Speeding Up Communications Networks

Electrical Engineering Ph.D. student Jeffrey Driscoll's research on speeding up silicon chips has not only won him a major award but may also lead to more versatile optical communications networks.

Driscoll's paper, "First Demonstration of Quasi-Phase-Matched Four-Wave-Mixing in Silicon Waveguides," earned him top honors in the annual Theodore Maiman Student Paper Competition

(http://engineering.columbia.edu/files/engineering/bone1200.png)

Jeffrey Driscoll, right, with Electrical Engineering Professor Tony Heinz, the David M. Rickey Professor of Optical Communications

Jeffrey Driscoll

Age: 27

Hometown: Metro-Detroit (Clarkston, Michigan).

Undergraduate: B.S. Michigan Technological University in Michigan's Upper Peninsula.

Expected graduation date: Ph.D. Electrical Engineering 2012-2013

Why engineering? I think I was always attracted to science, and by that I mean always had natural curiosity about why the world was the way it was. Actually I started Michigan Tech as an undeclared major leaning towards physics. I ended up gravitating toward electrical engineering, because the more I learned, the more I realized that the whole field is really the study of how to extend modern technology by understanding and utilizing very fundamental physics. Luckily at Columbia, I have had a chance to contribute to the understanding of some very fundamental optical physics in these sub-wavelength silicon structures, and also to use that new understanding to engineer, fabricate, and test new devices.

Memorable courses: One was Lightwave Devices taught by Professor Tony Heinz. It was my first exposure to nonlinear optics in the classroom – the field I've now done the majority of my research in – but what I really took away from the class was the clarity with which Professor Heinz taught the material and addressed questions. It provided one example of what it looks like to have a deep understanding of a subject. Another course I found inspiring was the Mathematics of Quantum Mechanics with Professor Brian Greene. The class was taught from the perspective of Quantum Mechanics, but the lesson I learned was very general: If we continue to honestly ask ourselves if we understand what is happening, on deeper and deeper levels, we eventually confront fundamental unanswered questions. This shows that as scientists and as engineers, there is plenty of work to be done.

(http://www.osa.org/About_Osa/Newsroom/News_Releases/Releases/05.2012/Maiman-Student-Paper-Winners-Announced.aspx) . This competition was established by the Optical Society of America (OSA) in 2008 in memory of Theodore Maiman and in acknowledgement of his amazing invention, the first working laser, and recognizes student innovation, research excellence, and presentation skills in the areas of laser technology and electro-optics.

Tony Heinz (http://heinz.ee.columbia.edu/) , the David M. Rickey Professor of Optical Communications and president of the OSA, says Driscoll's research "has the potential for significant impact on ultrafast communication networks." Although the winning paper is not yet online, an extended version of the work (http://www.opticsinfobase.org/oe/fulltext.cfm?uri=oe-20-8-9227&id=231767) is available.

"His creative research, carried out as part of his doctoral dissertation in Professor Richard Osgood's group (http://cumsl.msl.columbia.edu/) , has identified a new way to control optical signals in silicon," Heinz says. "While silicon is the material that forms the basis of modern electronics, only recently are researchers — through advances like Jeff's — learning how to exploit the properties of silicon for the control of light waves."

Driscoll says his work improving the efficiency of nonlinear optical processes on silicon chips has significant practical application, as it "essentially allows the diverse collection of sources, detectors, and components developed for the mature telecommunications industry to be connected directly to mid-infrared applications." Near infrared is the region closest in wavelength to the radiation detectable by the human eye; mid and far infrared are progressively further from the visible spectrum.

Osgood, the Higgins Professor of Electrical Engineering and Applied Physics, says Driscoll uses ultrathin nanometer-scale silicon wire waveguides to realize a new device concept.

"His device, really an invention, uses subtle angstrom scale wiggles in the width of the wire to make mixing optical frequencies very efficient," Osgood says. "In fact his approach is powerful in that it enables conversion of light from a wavelength of 1.55 micrometers to 2-3 micrometers; that is from the near infrared to mid-wavelength infrared—a region of many applications in free-space communications and in nonlinear optics."

Driscoll credits Osgood for pushing him to make theoretical research into practical demonstrations.

"This particular device is challenging because it requires extremely precise fabrication processes that took a long time to develop," Driscoll says. "Professor Osgood continued to push the fabrication, and maintained confidence we would be successful. Eventually we developed the processing to a point where we could make high-quality Si photonic devices, enabling this experiment."

Driscoll was the lead author on the research and gives credit for the success of the project to the assistance and guidance of several others involved, including others working with Professor Osgood (graduate student Richard Grote and research scientist Jerry Dadap), another graduate student here with Professor Keren Bergman (http://lightwave.ee.columbia.edu/bergman/) (Noam Ophir), the Charles Batchelor Professor of Electrical Engineering, Professor Nicolae Panoiu (https://research.ee.ucl.ac.uk/people/academic/npanoiu) at University College in London, and the cleanroom staff at the Center for Functional Nanomaterials at Brookhaven National Labs.

—Story by Jeff Ballinger (mailto:jlb2180@columbia.edu)

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Posted: May. 22, 2012

