Record speed for thin-film transistors could open door for flexible electronics

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A pair of University of Wisconsin-Madison researchers have developed a method of making flexible, thin-film transistors (TFTs) that are not only inexpensive to produce, but also capable of high speeds — even microwave frequency, impossible before now.

Assistant professor of electrical and computer engineering Zhenqiang (Jack) Ma and graduate student Hao-Chih Yuan recently demonstrated flexible TFTs capable of operating at a world-record speed of 7.8 GHz.

TFTs are transistors that are currently widely used in electronics such as liquid crystal displays (LCD) and electronic and radio-frequency tags. For example, in an LCD screen, TFTs control individual pixels for high-quality images. TFTs made on flexible substrates could have a variety of applications, says Ma, including flexible and wearable electronics, flexible sensors, large-area surveillance radar, embedded signatures and more.

Until now, flexible TFTs have been relatively slow, operating in the 0.5 GHz range, says Yuan. This is fine for applications such as LCD, but not for applications such as military surveillance antennas that require high-performance but flexible circuitry for easy storage. "The application of current low-speed TFTs is very limited," says Ma. "Fast TFTs offer significant advantages in terms of power consumption and operation frequency, beside their flexibility and robustness against breakage."

Flexible TFTs are usually made of organic materials or amorphous or poly silicon, but the research team instead uses nanoscale-thin membranes of single-crystal silicon, which has greater electron mobility and greater speed. The membranes can be peeled off from the bulk silicon used for fabrication with an inexpensive, patent-pending method. But mobility is not enough to bring the TFTs up to speed, Ma says. Low-resistance electrode contacts are also important.

However, achieving this is challenging because the high temperatures needed to activate low-resistance contact connections melt the polymer substrates on which the transistors are fabricated. "That is the major obstacle to realizing the high speed operation of TFTs, regardless of the fact that high mobility has been already demonstrated in single-crystal silicon on flexible substrate," says Ma.

Ma and Yuan overcame this obstacle with an innovative technique. They made the transistors in "hot" and "cold" steps. First, they made the contact connectors on a bulk silicon substrate to achieve low resistance, and then transferred the single-crystal nanomembranes to the flexible substrate to continue fabrication. Ma and Yuan published a paper detailing this novel method in a recent issue of *Applied Physics Letters*.

Another factor in the new TFT's speed is that instead of the usual silicon dioxide, they made the gates of silicon monoxide, which carries the advantage of lower processing temperatures. "In addition, silicon monoxide has higher electric capacity and can be made thinner than the dioxide. As a result, the device speed becomes even faster," says Yuan.

The next step, says Ma, is developing even more advanced processing technologies and materials for even higher speed TFTs. He also hopes for the realization of potential applications, including an entire flexible radio-frequency system. "We opened numerous possibilities with this breakthrough," he says.

Source: University of Wisconsin-Madison