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Press Release

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Canadian Breakthrough Opens Door for Using Light in Advanced Telecommunications

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TORONTO, May 26 /CNW/ - Researchers affiliated with The Canadian Institute for Advanced Research (CIAR) and the University of Toronto, have produced a silicon-based material that can "cage", or trap light, controlling it in the same way that microchips control electrons. This new discovery may lead to the first optical microchip, where light instead of electricity moves through tiny circuits. If this new material can be reliably mass produced, and incorporated into telecommunications networks and computers, it can be a major technological revolution. Information would travel at light-speed, the fastest in the universe, allowing smaller and faster communications devices to be built.

This novel material is the result of collaboration between Sajeev John, a theoretical physicist and Geoffrey Ozin, a materials chemist. Both are professors at the University of Toronto and Associates of CIAR's newest program -- Nanoelectronics, the science of developing and using circuits and devices only a few nanometers (1 billionth of a meter) in size. Their results appear in this week's issue of the British science journal, Nature.

Dr. John first developed the idea of "caging" light in his PhD. thesis at Harvard in 1984. "I realized that if you could cage it, then you could perform functions with light, similar to the way in which electrons behave in semiconductors." While at Princeton in 1987, he refined his idea by introducing the concept of a "photonic band gap" material that could control light in the same way that today's semiconductor chips control electrons.

A worldwide effort has been going on for a decade to produce this photonic material. Ideally, it needed to meet four criteria: First, it had to be silicon-based, the most common microchip material. Second, it had to control light at the same wavelength used in today's fibre optics. Third, there had to be a way taking the micro-scale structures and building them into larger structures. Fourth, the material should be inexpensive to make, and the only way to do this was to find a way for molecules to assemble themselves naturally into the required 3-D structure, rather than having to build the structure piece by piece.

"Going from the idea to developing an actual material," says Dr. John "has been the biggest bottleneck in the field up to now."

The breakthrough emerged from a collaboration at the University of Toronto that would not have been possible without the CIAR. First, Dr. John would still have been in Princeton, not Toronto. "CIAR's offer to be part of one of their programs was the edge that ultimately made me leave Princeton in 1989 to come to Toronto," recalls Dr. John. Second, about a year ago CIAR was instrumental in convincing Dr. Ozin to stay in Toronto, and turn down a prestigious appointment in the United Kingdom. Finally, both researchers were invited to join CIAR's new nanoelectronics program at about the time that a collaboration between them would be critically needed to move forward.

Dr. Ozin had been working independently in the building next door to Dr. John's, creating new techniques for growing silicon into porous materials. In traditional microelectronics, silicon chips are "grown" on flat surfaces. Dr. Ozin's techniques for growing silicon in holes were just what Sajeev John needed.

"When Sajeev first approached me and asked if I could use my techniques to grow this material," says Dr. Ozin, "I thought it was impossible." Their discussions continued during early meetings of CIAR's nanoelectronics group. "This CIAR interaction catalyzed our collaboration," says Ozin. "I became motivated to 'try the impossible.'" "I think meeting Geoff at this particular time was destiny," says John.

Researchers knew that opals have an orderly crystal structure with some of the earmarks of the materials that Dr. John had predicted. The idea was to use opals to create a template (a regularly spaced lattice of tiny cavities, or holes) on which to grow the new material. Sajeev John found a group of physicists in Spain who had developed a technique for producing just such a template. The group, knowing about John's theoretical work and Ozin's materials research, were happy to collaborate by providing a template.

"We knew that unless the templates were really good it would be very hard to get silicon to infiltrate their tiny cavities. In our initial trials my worst fears were confirmed," recalls Ozin. "Our yield was only a few percent, while Sajeev's theoretical road map called for 90 per cent!"

The Spaniards perfected their templates, and finally Ozin's group was able to get the yields that John needed. With this obstacle removed, they began to work with a laser group at the University of Toronto, led by Dr. Henry van Driel. "We had a unique, three-way collaboration," says Ozin. "My group would use Sajeev's specifications to produce some material. Henry's people would measure its optical properties. Sajeev would look at the numbers, crunch them in his computer, and tell us precisely what to change. Then we would start again." Finally, in November 1999, they produced their magic material.

"There have been two technological revolutions that have come out of condensed matter physics in this century," explains Dr. John. "The first was the semiconductor revolution for electronics. The second revolution was the invention of the laser. But even with the laser and all the things it can do, there has not been any real material that can micro-manipulate the flow of light in the same way that the semiconductor does to electrons. And that's why this line of research, and in particular this breakthrough, is really important."

Founded in 1982, The Canadian Institute for Advanced Research is Canada's research university without walls. Over 190 renowned scholars work within the Institute's eight major research programs. Their collaboration within and among the programs influences health, social and economic policies as well as science and technology in Canada and abroad.

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