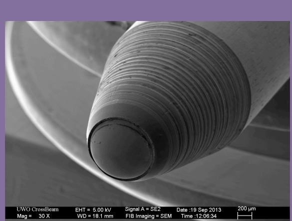


Figure (a) Plasmonic nanostructure fabricated at Western Nanofabrication Facility. **(b)** Raman spectra of a monolayer of 4-NTP adsorbed on the nanostructured surface (nanotriangles) and on a flat gold substrate.

Collaborators: G. Wallace, R. Hou, M. Tabatabae



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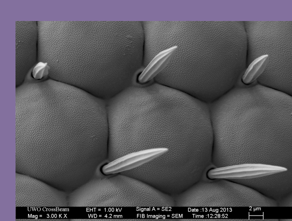


Spatial Control over the Anion-Exchange Process using Contact Printing

Ryan Guterman *Supervisors: Dr. Paul J. Ragogna and Dr. Elizabeth R. Gillies*
Department of Chemistry, Western University, London, ON, Canada

Surface patterning is an old, yet growing discipline within the field of chemistry, engineering, and materials science. While there are countless ways to pattern a surface, each of them relies on one requirement, the ability to control where and when chemistry occurs. We are interested in using anion-exchange chemistry as the means to controllably functionalize a cationic polymer coating. With this in mind, we have developed contact printing techniques as our principle method for patterning this chemistry on to a polymer. Contact printing is widely used to create patterned monolayers on gold and glass surfaces, and is amenable to scale up using high-throughput techniques. There are few examples of how anion-exchange chemistry may be applied to this technique. Using standard photolithography fabrication processes available at the Western Nanofabrication Facility, patterned poly(dimethylsiloxane) (PDMS) molds may be fabricated with ease. Figure 1 demonstrated how molds functionalized with a hydrophobic anion such as dodecylbenzene sulfonate and brought in to contact with the cationic polymer facilitating the anion-exchange reaction. Regions of the polymer substrate that are in contact with the PDMS mold undergo a change in interfacial properties. Due to the presence of the hydrophobic anion, these regions repel water. The regions that were not in contact however remain hydrophilic, allowing water and an anionic dye such as sodium fluorescein to permeate the polymer and undergo additional anion-exchange chemistry (Figure 1). This orthogonal behaviour in water permeation can only occur by directed patterning. Using this general process, virtually any anion may be patterned in a controlled manner. Future work includes miniaturization of this process for microtechnology applications.

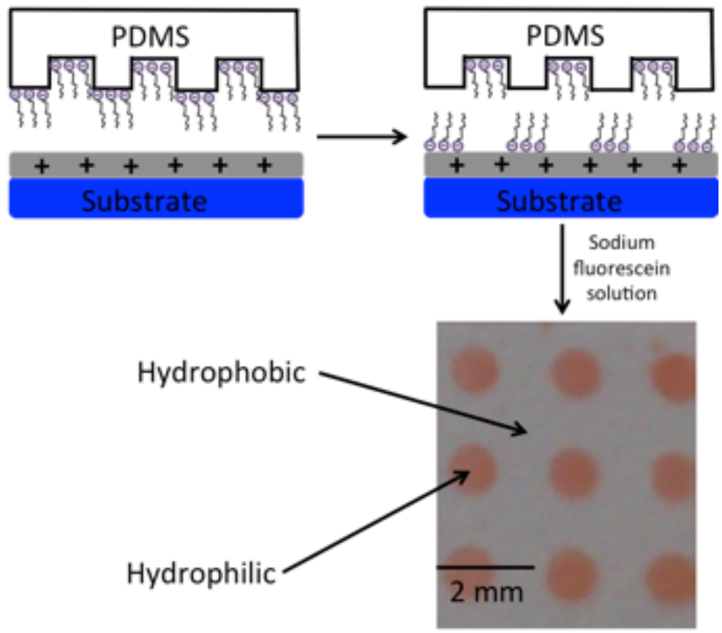
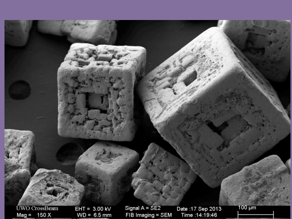
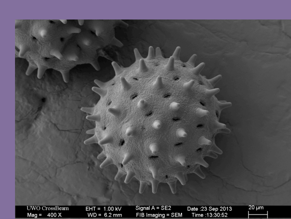


Figure 1: Scheme for the contact printing process on a cationic polymer substrate.





An Accurate Determination of Shock Level in Feldspar Group Minerals

Annemarie E. Pickersgill *Supervisors: Dr. Gordon R. Osinski (Department of Earth Sciences/Department of Physics and Astronomy), Dr. Roberta L. Flemming (Department of Earth Sciences)Western University, London, ON, Canada)*

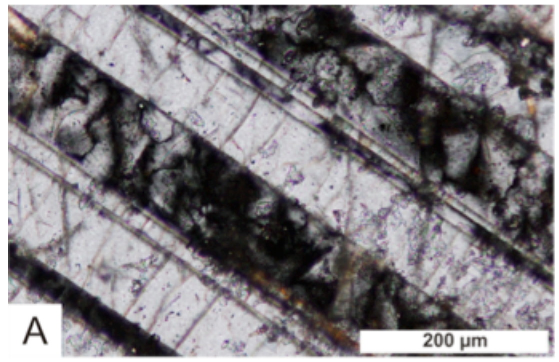
Meteorite impact craters are the dominant surface feature on most terrestrial planetary bodies and provide important information about planetary evolution [1]. As the shockwave from impact excavates a crater, rocks and minerals of the target material undergo pressure-dependent micro-structural solid-state deformation, termed shock metamorphism [1]. Studies of shock metamorphism in feldspars have been limited thus far, resulting in a purely qualitative shock classification scale for them.

This project aims to develop a more quantitative scale of shock deformation in feldspar group minerals in order to expand the utility of feldspar for determining shock level in quartz-limited systems (e.g. anorthosite, syenites, ultramafic rocks, and meteorites).

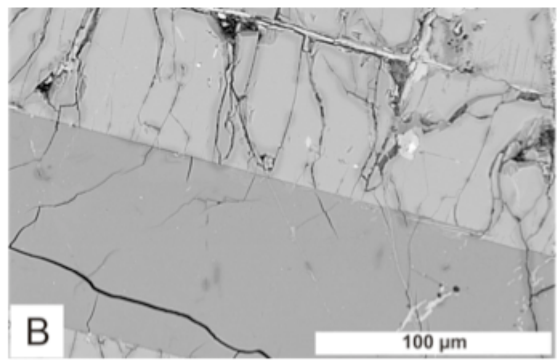
A suite of polished thin sections containing shocked feldspar from multiple locations, including the Mistastin (Kamestastin) Lake impact structure, Labrador, Canada, and the Apollo landing sites have been examined. Initial optical observations have been carried out using petrographic microscopes with follow-on in-depth studies using the LEO (Zeiss) 1540XB scanning electron microscope at the Western Nanofabrication Facility. These investigations revealed visible shock metamorphic effects, such as planar features in the crystal structure, diaplectic glass, and a unique plumose texture related to the ambiguous formation of maskelynite (fig. 1).

Understanding shock in feldspars on Earth, will set the groundwork for future studies of samples returned from the Moon, Mars, and asteroids thus increasing the scientific return of sample return missions – which is a primary goal of space agencies the world over.

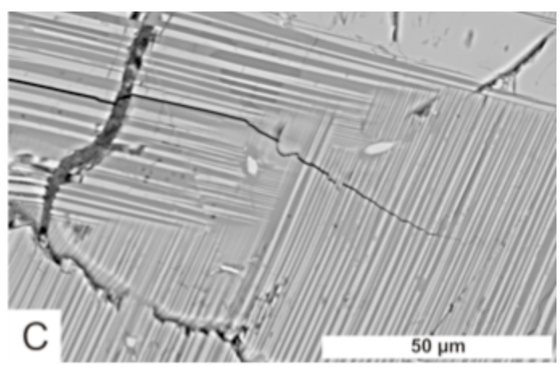
[1] French B.M., and Koeberl C. 2010. *Earth-Science Reviews* 98:123-170.



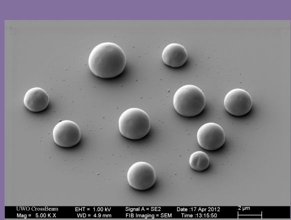
A. Plumose extinction displayed in alternate twins of feldspar, reminiscent of the manner in which maskelynite sometimes forms in only alternate twins. Cross-polarized transmitted light.



B. Plumose twin/regular twin boundary. Note change in tone and texture across boundary. BSE image.



C. Planar features in two directions in one twin. BSE image.



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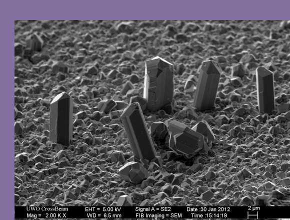

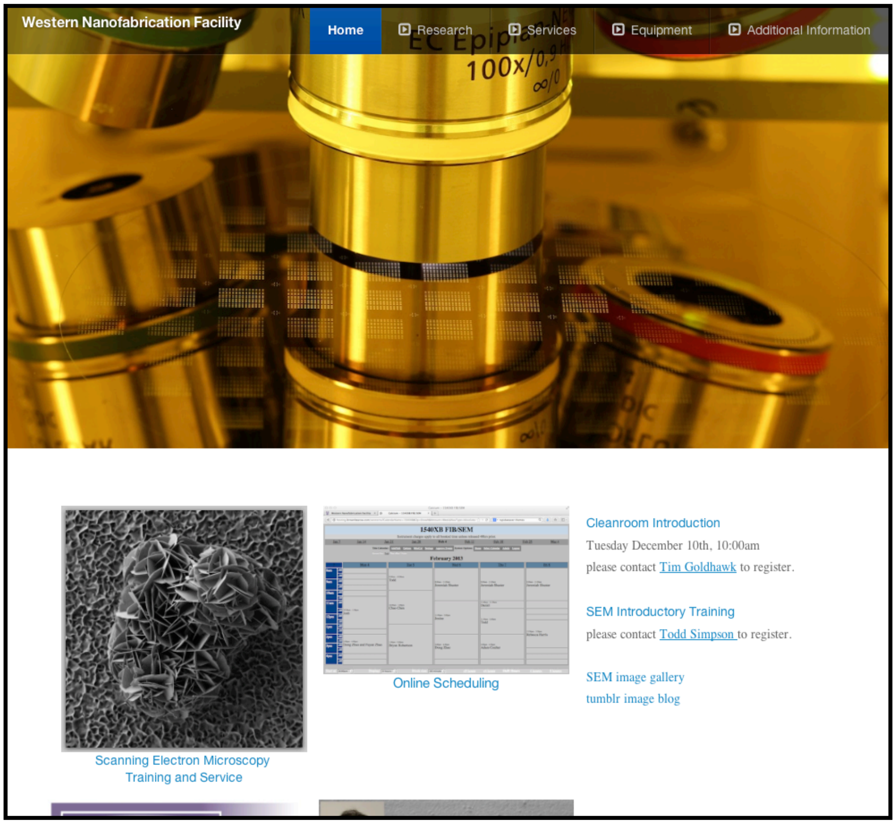

Please visit our newly designed website at nanofab.uwo.ca
You will find all the information needed to become a user of the facility, plus learn about what type of research that students are performing in the cleanroom.
Our SEM image gallery showcases our imaging capabilities and provides examples of structures fabricated in the facility.

Dear Western Researchers,

The Western Nanofabrication Facility is pleased to support three projects to be conducted in our facility by Western Researchers. The “Nanofabrication Facility Sponsorship Award” will cover up to $1500 of expenses (standard academic cost of nanofab usage) for projects involving graduate students who will be trained in the facility on the desired fabrication instruments. This year the three selected graduate student nominee’s are:

Amira Moustafa - (Prof. E.R. Gillies, Department of Chemistry and Chemical and Biochemical Engineering) - Fabrication and Characterization of sub-100nm particles optimize for controlled drug release.
Jaewoo Park - (Prof. G. Fanchini, Department of Physics and Astronomy)- Characterization of Nano-porous Graphene Films by Scanning electron Microscopy and EDX Analysis.
Mariachiara Zuin - (Prof. M. Workentin, Department of Chemistry) - Patterned self-assembled monolayers for use in biosensing.

All three students are new users of the facility, with a well defined nanofabrication and/or nano characterization project. We hope to continue offering such awards every year.

Sincerely,

Western Nanofabrication Facility.

Western Nanofabrication Facility

Western University
Physics and Astronomy Building Room 14
London, Ontario N6A 3K7

nanofab.uwo.ca

Western Science

Prof. François Lagugné-Labarthet
Facility Director
flagugne@uwo.ca

Todd Simpson Ph.D.
Senior Research Scientist
tsimpson@uwo.ca

Tim Goldhawk
Laboratory Supervisor
tim.goldhawk@uwo.ca

Dear Nanofabrication graduate students and post-docs. Send us a summary of your research project that was done in the Nanofab and receive a $100 gift card for the Western University bookstore. Your summary could be published in the next NanoWestern newsletter