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A Tighter Grip on Light

BY BRETT KRAABEL

Physics. Two research teams make significant headway in the ongoing effort to miniaturize optical interconnections for integrated electronics and photonics.

By confining light into glass fibers 50 times smaller than a human hair, Jean-Charles Beugnot and Thibaut Sylvestre, of the FEMTO-ST,[1] detected for the first time light scattering from surface acoustic waves (phonons).[2] To obtain this result, the team injected a laser beam into silica fibers tapered down to 500 nanometers in diameter, which is several times smaller than the wavelength of the light. As the beam travels through the fiber, it induces infinitesimal vibrations in the wire, displacing its surface by a few nanometers. The distortions lead to phonons that travel along the fiber surface at 3400 m/s. These phonons in turn affect the propagation of the light because, in a process called "Brillouin scattering," part of the light is reflected with a change of color (i.e., a shift in frequency).

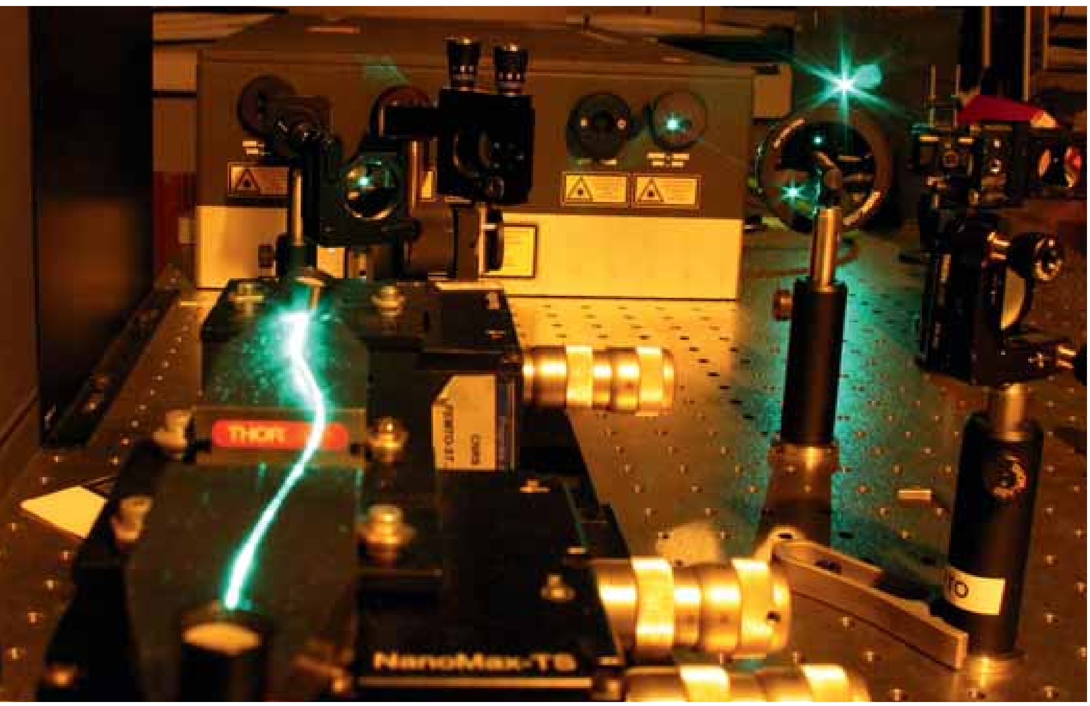
This is the first observation of surface Brillouin scattering in subwavelength optics. By exploiting the frequency shifts, these nanowires could be used for information processing or as microlasers. In addition, "because the fiber's surface is much more sensitive to its environment than the bulk of the wire, surface Brillouin scattering opens up new possibilities for sensing temperature, pressure, or even gas or biological molecules," concludes Sylvestre.

In another study,[3] Erik Dujardin and his team at CEMES,[4] along with colleagues in the UK and Singapore,[5] converted light into plasmons—collective oscillations of electrons that can be confined into much smaller conduits.

"Plasmons travel very fast and with very little energy loss compared with electrical signals," explains Dujardin. The nanowires on which the plasmons oscillate are hundreds of nanometers long and are obtained by stringing together crystalline gold particles 10 nanometers in diameter before fusing them with an electron beam. Scanning the beam over the nanowires, the researchers can detect where plasmons of certain frequencies transfer energy to their surroundings.

This method reveals that plasmons of various frequencies propagate or, conversely, concentrate their energy in different regions of the nanowire, which makes them interesting not only for information processing but also for collecting light energy. Such light-harvesting antennas could be used, for example, to significantly increase the efficiency of solar cells.

Another potential application comes from what was originally considered a defect. If a junction between nanoparticles is not fused, the plasmons lose energy at that particular spot. This provides an extraordinarily localized heat source that could be used to kill bacteria or biological cells. II



◢ Instruments at the FEMTO-ST, used to guide a laser beam (emitting at 500 nm wavelength) into the optical microfiber.

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1. Institut Franche-Comté électronique mécanique thermique et optique–sciences et technologies (CNRS / Université de Franche-Comté / Université de Technologie de Belfort-Montbéliard / ENSMM). 2. J.C. Beugnot et al., "Brillouin light scattering from surface acoustic waves in a subwavelength-diameter optical fibre," *Nature Communications*, 2014. 5: 5242. 3. A. Teulle et al., "Multimodal Plasmonics in Fused Colloidal Networks," *Nature Materials*, 2015. 14(1): 87-94. 4. Centre d'élaboration des matériaux et d'études structurales (CNRS). 5. Centre for Organized Matter Chemistry, University of Bristol (UK) and Institute of Materials Research and Engineering, A*STAR (Agency for Science, Technology and Research) (Singapore).