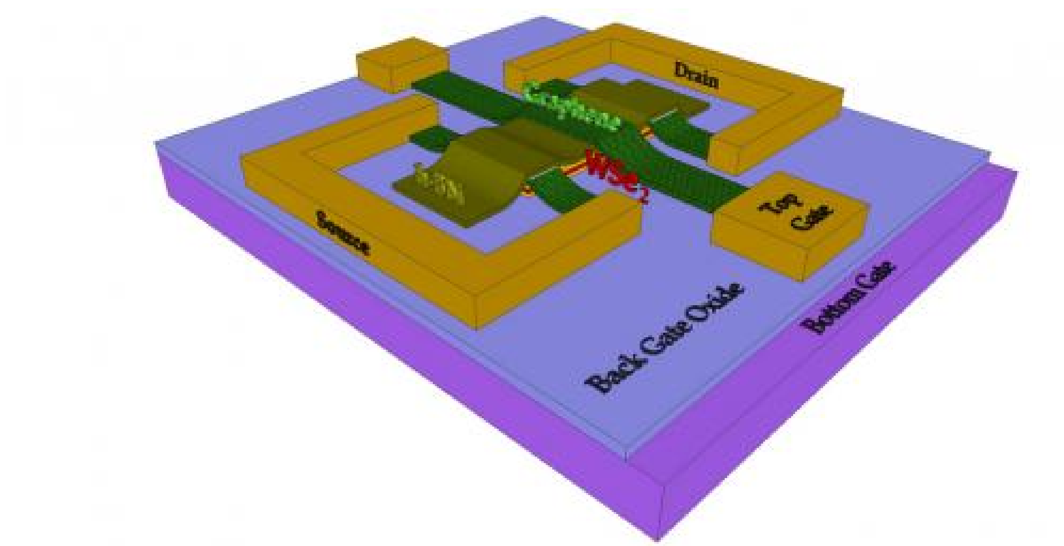
Flexible, transparent thin film transistors raise hopes for flexible screens

May 28 2014, by Louise Lerner



This illustration shows the landscape of the thin-film transistor created by Argonne scientists, which is just 10 atomic layers thick. The transistor is transparent and can be bent without loss of performance. Credit: Saptarshi Das.

(Phys.org) —The electronics world has been dreaming for half a century of the day you can roll a TV up in a tube. Last year, Samsung even unveiled a smartphone with a curved screen—but it was solid, not flexible; the technology just hasn't caught up yet.

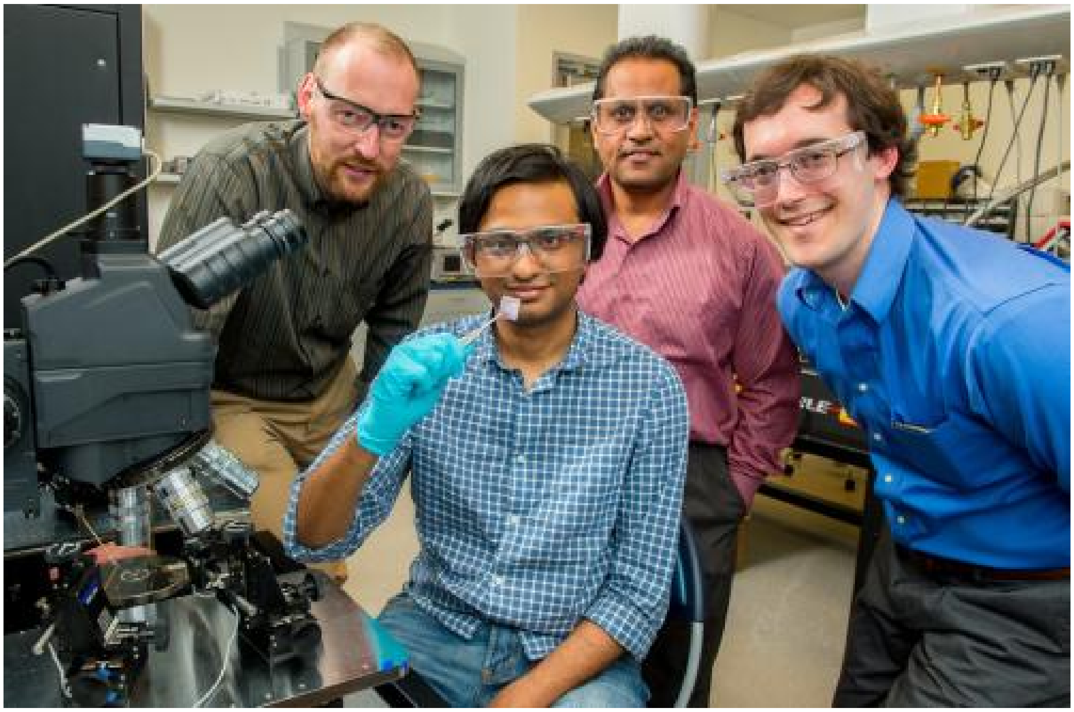
But scientists got one step closer last month when researchers at the U.S. Department of Energy's Argonne National Laboratory reported the creation of the world's thinnest flexible, see-through 2-D thin film transistors.

These transistors are just 10 atomic layers thick—that's about how much your fingernails grow per second.

Transistors are the basis of nearly all electronics. Their two settings—on or off—dictate the 1s and 0s of computer binary language. Thin film transistors are a particular subset of these that are typically used in screens and displays. Virtually all flat-screen TVs and smartphones are made up of thin film transistors today; they form the basis of both LEDs and LCDs (liquid crystal displays).

"This could make a transparent, nearly invisible screen," said Andreas Roelofs, a coauthor on the paper and interim director of Argonne's Center for Nanoscale Materials. "Imagine a normal window that doubles as a screen whenever you turn it on, for example."

To measure how good a transistor is, you measure its on-off ratio—how completely can it turn off the current?—and a property called "field effect carrier mobility," which measures how quickly electrons can move through the material.



Scientists from Argonne created the world's thinnest flexible, transparent thin-film transistor, which could one day be useful in making a truly flexible display screen for TVs or phones. From left: Andreas Roelofs, Anirudha Sumant, and Richard Gulotty; in foreground, Saptarshi Das. Credit: Mark Lopez/Argonne National Laboratory

"We were pleased to find that the on/off ratio is just as good as current commercial thin-film transistors," said Argonne postdoctoral scientist and first author Saptarshi Das, "but the mobility is a hundred times better than what's on the market today."

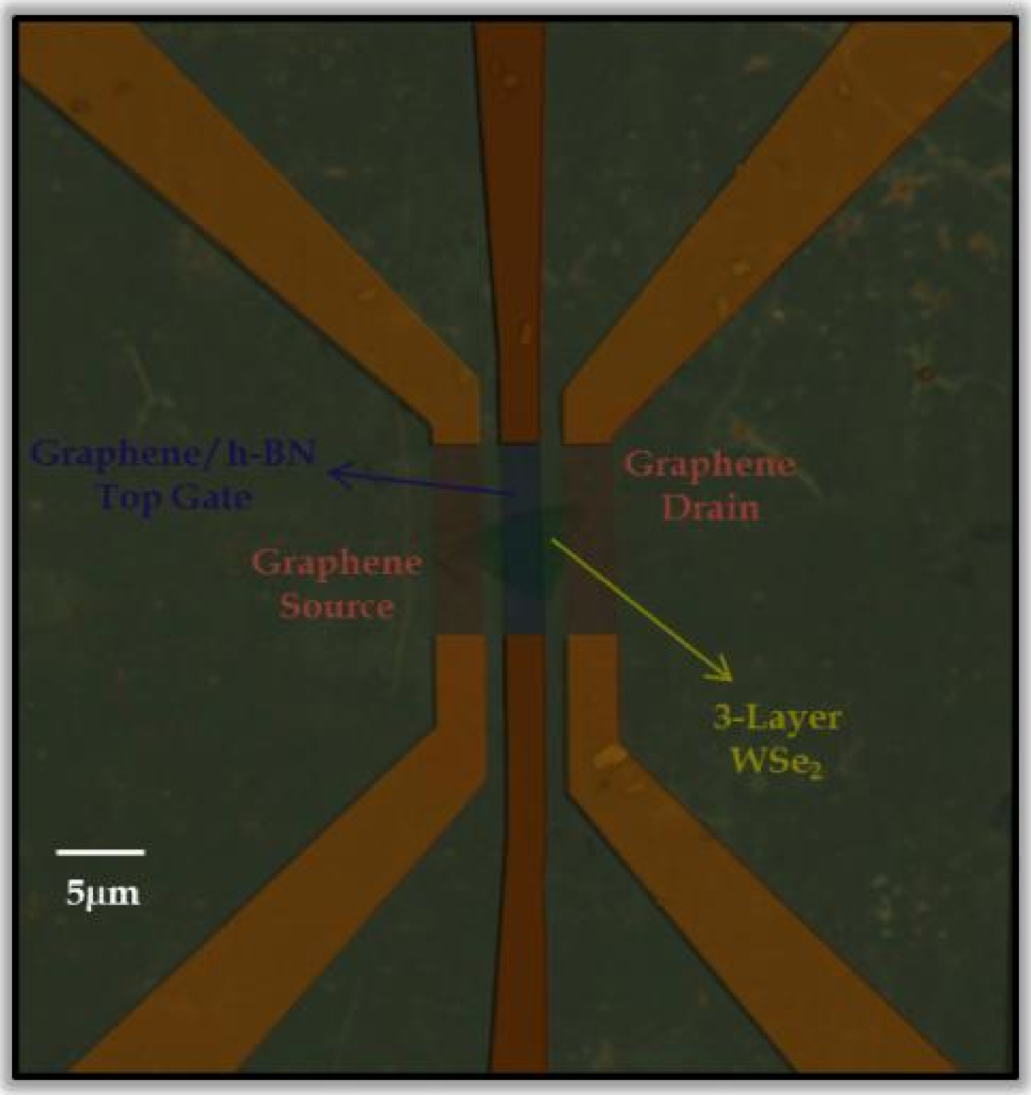
The team also tried bending the films to test what happens under stress. In most thin film transistors, the material starts to crack, which, as you might imagine, affects performance. "But in ours, the properties didn't change at all," Roelofs said. "The layers just slide and don't crack."

The thin-film transistor is flexible, transparent and performs just as well as commercial versions. Displayed is an array of transistors – each of which are just 10 atomic layers thick. Credit: Mark Lopez/Argonne National Laboratory.

The transistors also maintained performance over a wide range of temperatures (from -320°F to 250°F), a useful property in electronics, which can run very hot.

To build the transistors, the team started with a trick that earned its original University of Manchester inventors the Nobel Prize: using a strip of scotch tape to peel off a sheet of tungsten diselenide just atoms thick.

"We chose tungsten diselenide because it provides the electron and hole conduction necessary for making transistors with logic gates and other pn junction devices," said Argonne scientist and coauthor Anirudha Sumant.



A scanning electron microscope image of the thin-film transistor, fabricated using single-atom-thick layers of graphene and tungsten diselenide, among other materials. The white scale bar shows 5 microns, which is about the diameter of a strand of spider silk. Credit: Saptarshi Das.

Then they used chemical deposition to grow sheets of other materials on top to build the transistor layer by layer. The final product is 10 atomic layers thick. (See sidebar for an illustration).

Next, the team is interested in adding logic and memory to flexible films, so you could make not just a screen but an entire flexible and transparent TV or computer.

"However, more work needs to be done in developing large-area synthesis of tungsten selenide to realize the true potential for applications of our work," said Sumant.

More information: "All Two-Dimensional, Flexible, Transparent, and Thinnest Thin Film Transistor." Saptarshi Das, Richard Gulotty, Anirudha V. Sumant, and Andreas Roelofs. *Nano Letters* 2014 14 (5), 2861-2866. DOI: 10.1021/nl5009037

Provided by Argonne National Laboratory

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