MANIPULATING NANOMATERIALS TO MANUFACTURE LARGE-SCALE COMPONENTS

By Patrick McDonagh

McGill Engineering has an ambitious program to recruit world-class researchers with expertise in areas vital to the education of our students.

One of the tools being used to attract and retain these first-in-class professors is a three-year, $75,000 prize called the Faculty Scholar Award. The award augments funding that professors obtain from external agencies or other sources at McGill. It helps to pay for such items as laboratory expenses and technician support, graduate student support, undergraduate research projects and publication costs.

Five prizes have been awarded to date. If funding is obtained, the Faculty would like to create at least 20 such positions.

The first three recipients, titled Hatch Faculty Fellows, were Mining and Materials Engineering Professors George Demopoulosm In-Ho Jung and Shown Nazhat. They are being supported through a gift from alumnus Gerald G. Hatch, BEng'44, DSc'90.

The two newest Faculty Scholars, Mining and Materials Engineering Department professor Mathieu Brochu and Electrical and Computer Engineering Department professor Zetian Mi, are being funded through gifts from Hydro-Québec. Both hold the title of Hydro Québec Nano-Engineering Scholar.

The following article about professor Brochu's Faculty Scholar award is reprinted from the fall 2009 issue of the Faculty of Engineering *Dean's Report*.

Professor Mathieu Brochu
Hydro-Quebec Faculty Scholar
PHOTO: Owen Egan

Nanomaterials are, by definition, tiny, but Professor Mathieu Brochu has taken on the challenge of using nanomaterials to fabricate large objects as well.

The Mining and Materials Engineering Department researcher says that "fabricating laboratory-scale nanomaterials is easy, but to make an actual large-scale component economically — such as a mechanical device or an aircraft part — is no simple task."

While they boast extremely useful features for large-scale objects, bulk nanomaterials also present daunting problems. For instance, because of their low fracture toughness, an impact could cause something constructed with bulk nanomaterials to break. As a result, such materials are restricted to applications having a static load, which is a significant constraint to their widespread use.

Brochu's research explores different ways of manipulating and applying nanomaterials to enhance their exceptional qualities — including hardness, strength and oxidation resistance — for use in bulk applications.

Brochu, who is a Canada Research Chair in Manufacturing Nanomaterials as well as a Hydro-Québec Nano-Engineering Scholar, says that one way of dealing with low fracture toughness is to develop a type of nanocladding, in which the bulk of a component is made of conventional materials, while the surface uses nanostructures.

"This approach gives us the desired toughness for the component, along with the nano characteristics we want for the surface."

Practical applications are easy to find. "For example, the de-icing sand used on roads in winter accumulates inside the rims of bus wheels and erodes their surface. I am working on a project to make wheels out of conventional materials, but with a nanomaterial coating that would provide higher resistance to abrasion."

Applying this nanocladding to conventional material is challenging in its own right, but last summer Brochu and members of his research team — including 13 graduate students and an undergraduate from the Summer Undergraduate Research in Engineering (*SURE*) program engineered an advanced welding process capable of depositing nanomaterials on a surface.

A reputation for teaching prowess

An arc weld with a high-frequency pulse having a duration of a few microseconds provides the energy to deposit and fuse materials without causing them to lose their nanostructure — as would be the case with a longer duration or different cooling period.

PhD student Ramona Vintila uses the Spark Plasma Sintering Press to research improved methods of sintering ceramics and metals.
PHOTO: Owen Egan

"This sort of freeforming has never been done before, so I am really proud of it," Brochu says.

"But the concept is very new, so there are still issues to address, such as a low deposition rate that demands a time-consuming layering process."

PhD students Bamidele Akinrinlola and David Heard, working an electrospark welder.
PHOTO: Owen Egan

Brochu's welding-edge research is clearly catching the interest of students, but he also has gained a reputation for his pedagogical prowess. After winning last year's Class of '44 Teaching Award in recognition of outstanding teaching in the Faculty of Engineering, this fall he received ASM International's 2009 Bradley Stoughton Award for Young Teachers. The annual prize is presented to the world's top young materials science educators. "Some really impressive researchers have won this award before," Brochu says, "so I'm honoured to be included among them."