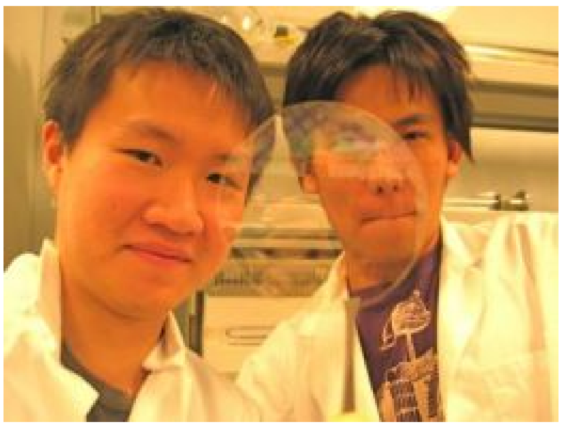
Scientists print dense lattice of transparent nanotube transistors on flexible base

December 16 2008



See-through circuit makers: Hsaioh-Kang Chang, left, and Fumiaki Ishikawa, with their transparent, flexible transistor array. Credit: USC Viterbi School of Engineering

It's a clear, colorless disk about 5 inches in diameter that bends and twists like a playing card, with a lattice of more than 20,000 nanotube transistors capable of high-performance electronics printed upon it using a potentially inexpensive low-temperature process.

Its University of Southern California creators believe the prototype points the way to such long sought after applications as affordable "head-up" car windshield displays. The lattices could also be used to create cheap, ultra thin, low-power "e-paper" displays.

They might even be incorporated into fabric that would change color or pattern as desired for clothing or even wall covering, into nametags, signage and other applications.

A team at the USC Viterbi School of Engineering created the new device, described and illustrated in a just-published paper on "Transparent Electronics Based on Printed Aligned Nanotubes on Rigid and Flexible Structures" in the journal *ACS Nano*.

Graduate students Fumiaki Ishikawa and Hsiaoh-Kang Chang worked under Professor Chongwu Zhou of the School's Ming Hsieh Department of Electrical Engineering on the project, solving the problems of attaching dense matrices of carbon nanotubes not just to heat-resistant glass but also to flexible but highly heat-vulnerable transparent plastic substrates.

The researchers not only created printed circuit lattices of nanotube-based transistors to the transparent plastic but also additionally connected them to commercial gallium nitrate (GaN) light-emitting diodes, which change their luminosity by a factor of 1,000 as they are energized.

"Our results suggest that aligned nanotubes have great potential to work as building blocks for future transparent electronics," say the researchers.

The thin transparent thin-film transistor technology developed employs carbon nanotubes - tubes with walls one carbon atom thick - as the active channels for the circuits, controlled by iridium-tin oxide electrodes which function as sources, gates and drains.

Earlier attempts at transparent devices used other semiconductor materials with disappointing electronic results, enabling one kind of transistor (n-type); but not p-types; both types are needed for most applications.

The critical improvement in performance, according to the research, came from the ability to produce extremely dense, highly patterned lattices of nanotubes, rather than random tangles and clumps of the material. The Zhou lab has pioneered this technique over the past three years.

The paper contains a description of how the new devices are made.

"These nanotubes were first grown on quartz substrates and then transferred to glass or PET substrates with pre-patterned indium-tin oxide (ITO) gate electrodes, followed by patterning of transparent source and drain electrodes. In contrast to random networked nanotubes, the use of massively aligned nanotubes enabled the devices to exhibit high performance, including high mobility, good transparency, and mechanical flexibility.

"In addition, these aligned nanotube transistors are easy to fabricate and integrate, as compared to individual nanotube devices. The transfer printing process allowed the devices to be fabricated through low temperature process, which is particularly important for realizing transparent electronics on flexible substrates. … While large manufacturability must be addressed before practical applications are considered, our work has paved the way for using aligned nanotubes for high-performance transparent electronics "

The article can be read at: pubs.acs.org/doi/abs/10.1021/nn800434d

Source: University of Southern California