Reactive silver ink is airbrushed onto a thin, stretchy plastic film to make a flexible silver electrode. *Photo by S. Brett Walker*

we print," Walker said.

The reactive ink has several advantages over particle-based inks. It is much faster to make: a batch takes minutes to mix, according to Walker, whereas particle-based inks take several hours and multiple steps to prepare. The ink is also stable for several weeks.

The reactive silver ink can print through 100-nm nozzles, an order of magnitude smaller than for particle-based inks, an important feature for printed microelectronics. Moreover, the ink's low viscosity makes it suitable for inkjet printing, direct ink writing, or airbrush spraying over large, conformal areas.

"For printed electronics applications, you need to be able to store the ink for several months because silver is expensive," Walker said. "Since silver particles don't actually form until the ink exits the nozzle and the ammonia evaporates, our ink remains stable for very long periods. For fine-scale nozzle printing, that's a rarity."

The reactive silver ink boasts yet one more key advantage: a low processing temperature. Metallic inks typically need to be heated to achieve bulk conductivity through a process called annealing. The annealing temperatures for many particle-based inks are too high for many inexpensive plastics or paper. By contrast, the reactive silver ink exhibits an electrical conductivity approaching that of bulk silver upon annealing at 90°C.

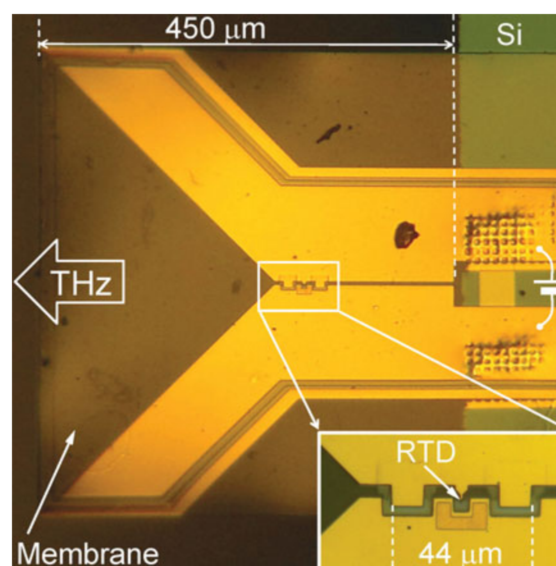
"We are now focused on patterning large-area transparent conductive surfaces using this reactive ink," said Lewis, who is also affiliated with the Beckman Institute for Advanced Science and Technology, the Micro and Nanotechnology Lab, and the Department of Chemical and Biomolecular Engineering at UIUC.

Terahertz transmitter sets frequency record

A terahertz transmitter developed at the Technical University (TU) of Darmstadt, Germany, has set a new frequency record, 1.111 THz, for microelectronic devices. The innovative device is also minuscule and operates at room temperature, which could lead to its paving the way for new applications in, for example, nondestructive testing or medical diagnostics.

As reported in the December 8, 2011 advanced online issue of *Applied Physics Letters* (DOI: 10.1063/1.3667191), a team of physicists and engineers led by Michael Feiginov at the TU Darmstadt's Institute for Microwave Technology and Photonics developed a resonance tunnel diode (RTD) for generating terahertz electromagnetic radiation. The RTD terahertz transmitter occupies less than a square millimeter in area and can be produced using mostly conventional semiconductor-device fabrication technologies.

The heart of their RTD is a dual-barrier structure, within which a quantum well (QW) is embedded. The QW is a very thin layer of indium-gallium arsenide semiconductor sandwiched between a pair of ultrathin barrier layers of aluminum-arsenide semiconductor. Each of these layers is one nanometer to a few nanometers thick. Due to a quantum-mechanical effect, this dual-barrier structure ensures that electromagnetic waves generated within a terahertz oscillator will be repeatedly amplified, rather than attenuated, which means that the oscillator will emit continuous-wave electromagnetic radiation at terahertz frequencies. The group of TU Darmstadt researchers collaborated with ACST GmbH, Germany, a fabricator of microelectronic circuit components, in producing their diode. Other authors of the article are C. Sydlo and P. Meissner of TU Darmstadt and O. Cojocari of TU Darmstadt and ACST GmbH. □



Terahertz transmitter; RTD stands for resonance tunnel diode. *Image: Michael Feiginov/TU Darmstadt.* Reproduced with permission from *Appl. Phys. Lett.* (2011), DOI: 10.1063/1.3667191. © 2011 American Institute of Physics.

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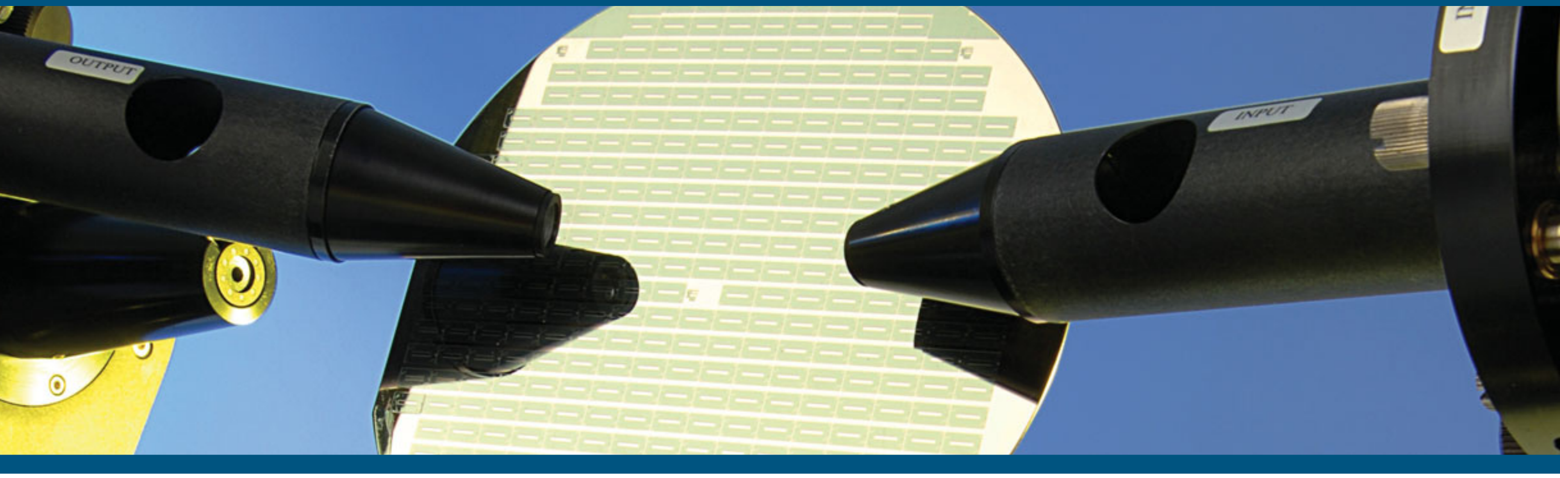

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