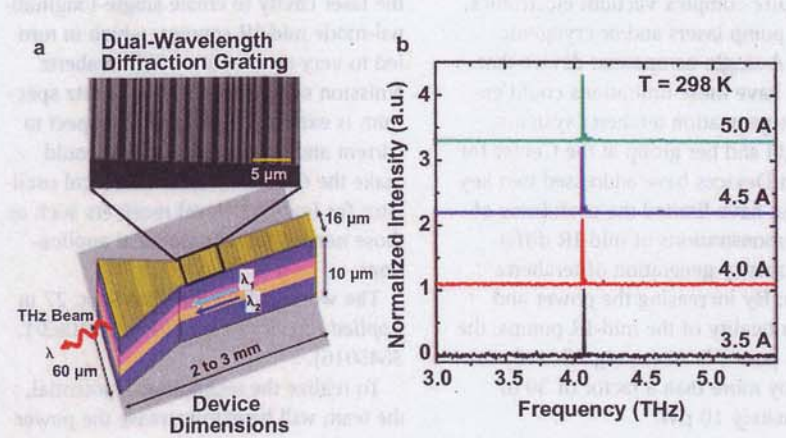
Compact terahertz device could improve security screening

EVANSTON, Ill. – Using two mid-infrared laser beams, researchers have finally generated single-chip terahertz radiation at room temperature. The technology could speed up and improve a range of processes, including high-sensitivity biological and chemical analysis, astronomical study, security screening, border protection and agricultural inspection.

The project got its start in an unscientific place: the airport security lineup. Like most travelers, Manijeh Razeghi, a professor at Northwestern University's McCormick School of Engineering and Applied Science, was concerned with both the delays in the process and its accuracy. The technology to safely and easily inspect items for hazardous substances is expensive and bulky, so much of it is underused, Razeghi said. The same concerns – time, reliability and cost – are found in medical diagnostics, tumor detection and package inspection. She wanted to come up with "something useful that can overcome these basic limitations and allow terahertz technology to truly become pervasive in order to make everyone's life a little safer and easier."



(a) Schematic of an integrated dual-period distributed feedback quantum cascade laser. λ_1 and λ_2 represent the mid-infrared wavelengths. λ represents the terahertz wavelength. (b) The room-temperature terahertz emission spectra at different operating currents, showing stable single-mode operation. Courtesy of Manijeh Razeghi, Northwestern University.

Coherent terahertz radiation historically has been very difficult to generate, and the search for a compact easy-to-use source continues today. Existing terahertz sources are large multicomponent systems that may require complex vacuum electronics, external pump lasers and/or cryogenic cooling. A single-component device that does not have these limitations could enable next-generation terahertz systems.

Razeghi and her group at the Center for Quantum Devices have addressed two key issues that have limited the usefulness of initial demonstrations of mid-IR difference-frequency generation of terahertz radiation: By increasing the power and the beam quality of the mid-IR pumps, the terahertz power has been significantly increased by more than a factor of 30 to approximately 10 μW.

The researchers also incorporated a dual-wavelength diffraction grating within the laser cavity to create single-longitudinal-mode mid-IR sources, which in turn led to very narrow linewidth terahertz emission near 4 THz. The terahertz spectrum is extremely stable with respect to current and temperature, which could make the device valuable as a local oscillator for low-light-level receivers such as those needed for astronomical applications.

The work appeared online Sept. 27 in *Applied Physics Letters* (doi: 10.1063/1.3645016).

To realize the technology's potential, the team will have to increase the power and efficiency at room temperature and also explore on-chip tunability.

Work in this area was partially supported by DARPA, and Razeghi would like to acknowledge the interest and support of Scott Rodgers of DARPA and Tariq Manzur of the Naval Undersea Warfare Center.

"When we started mid-infrared lasers, we started with a few microwatts," she said. "With interest and funding from DARPA, we increased the output power to 120 W. We are very proud of our terahertz demonstration, but the funding is limited at present."

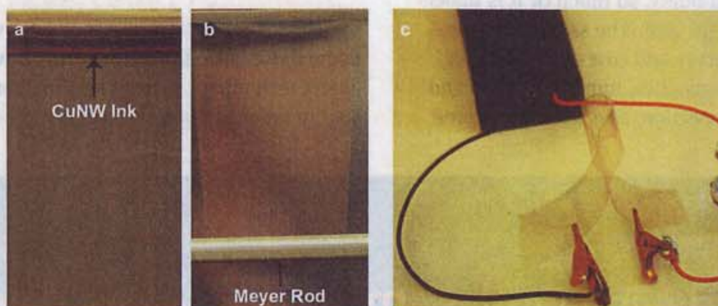
Copper nanowires enable cheaper foldable electronics, solar cells

DURHAM, N.C. – Copper nanowires could bring down production costs for electronic displays, foldable electronics and solar cells – helping engineers build more affordable e-readers, iPads, cell phones, photovoltaic panels and more.

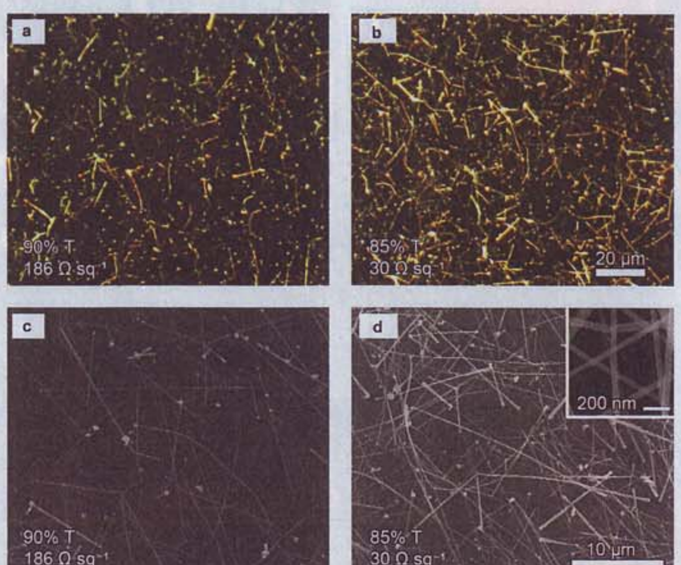
A new technique arranges copper atoms in water to form long, thin, nonclumped nanowires, which are then transformed into transparent conductive films and coated onto glass or plastic.

"I was contacted by a solar cell company frustrated with the low production rate of transparent conducting films made by depositing indium tin oxide from a vapor," said Benjamin Wiley, a Duke University chemist. "They were interested in coating silver nanowires from solution to increase the production rate by at least 100 times … I thought, if I can obtain the same properties with copper nanowires as have previously been obtained with silver nanowires, we could reduce the cost of producing thin-film solar cells to an even greater extent."

The copper nanowire films have the same characteristics as those currently used in solar cells and electronic devices, but they are less expensive to manufacture. In electronic screens, films that currently connect pixels are made of indium tin oxide (ITO). This highly transparent material transmits information well but is an expensive rare-earth element and must be deposited from a vapor in a process that is a thousand times slower than newspaper printing. Also, ITO-containing devices can crack easily.



Images (a) and (b) represent copper nanowire (CuNW) ink before and after coating on polyethylene terephthalate with a Meyer rod. (c) A bent CuNW film (25 Ω sq⁻¹ and 83% transparent) completing an electrical circuit with a battery pack and a LED. Images courtesy of Aaron Rathmell, Duke University.



Images (a) and (b) depict dark-field optical microscope images showing uniformly dispersed networks of copper nanowires that are 90% and 85% transparent, with sheet resistances of 186 and 30 Ω sq⁻¹, respectively. Images (c) and (d) are corresponding scanning electron microscope images of the copper nanowire films from images (a) and (b) showing the average length (20 ±5 μm) and diameter (52 ±17 nm) of the copper nanowires.