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# The dance of the particles

**McMaster researchers are at the bleeding edge of innovation in solar energy technologies**

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MCMASTER UNIVERSITY PHOTO
McMaster University physics professor Ray LaPierre points to images taken by the Titan electron microscope showing nanowires he has grown in the lab.

HAMILTON–Gianluigi Botton fires up a computer and a mysterious image pops up on the screen. It doesn't look like much. A bunch of blurry white dots tightly packed together on a black background. Kind of like looking through a screen door on a blindingly sunny day.

"Those would be silicon atoms," he says casually, like someone who works at the atomic level every day and is not easily impressed.

Behind the computer is an awkwardly shaped, vaulted room. Soundproofed and strictly climate controlled, the room is almost a building within a building. It rests on its own foundation, undisturbed by the vibrations around it. Inside sits a machine called Titan – a $14 million electron microscope, and one of only a handful in the world capable of zeroing in on the nearly invisible fabric of our existence.

"The world's most powerful microscope," says Botton, director of McMaster University's Centre for Electron Microscopy.

Like satellites that can seek out new planets and submarines that can venture into the undiscovered depths of the ocean, Titan can peek into the miraculous world where protons and electrons dance. We're talking smaller than viruses, molecules, DNA and even "nano" particles. Titan can zoom in on objects slightly less than one angstrom in size, or a million times thinner than a sheet of photocopy paper.

It's part of the reason why McMaster is fast becoming a global leader in material sciences and, under that umbrella, at the leading edge of innovation in the red-hot market for solar technologies.

Flexible Solar Cell, Cleanfield Energy and Arise Technologies are just three companies hoping to launch commercial products based on innovations coming out of the Hamilton university.

Researchers here say solar could fill the vacuum left behind by the collapse of the telecommunications industry, from which once proud giants such as Nortel Networks and JDS Uniphase have never fully recovered.

Engineering professors Ray LaPierre, who is working with Cleanfield on solar cells made from a dense turf of nanowires, and Adrian Kitai, who co-founded Flexible Solar to make bendable solar panels that are less costly to manufacture, are showing how skills typically prized in the telecom sector can be repurposed to build better solar technologies.

Similar efforts are also being made at the University of Toronto's Institute for Optical Sciences, where a new spin-off called The Solar Venture aims to improve the economics of solar.

"Ontario was a global leader in telecom, but now that has slowed down," says Rafael Kleiman, professor of engineering physics and director of McMaster's Centre for Emerging Device Technologies.

"All the people, all this research (in telecom), is finding a new home. I really believe Ontario can make itself a global hub in solar photovoltaic technologies."

Semiconductor research has long been at the heart of Canada's telecom industry, earning Ottawa the reputation as Silicon Valley North. Apply electricity to a semiconductor and it can create light, allowing for the development of lasers and detectors used in high-speed telecom switches and fibre-optic networks.

But the materials used to make semiconductors, silicon as well as so-called Group III-V elements such as gallium, indium, phosphorus and arsenic, can operate in reverse. Shine light on them and they can absorb the energy and turn it into electricity. In other words, semiconductors are solar cells that operate in reverse.

"A solar cell is just a big specialized chip, so everything we've learned about making chips applies," Paul Saffo, an engineering professor at Stanford University, recently told the *New York Times*.

There's a reason why California's Silicon Valley, the headquarters of data-networking king Cisco Systems and semiconductor goliath Intel, is positioning itself as Solar Valley. Companies such as SunPower, Miasole, Nanosolar and Optisolar are all aiming to create cheaper and more efficient solar cells. They hope to hit their target by applying lessons learned from telecom and computing, where Moore's Law has led to a dramatic reduction in the cost of cellphones, laptops and all the networking in between.

Some say the solar industry is where the computing industry was in the mainframe-era of the 1970s, before the personal computer and Microsoft.

Last month, Waterloo-based solar-cell manufacturer Arise Technologies and the Ontario Centres of Excellence awarded Kleiman and his research team $4.1 million to help commercialize a new way of making more efficient solar cells.

Conventional solar cells are essentially made from thin wafers of silicon, capturing between 12 and 21 per cent the energy in sunlight. When the sun hits the silicon, it excites the electrons in the material, knocking them free. That flow of free-moving electrons is harvested as electricity.

Kleiman and colleague John Preston, also a professor of engineering physics at McMaster, have come up with a way to grow an extremely thin layer of Group III-V materials, such as gallium-arsenide, on top of a silicon wafer.

Silicon absorbs energy from the invisible part of light spectrum, such as ultraviolet light, while gallium-arsenide can capture energy from the visible light. By capturing more of the energy across the light spectrum, Kleiman says the new "double-junction" cells can theoretically achieve 43 per cent efficiency.

The trick is in properly aligning the top layer with the bottom layer in a way that's consistent enough for mass production. It's a process that the McMaster team believes it has figured out, with help from the Titan microscope.

"We figure we could get this to market in three years," says Kleiman.

He admits that Canada is behind in the solar market when compared to Japan, Germany and now Silicon Valley. But at a time when other sectors are hurting and the world demand for renewable energy technologies such as solar is booming, Kleiman suggests there's still an opening in a race that's far from over.

"We have the ability to play catch up, and to succeed," he says.

Mark Romoff, president of the Ontario Centres of Excellence, says there's no reason technology from Ontario automotive manufacturing, telecommunications and microelectronics couldn't be modified and applied to solar-energy innovation.

"One of Ontario's strengths is its ability to transfer technology, knowledge and expertise from one sector to another," he says.