NANOMATERIALS RESEARCH COULD LEAD TO MAJOR REDUCTIONS IN GLOBAL ENERGY CONSUMPTION

By Patrick McDonagh

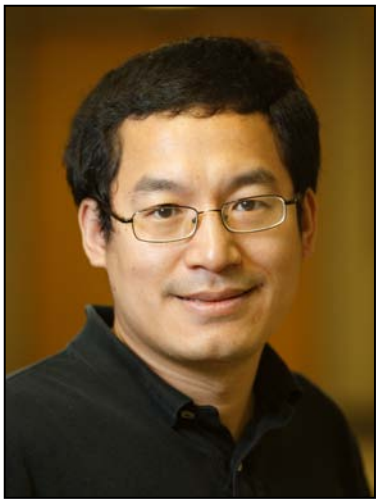
McGill Engineering has an ambitious program to recruit world-class researchers with expertise in areas vital to the education of our students.

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

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



Professor Zetian Mi
Hydro-Quebec Faculty Scholar
PHOTO: Owen Egan

The U. S. Department of Energy cast down the research gauntlet recently when it announced a goal of replacing light bulbs by 2025 with solid state lighting that draws on electricity converted directly from semiconductors. And professor Zetian Mi has answered the challenge.

Since arriving at the Electrical and Computer Engineering Department in September 2007, Mi has established the only facility at a Canadian university for researching gallium nitride (GaN) nanoscale materials, making him a leading researcher in the field of GaN semiconductors.

Semiconductors such as these could provide an inexpensive, long-lasting light source that is 50% more energy-efficient than current technology. "Since almost 20% of global electricity use is due to lighting, the energy savings would be significant," Mi says.

Research on GaN and other nitride-based semiconductors dates only from the 1990s, so they still pose many questions. "But that means that they also offer a lot of potential," Mi says.

"To use them effectively, however, we must understand GaN more thoroughly and develop the technology that would make it more appropriate for the market." While some companies are commercializing this technology, concerns about efficiency, cost and yield remain among the major roadblocks.

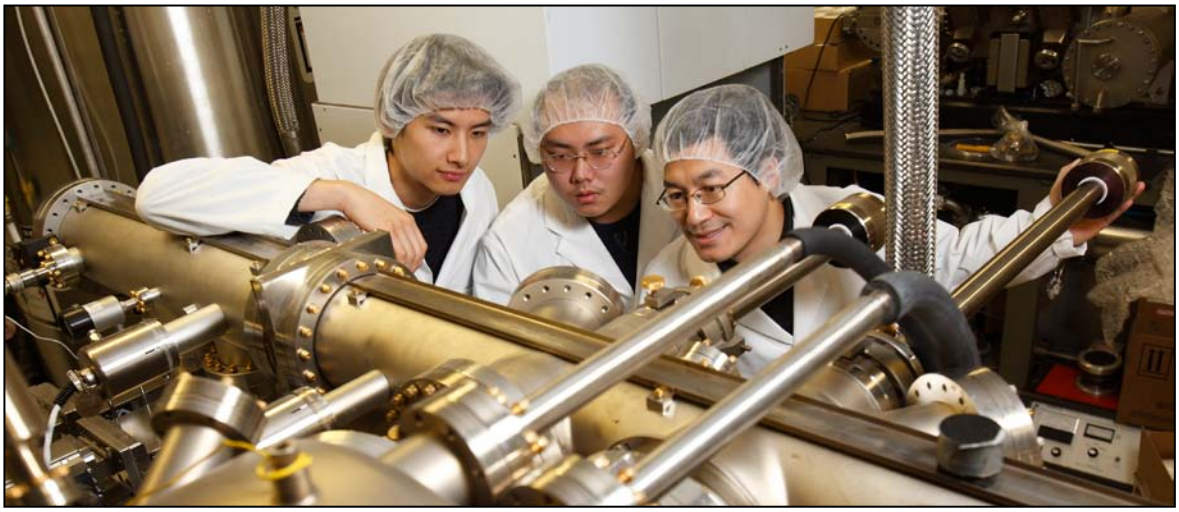
Mi, who was recently named a Hydro Québec Nano-Engineering Scholar, is exploring inexpensive fabrication strategies that involve growing highly efficient nanostructures — such as nanowires and

quantum dots — on a large-area silicon substrate, an innovative approach that could scale up to levels demanded for industrial manufacturing. Mi's group (three doctoral students, a post-doctoral fellow and an undergraduate) has already grown green, yellow, amber and red-emitting indium gallium nitride nanowires on a silicon substrate, with these nanowires showing internal quantum efficiencies of more than 45%, as opposed to currently reported values of less than 10% for other approaches.

GaN nanostructures offer a stunning range of potential applications. "The nanowires we grow here are just a little larger than DNA sequences, and when they are combined with DNA, their electrical properties change," Mi explains.

"This characteristic can be used to tell us detailed information about the DNA that may not be obtained otherwise. As such, ultra-sensitive DNA sensors are being developed." Mi's unique nanowire research was featured with a photo on a recent cover of the prestigious international journal *Nanotechnology*.

Harvesting solar energy



Doctoral students Yi-Lu Chang (left), Feng Li (centre) and Professor Zetian Mi (right) use a sophisticated Nitride Molecular Beam Epitaxial Growth System to grow nanostructures in professor Mi's McConnell Engineering Building laboratory. The million-dollar-plus apparatus enables the team to explore low cost, high quality nanomaterials manufacturing strategies for industry**.**
PHOTO: Owen Egan

In addition, Mi's research group is investigating GaN's potential for harvesting solar energy.

Most solar panels absorb only a portion of the solar spectrum, and even the most advanced solar energy technologies, such as those used on the International Space Station, can take advantage of the entire spectrum only by using a combination of different materials – an approach that is far too expensive for more mundane applications. Systems using nitride-based materials, such as GaN, indium nitride, aluminum nitride and their alloys, can absorb the entire solar spectrum.

"The major problem in tackling this issue is growing sufficiently high-quality nanomaterials, and that is exactly the edge my group has gained in the last two years," Mi says.