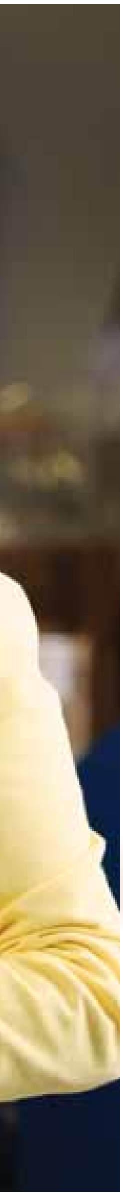
Q&A

DREAMS Weaver

A professor of chemistry since the early 1980s, Mary Anne White is now director of the Dalhousie Research in Energy, Advanced Materials and Sustainability (DREAMS) program, inspiring a host of young scientists to take on energy and sustainability challenges through advanced materials research.

By **Roberta Staley**

Dalhousie University chemistry and physics professor Mary Anne White likes to talk. She's good at it. She's good at materials science too — renowned in fact. And when White combines the two — science and public discourse — she is as fascinating to the non-specialist as she is to those with a science background. White has been a guest scientist on CBC radio's *Quirks and Quarks* more than a dozen times, fielding eclectic queries from listeners. She is a regular on CBC's *Maritime Noon* radio, entertaining idiosyncratic questions from science-curious Maritimers. And last fall, White schooled CBC radio host Michael Enright in materials science — the study of how the properties of chemical substances influence their function — on *The Sunday Edition*.



Mary Anne White in a DREAMS laboratory at Dalhousie University. She is holding a sample holder (right) from the Physical Property Measurement System (PPMS) that is used to measure thermal and electrical resistance.

MILOS TOSIC

White's outreach hasn't gone unheralded; she was awarded the Royal Society of Canada's McNeil Medal for the Public Awareness of Science in 2007. Late last year, the 132-year-old collegium of distinguished Canadian scholars, artists and scientists, acknowledged White once again, bestowing the title of Fellow in honour of her experimental investigations of the thermal properties of materials.

Materials science is interdisciplinary, drawing from civil, electrical and mechanical engineering as well as chemistry and physics. White's area of expertise — thermal properties of materials — is a field more than a century old. Yet a key trait of materials science is its dynamism: it discovers new materials and invents new uses for old ones. Breakthroughs are ongoing, such as the isolation a decade ago of graphene, which has a rare combination of electrical conductivity with optical transparency. These properties are just beginning to be used in electronic devices, says White, the author of the text book *Physical Properties of Materials* as well as more than 150 journal papers.

As the planet experiences more extreme weather events linked to climate change, White's studies are becoming increasingly relevant; materials science holds the promise of discoveries leading to more sustainable energy use in the future. She is probing how thermoelectric materials can convert waste heat into useable power, as well as phase-change heat-storage materials for solar energy applications. White's research also embraces sustainable approaches to materials research. But it is White's leadership as program director of the Dalhousie Research in Energy, Advanced Materials and Sustainability (DREAMS) program that is promising to be the most revolutionary, creating partnerships not only between young researchers from an array of science backgrounds but connections with some of the top laboratories in the world — pushing towards solutions to the planet's most pressing challenges.

ACCN explored the scope of the DREAMS program and the world of materials science with White.

▶ Why did you gravitate toward materials science? What is it about the field that fascinates you?

We're discovering new materials all the time like graphene, which wasn't on the scene until 10 years ago. And suddenly we had this new material that has all these tremendous properties — actually we don't know all its properties yet — they open up whole new vistas. Graphene has a rare combination of properties; it is electrically conducting yet optically transparent, useful for electronic devices.

Even with really common materials like boron, an element that was discovered nearly two centuries ago, nobody knows what the stable form of this element is. It is very difficult to study, both experimentally and theoretically. It's a very hard material and difficult because of its unusual bonding. Yet it can be used to make compounds that are super hard or superconducting. So even with things that have existed for a long time there are big gaps in our basic knowledge.

▶ What do chemists bring to the study of materials science that makes them valuable partners in this field?

First off, chemists bring an atomic view because we think in terms of atoms and molecules. That's something that engineers don't think about as much; we are on the microscopic side and they are on the macroscopic side. But I've always had one foot in chemistry and one foot in physics. I teach a course given to both chemists and physicists; they speak different dialects and I speak both those dialects.

▶ You are the program director of DREAMS. How did this initiative come about?

A lot of Dalhousie colleagues were working together on materials related to energy and sustainability. Funded by an NSERC CREATE grant since 2010, DREAMS' goal is to train a cohort of people: undergraduates, graduates and post-docs, who think about energy and sustainability problems in a more thematic way while interacting with people from chemistry, physics or engineering and to open their eyes to the possibility of interactions to solve bigger problems to do with energy. As part of the program, the graduate students also spend time in industry working on related projects. One student went to Toshiba in Japan, one to Hydro Québec and several have gone to 3M in Minneapolis.

▶ What's the connection between this 'big problems' to do with energy and the field of materials science?

One of the things we're working on is thermoelectric materials, which turn waste heat into power. In particular, we're looking at how to make those materials have very low thermal conductivity, because that's key to making those materials more efficient. There is a lot of waste heat that goes up chimneys and out the tail pipes of cars. If that can be turned into power in the car or home or factory where waste heat is going out, the efficiency of the overall system will increase significantly.

We're also looking at other materials that have solar thermal applications, to store solar energy. One of the big problems is: what do you do when the sun's not shining? So we're working with a couple of industries, including a local solar company, to develop a prototype for phase change materials to store heat.

▶ What are these materials, and how do you hope they will improve storage of thermal energy?

Right now, heat is generally stored in water but you need a big volume of water. However, if we can use a smaller amount of material then maybe we can install solar thermal hot water heaters in buildings that otherwise couldn't accommodate that. We're interested in materials that store more energy in a given volume, namely materials that change phase — melt for example. We also have discovered a family of materials that undergo a phase change from solid to solid. Although those materials are too expensive for applications where you need big quantities, they are useful for niche applications.

▶ What are the biggest challenges you are facing?

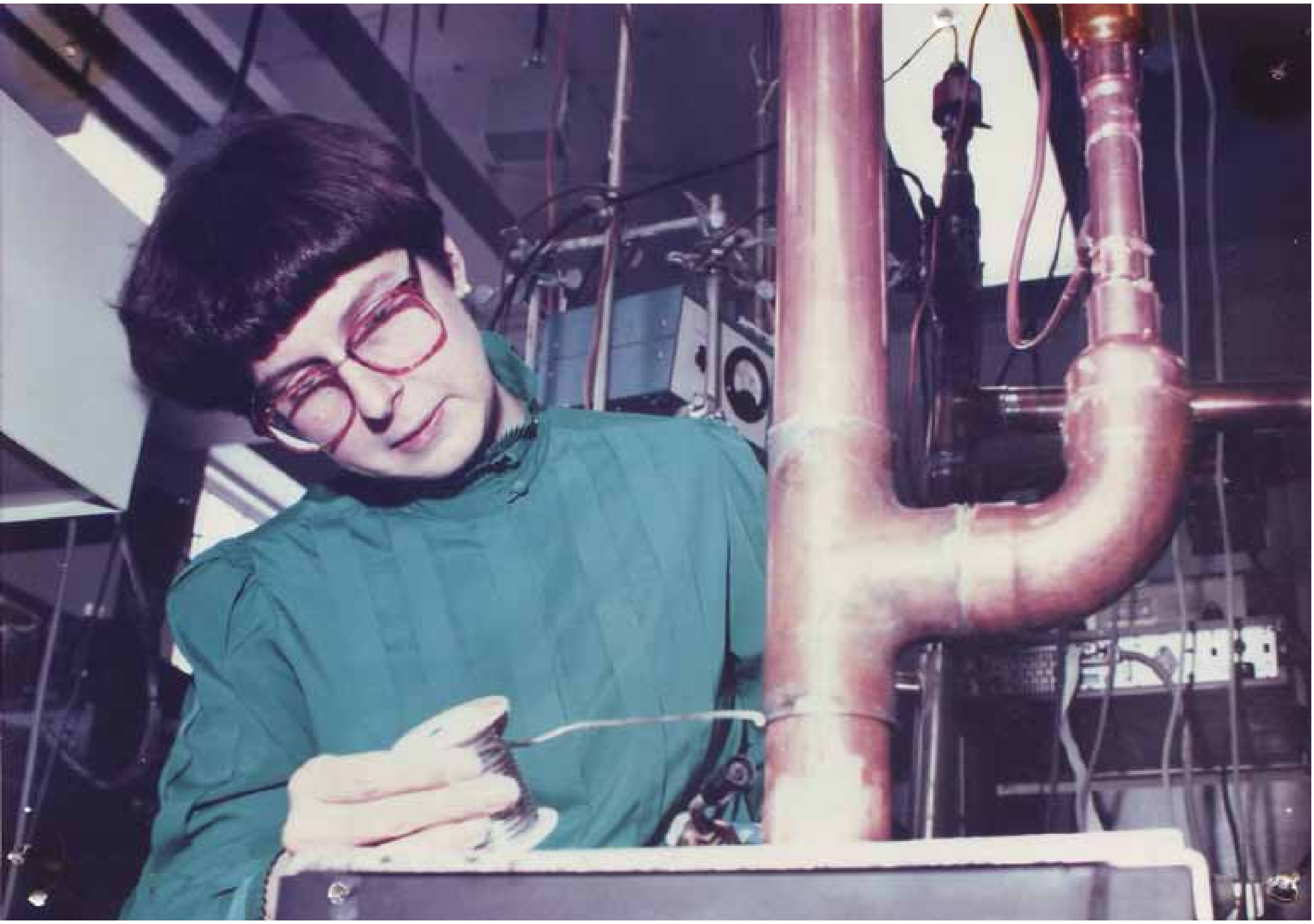
You need a fairly high temperature to get a waste heat that is reasonably useful. To turn the heat into power you have to have properly designed semiconductor materials that use that heat to drive the motion of electrons. Yet it must have very low thermal conductivity to prevent the heat from leaking back across the materials. Finding a material that has a high enough efficiency to allow the electrons to move while minimizing the heat flow is challenging. Usually when something is a good conductor of electricity it is also a good conductor of heat. So we're looking at the thermal conductivity side of this.

▶ Are any of these materials undergoing real-life testing?

We have a test site at Nova Scotia Community College in Dartmouth where we are using a solar panel with some of our materials. It's the first time that an operational commercial solar panel has been tested with a phase-change material for storage.

▶ What other advances are being made in the DREAMS program?

We are taking sustainable approaches, such as making lead-free optical materials. Several of my colleagues in the DREAMS program are working on advanced batteries and next-generation solar cells, for future energy storage. The approaches involve chemistry, physics and engineering. We need many different solutions to be able to solve the energy problem.



MARY ANNE WHITE

Mary Anne White is shown in this photo from the 1990s soldering a vacuum system at Dalhousie University in Halifax.

▶ Do nanostructured materials like carbon nanotube materials or carbon nanotube/polymer composites constitute a significant part of the research in your labs?

We're interested in trying to break up heat flow on a nano-length scale. We look at carbon nanotube materials and also natural and synthetic nanostructures like ivory, nacre and synthetic nacre to study the basic science of thermal conductivity. The ivory we used, which was loaned to us from Canada Customs who use it to train their agents on contraband, is very tough and strong yet with low thermal conductivity, which is an odd pairing of properties. Such natural materials can teach us how to make artificially structured materials.

▶ Why is science outreach important? What do you enjoy about it?

Scientists are mostly funded by the general public and have a responsibility to share knowledge. And I like that it makes me explain things in a general way. One of my all-time favourite questions from my Maritime radio show was, "What would life be like if there was no moon?" The day would be shorter, estimated at 21 hours instead of 24 hours, and we wouldn't have tides. Since most of life developed in intertidal areas, life would have evolved in a different way. I wouldn't have thought of a question like that and I'm still thinking about it.

▶ Is materials science on the verge of a revolution – is it the future?

Well, there are many things that are the future; materials science is a very important topic to chemistry, physics and engineering. It has great promise to help bring us solutions to some of the top problems in the world, especially energy related problems. accn