Volume I, 2011

impact

Alumni + Industry Magazine

Materials Science & Engineering | University of Toronto

LIGHT IT UP

Nazir Kherani shines on in the quest for sustainable energy

Wave of the Future

Making a splash with H_2 nanotechnology

Material Interest

The latest advanced materials in action

Materials Science & Engineering
UNIVERSITY OF TORONTO

impact

Jun Nogami — **Publisher**
EngSci 8To
Professor & Chair

Luke Y. H. Ng — **Editor-in-Chief**
ChemE 0T7
External Relations & Student Life Officer

Anna-Kaisa Walker — **Associate Editor & Writer**
BA 2002 UC

Vincent Chan — **Art Director**
Kaktus Studios

Maloney Aguirre — **Photographer**
photographica

Uwe Erb
Zheng-Hong Lu — **Contributing Editors**

Engineering Strategic Communications — **Design Consultants**
University of Toronto

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IMPACT
Department of Materials Science & Engineering
Faculty of Applied Science & Engineering
University of Toronto
Wallberg Building
184 College Street, Suite 140
Toronto, Ontario M5S 3E4 CANADA

Editor-in-Chief
T: +1 416 946-3211
mse.impact@utoronto.ca

General Inquiries
T: +1 416 978-3012
F: +1 416 978-4155
materials.engineering@utoronto.ca

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www.mse.utoronto.ca

publisher's letter

Over the last century, our department has gone through many transformations. From our roots in metallurgical engineering, we've greatly expanded our scope of inquiry and grown into one of the largest departments of Materials Science & Engineering in North America. And we now have our very own magazine, the inaugural issue of which is in your hands. We chose the name "IMPACT" for its relevance to materials testing, and to describe how members of our community make a difference through excellence and dedication.

The theme of this issue, as you'll see, is sustainability. Materials Science & Engineering is uniquely positioned to impact many aspects of this area, whether it's greener resource extraction and materials processing, advanced materials for energy efficiency in diverse applications, or cheaper and better photovoltaics. As Professor Nazir Kherani says in our cover story, "The single biggest challenge we face isn't just powering the planet, but doing it sustainably."

With student applications for admission at a record high, it's our responsibility to deliver on our promises by continuing our excellence in research, as well as delivering a curriculum that will train materials engineers to work towards a greener and more sustainable future.

We hope you enjoy our new magazine, and we welcome your feedback.

Jun Nogami PhD, PEng
Professor & Chair
Department of Materials Science & Engineering
University of Toronto

contents

JUST ADD WATER

Saving the planet, one drop at a time

Essential to all forms of life, it covers 70 percent of the Earth's surface. But water is an increasingly precious commodity. Canadians are some of the heaviest users in the world, but elsewhere on the planet, an estimated 1.1 billion people don't have access to water that's safe to drink.

Professor Steven Thorpe (MMS 8T0, MASc 8T2, PhD 8T5) and the Surface Engineering and Electrochemistry (SEE) Group are trying to change that. To boot, they're also fixing the energy crisis. They're creating new materials on the nano-scale that can be used to treat wastewater, and at the same time produce clean, cheap hydrogen fuel via electrolysis.

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"I always wanted to be a mad scientist," jokes Thorpe. Though he's minus the fly-away hair and lightning rod, inventing is his stock in trade, with a handful of new patents applications in the works in collaboration with longtime research partner, chemical engineering Professor Donald Kirk (EngSci 7T2, ChemE MASc 7T5, ChemE PhD 7T9).

One of the SEE Group's current projects is developing a new material that efficiently destroys Bisphenol A, a compound commonly found in plastic bottles. "It's a known endocrine disruptor that's been linked to various kinds of cancer and birth defects," Thorpe says. "What we're developing could be used to treat many different organic compounds in water either on a municipal or an industrial level."

Industry partner Xogen Technologies is currently translating some of the group's work to the real world, building a pilot plant in Orangeville, just outside Toronto. Slated for completion in late 2010, the company is working with the municipal water and hydro authorities to treat a side stream of the town's raw effluent, while producing hydrogen oxygen gas, an environmentally friendly potential fuel source.

Funded by Xogen Technologies, the National Sciences & Engineering Research Council of Canada (NSERC), Sustainable Development Technology Canada (SDTC), and the Ontario Centres of Excellence for Earth and Environmental Technologies, researchers from the Department of Materials Science and Engineering are playing a key role in product development and modeling, along with the Departments of Electrical & Computer Engineering, Chemical Engineering & Applied Chemistry, and Mathematics.

"We've got a wealth of really talented students taking apart a very complex process and breaking it down," Thorpe says.

In this field, if any innovation hopes to hit the mainstream, cost-effectiveness is paramount. "Our principal role is in creating new materials that are economical and energy efficient," he says. "There's no point developing a process that's unrealistically expensive."

"There's been a lot of speculation about the issue of pharmaceuticals in the water supply," Thorpe says. "If these substances are going to be regulated five or ten years from now, we need to do the science today. We need to develop methods to accurately detect these compounds at very low levels, and then use this technology to reach these limits. Drug companies may be the major benefactors going forward."

New clean water technologies could also have a profound impact on much of the developing world, Thorpe says, where accessing and bringing home drinking water sometimes takes eight hours a day, and women bear most of the load. "It could fundamentally change these societies," he says.

He's confident that the field's prospects can only grow. "If we can make it work in Orangeville, we can do it elsewhere," Thorpe says.

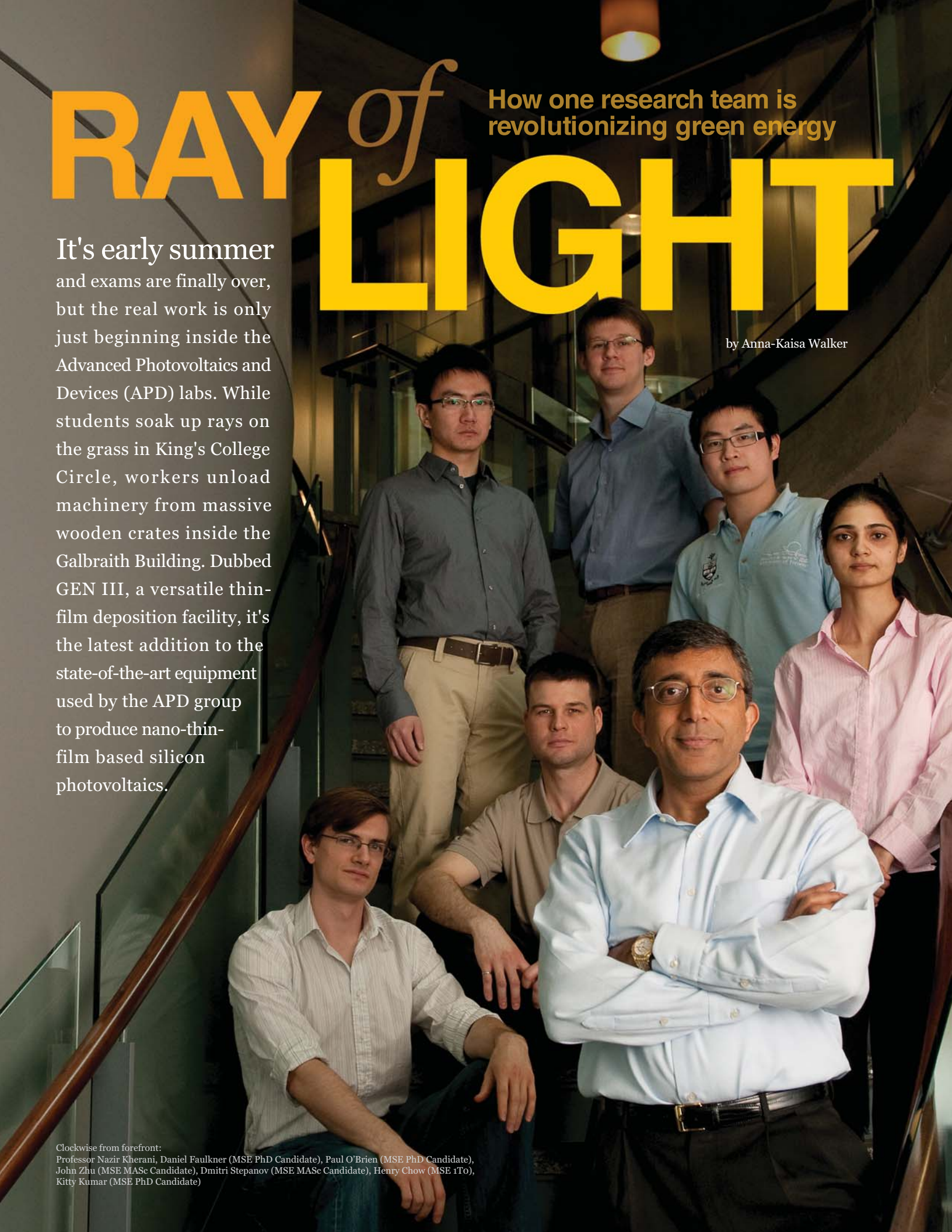
L: Professor Donald Kirk (ChemE)
R: Professor Steven Thorpe (MSE)

RAY *of* LIGHT

How one research team is revolutionizing green energy

by Anna-Kaisa Walker

It's early summer and exams are finally over, but the real work is only just beginning inside the Advanced Photovoltaics and Devices (APD) labs. While students soak up rays on the grass in King's College Circle, workers unload machinery from massive wooden crates inside the Galbraith Building. Dubbed GEN III, a versatile thin-film deposition facility, it's the latest addition to the state-of-the-art equipment used by the APD group to produce nano-thin-film based silicon photovoltaics.



Clockwise from forefront:
Professor Nazir Kherani, Daniel Faulkner (MSE PhD Candidate), Paul O'Brien (MSE PhD Candidate), John Zhu (MSE MASc Candidate), Dmitri Stepanov (MSE MASc Candidate), Henry Chow (MSE 1To), Kitty Kumar (MSE PhD Candidate)

“Using thinner materials down to the nano-scale makes manufacturing solar panels less expensive, which means “grid parity” - the point at which the price of sustainable energy is equivalent to conventional grid power – is finally within reach.”

PhD candidate Paul O'Brien (MSE 0T2, MASc 0T7) guides me on a tour through the lab, furnished in large part thanks to $15 million in grants from the Ontario government, industry partner ARISE Technologies, and the University of Toronto. "This one puts on a real light show," he says, pointing out the multi-target sputterer, which fills with glowing purple argon gas as it deposits a very thin layer of particles on a solar cell sample. By experimenting with different types of reflectors, O'Brien explains, selectively transparent and conducting photonic crystals integrated in solar cells can help harness more power from the sun's rays. It's all part of the team's grander mission: to make solar energy more efficient and affordable for all.

The man leading the charge here, Professor Nazir Kherani (EngSci 8T2, ChemE MASc 8T3, Physics PhD ’94), is modest about his contributions to the green revolution. But as he carefully cradles several plastic specimen trays containing the latest solar cell prototypes, he's confident about their tremendous potential. “Solar energy available to us dwarfs all existing fossil and nuclear reserves combined,” he says.

The APD group’s research aims to overcome the biggest stumbling block for solar energy: cost. Using thinner materials down to the nano-scale makes manufacturing solar panels less expensive, which means “grid parity” - the point at which the price of sustainable energy is equivalent to conventional grid power - is finally within reach. “It could happen within the next five to ten years in some regions,” Kherani says.

It’s an ambitious goal that would have sounded far-fetched when he first enrolled at UofT in 1978. "In the '80s, sustainability was not a going concern among Canadians," he explains. “Running out of resources was the furthest thing from our minds.”

At the time, nuclear power was considered the energy of the future, but it was soon beset by environmental and technical challenges. By the early 2000s, Kherani explains, many scientists were looking in a new direction for sources of sustainable energy.

His career path led him back to UofT after working in research and development at Ontario Hydro. In 2005, Kherani was jointly appointed to both the Edward S. Rogers Sr. Department of Electrical & Computer Engineering (ECE) and the Department of Materials Science & Engineering (MSE) as a core faculty member. He works with a multi-disciplinary team of co-investigators, including Professors Jun Nogami, Uwe Erb, Doug Perovic (MSE); Peter Herman, Stefan Zukotynski (ECE); Geoffrey Ozin (Chemistry); and Siva Sivoththaman (ECE, University of Waterloo).

Inside the labs, plasma-enhanced DC saddle-field and tunable deposition facilities share the space with multi-target sputtering and contacts deposition systems, along with various optical and electrical characterization tools. Researchers collaborate across various disciplines, maximizing the leading-edge equipment's potential. “There's a spirit of cooperation between groups, which really inspires innovation,” says O’Brien.

Much of the work being done here has long-term implications for Canadian consumers, who rank among the highest in energy use per capita among developed nations. “Most of our projects are application-motivated, which means the research has good potential for commercialization,” says PhD candidate Kitty Kumar.

For Kherani, it isn’t easy being the boy with the most toys. “My grey hair attests to that,” he says with a laugh. Significant financial support comes with greater expectations, especially in a field as hyped as sustainable energy. “Your counterparts in industry want to move as quickly as possible, understandably,” he explains. “But we’re dealing with complicated technology that needs its due.”

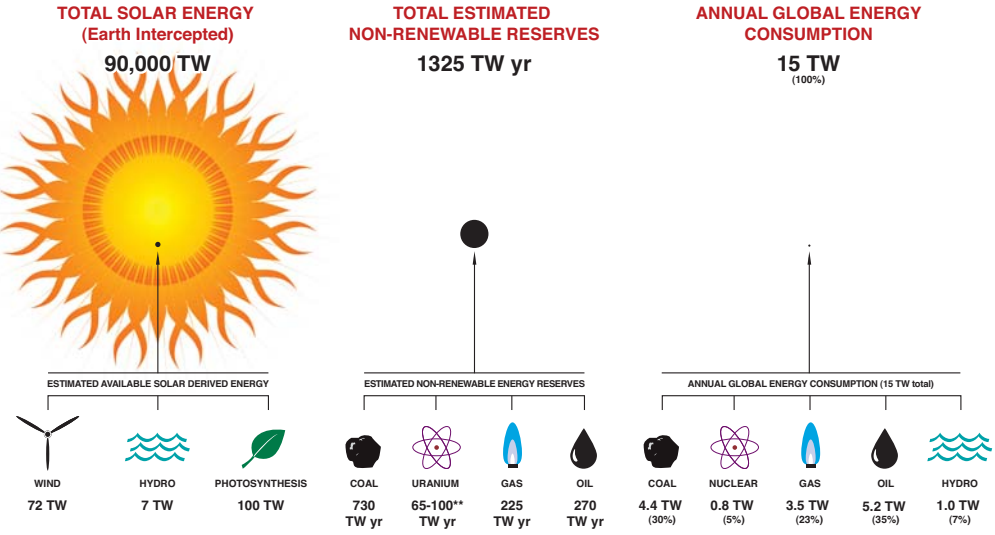
Meanwhile, he’s busy mentoring growing numbers of MSE and ECE students eager to blaze a trail in the energy industry. The MSE team members - including John Zhu, Dmitri Stepanov (EngSci 0T8), Daniel Faulkner, and Henry Chow (MSE 1T0) - are drawn from diverse backgrounds and different countries. "Everyone wants to do something relevant, and that's one of the better things about UofT," says Faulkner. "You're constantly being exposed to new ideas."

This year, with research associates Dr. Davit Yeghikyan and Dr. Tome Kosteski, Kherani will lead the APD group in commissioning GEN III, which will enable them to synthesize a whole range of new material and device integrations for photovoltaics and allied applications.

“There’s much greater awareness today of the practical reach of solar energy,” Kherani says. “The single biggest challenge we face isn’t just powering the planet, but doing it sustainably.”

THE POWER OF THE SUN*

1 TW = 10^{12} W = 10^{12} J/s



* The figures cited above are taken from a variety of sources and are deemed best order of magnitude estimates given the variability in assumptions and findings

** These figures increase 60-fold if breeder technology is implemented

material interest

What do state-of-the-art shirts, sporting goods, and portable electronics have in common? They're all enabled by **advanced materials design**. They're here, they're hip, they're now. Check out some of the latest and greatest.

Shirt Happens

That early-morning Starbucks spill won't have to ruin your big meeting, thanks to the Nano-Tex in your button-down. Liquids bead up and roll off, repelled by tiny whiskers made from fluoropolymers assembled in rows on the surface of the fibre. Because the technology is created on the nano-scale, it doesn't affect the feel or breathability of the fabric.
www.nanotex.com

A League of Their Own

Toronto-based Integran Technologies' Nanovate NP is a hybrid of nanocrystalline metal and injection-molded polymer. Applied to sporting goods, it's got best of both worlds — reducing grain size to nanometer scale improves the toughness and strength of the metal, while the polymer substrate preserves the lightness of plastic. Which means you can nail that last putt, reel in the big fish, and hit one out of the park with ease.
www.integran.com

Turn It On

Thanks to Samsung's new Galaxy S, the smartphone just got brighter. With the help of organic light-emitting diodes (OLEDs), the Android-enabled phone's touch-screen display doesn't have the vampiric qualities of its predecessors – it won't fade in sunlight or suck the life out of your battery. OLEDs, made out of nano-scale, thin-film organic molecules, have the ability to emit light on their own. "Their superior form factor, dynamic colour range, and energy-efficient properties make OLEDs well-positioned to overtake LCD and plasma technology," says MSE's Professor Zheng-Hong Lu. "Plus, they're much more environmentally friendly to manufacture."
www.samsung.ca

lasting impact

Materials Engineers use impact testing to determine the mechanical strength of applied materials under normal and variable environments. It seems fitting, then, that our back page is devoted to a few people at MSE who've not only demonstrated strength and perseverance, but commitment to making a difference. By truly giving back, they've inspired their peers and made our department better.

Diana Mollicone | MSE 1T0
Karl Visnovec | MSE 0T9

What do undergrads bring to MSE? Just ask Diana Mollicone and Karl Visnovec. As former MSE Club Chairs, they've taken the small department's community feel to a whole new level: organizing chariot races, alumni-student mixers and a common room facelift along the way. The recent grads talked to us about how they've made a difference — and why.

What's been your biggest contribution to student life?

KV: It was really important to us to make every student feel at home here. Two-third of MSE students are commuters, and half of those travel more than 30 minutes to campus. So we decided to renovate the common room, because that's where everyone hangs out between classes. We wanted it to be comfortable yet professional, so we could actually show it off to prospective students.

What motivated you to take time out of your schedule to get involved?

DM: Taking a little initiative has really been worthwhile — we've made a lot of improvements that way, like working with the Department to revamp the computer lab with new equipment, since everyone spends so much time there. These things actually make a big difference in the long run. We think of it as an investment in our department's future.

How do you think undergrads can benefit from interacting with alumni?

DM: I really found it valuable to get a different perspective from people who've been there, and can give you the nitty gritty about what it's really like in the workplace. It's helpful to see the big picture and to have conversations with people in your field that are more than just "What did you get for Question 3?"

Check out **www.mse.utoronto.ca** for Diana and Karl's and Professor Hibbard's full interviews with IMPACT.

Professor Glenn Hibbard
MSE PhD 0T2

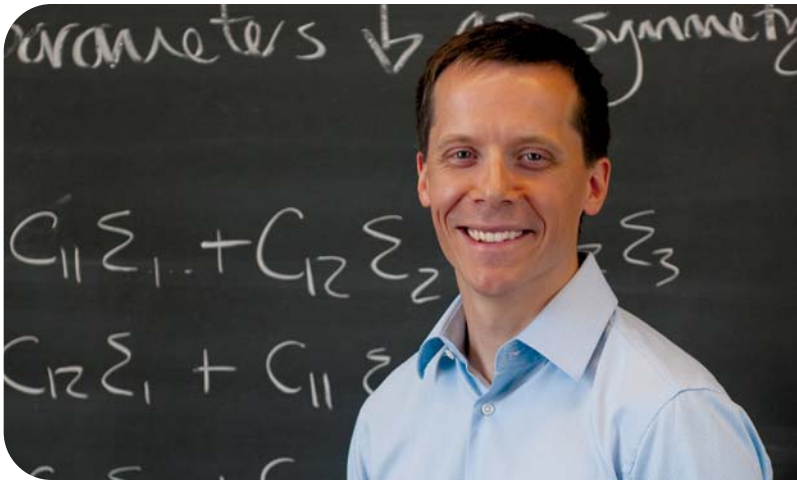
Glenn Hibbard's not one to brag. But the affable Associate Professor and Associate Chair of Undergraduate Studies, who recently won an Early Career Teaching Award from the Faculty of Applied Science & Engineering, doesn't hide the fact that he loves teaching. Especially in the fast-paced, research-driven field of Materials Science & Engineering, his patience and enthusiasm has made him one of MSE's most popular professors. Hibbard talked to IMPACT about what makes him tick.

You teach MSE 101, a broad introductory course for first-year students across the Faculty. How do you keep such a big class engaged and interested?

I try to make sure my classes are well-organized and well-presented, but I think it's really because I find the material interesting, so the students do too. The coolest thing is being able to understand the world around you on an atomic scale. My approach starts from the standpoint that MSE is a fundamentally beautiful discipline, and all it needs is someone to help the students understand how the pieces fit together.

What motivates you to keep improving your teaching?

Teaching is just more fun when it's going well. There's nothing worse than struggling through a lecture where the students are just counting the minutes before the end of class. The converse is also true: there's nothing better than having one of those great moments when the class is fully engaged and excited by what they've learned.



5th Annual MSE Industry Day

October 14, 2010

They came, they saw, they shook hands — industry representatives converged on the lobby of the Wallberg Building for MSE Industry Day, the department's annual mixer for students, alumni and executives. Armed with their CVs, about 180 undergraduate and graduate students got a primer on the latest industry developments, hitting up company reps for career advice. "We had a great turnout this year," said Professor Jun Nogami, Chair. "It was also wonderful to run the event in our foyer, where alumni and PEY students out in industry could 'come home' to talk with our students." MSE Industry Day is held annually in the fall.

1 TECK representatives Jeff Rossi (MSE 0T5+PEY, 2nd from left) and Paul Kolisnyk (MMS 8T1, middle) with MSE community **2 AMEC NSS** representatives Roy Chang (MSE 0T3+PEY, MASc 0T6, far left), Sharon Chow, Tanya Hunt (MSE 0T5, MASc 0T7, 3rd from left), and Pamela Chamberlain (2nd from right) with MSE community **3 GE Hitachi Nuclear Energy Canada** representative Laszlo Zsidai (MSE 0T5, left) with MSE community **4 Acuren** representative Jacqueline Lim (MSE 0T7, centre) with MSE community **5 Integran Technologies Inc** representatives Jonathan McCrea (MSE PhD 0T1, left) with MSE PEY intern **6 Celestica Inc** representative Eva Kosiba (MMS 9T8+PEY, 2nd from right) with MSE community

MSE Industry Day participants have included: Acuren Group Inc., AMEC Nuclear Safety Solutions, AECL, Buehler Canada, Celestica Inc., Electrovaya Inc., HATCH, Integran Technologies Inc., Liburdi Engineering Ltd., Ontario Power Generation (OPG), Pratt & Whitney Canada, Research in Motion (RIM), TECK, US Steel Canada, Vale Inco, Xstrata.

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Department of Materials Science & Engineering
Faculty of Applied Science & Engineering
University of Toronto