Inexpensive, flexible large area neutron detectors to monitor movement of fissile materials

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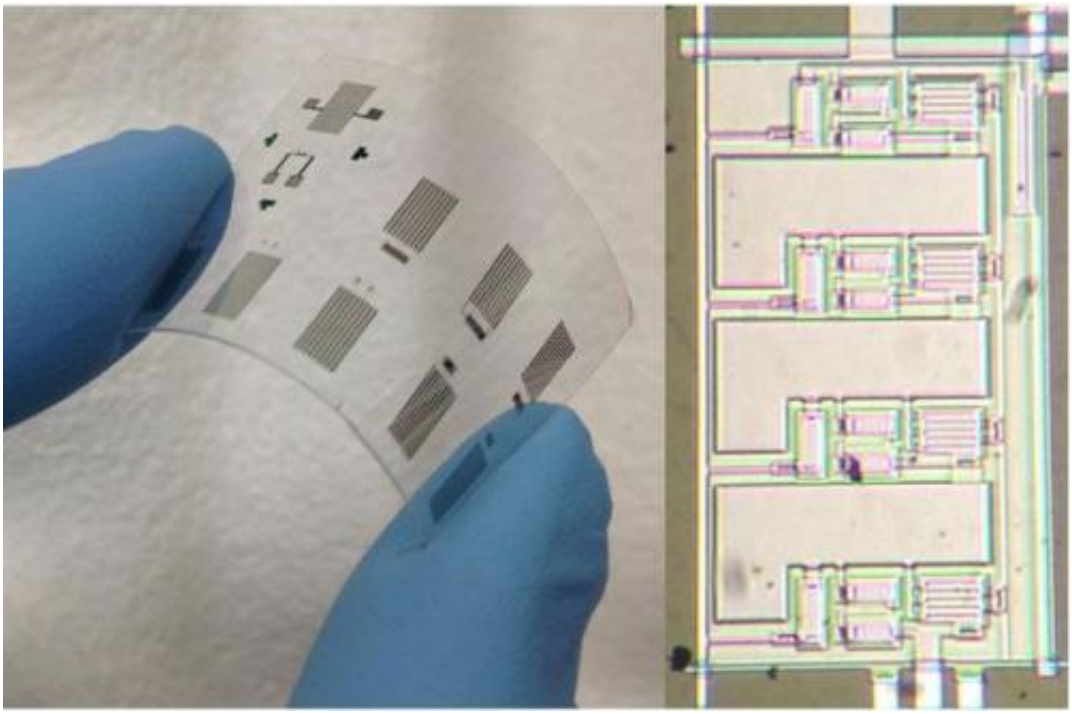


TFT active pixel sensor (L) and one of the 570 x 1060 μm 4-stage active pixel sensors (R)

Researchers in the US are capitalising on the falling cost of TFT-based flat panel display manufacture to produce inexpensive, flexible large area neutron detectors to help monitor the movement of fissile materials.

Cold war legacies

Neutron detection is used to detect thermal neutrons emitted by special nuclear material (SNM). SNM consists of fissile material used in the production of nuclear weapons. A typical use of neutron detection might be monitoring for SNM hidden in cargo at ports of entry to a country.

However, neutrons are difficult to directly detect because of their neutral charge. Instead, indirect methods are often used, which detect secondary charged particles, such as high energy alpha particles, that are emitted in thermal neutron capture reactions.

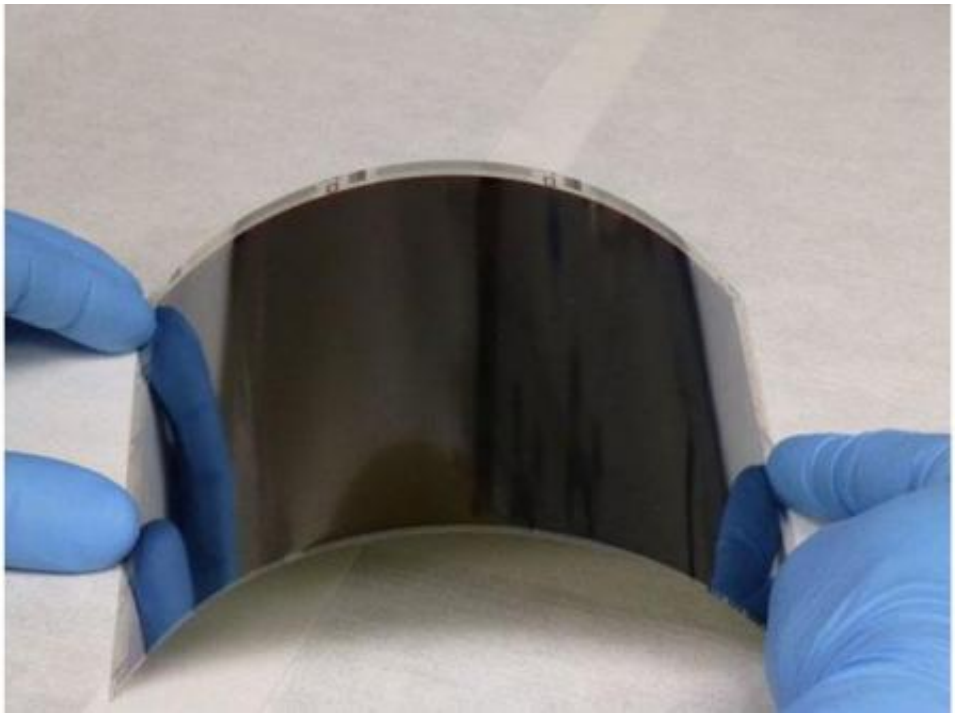
To date, neutron detection systems have primarily relied on ^{3}He gas proportional counters. These detect charged protons indirectly generated during thermal neutron capture. These have a number of drawbacks including high cost and, more critically, a dwindling supply of ^{3}He gas.

^{3}He gas is a by-product of nuclear weapons production, which means that the post–Cold War draw-down of nuclear weapon stockpiles has also diminished the ^{3}He gas supply. This has created a real need to identify methods for thermal neutron detection that do not use ^{3}He gas.

Sidelines

To address this need, as well as the need for large-area and low-priced neutron detectors, a team from Arizona State University (ASU), in the US, has been looking at a technology that has enabled low-cost manufacturing of 'flatscreen' televisions – thin film transistors (TFTs). "Our focus was to develop a low cost neutron detector that can be manufactured using large area flat panel display TFT-based technology. This is important because, in typical cargo inspection applications, increasing the size of the detector proportionally increases the

probability of detection. This is critical because many of the items being scanned for SNM, such as entire cargo containers, can be quite large," explained team member George Kunnen.



Flexible X-ray detector

"Using conventional flat-panel-display processing is also key to reduce detector manufacturing costs. As evident to anyone who has recently priced a flat-panel television, large LCD TVs currently cost only about $10 per diagonal inch, which translates to less than 10¢ per square centimetre of active area. This makes the use of conventional flat panel display manufacturing very appealing for low-cost large area sensor applications."

As a result of this work, researchers at ASU's Flexible Electronics

Display Center (FEDC) have now demonstrated the ability to reliably detect alpha particles using TFT-based amplifier pixel circuits produced using flexible flat panel display technology. This allows neutron detection – as the detection of alpha particles resulting from thermal neutron capture reactions, indicates the presence of a neutron flux.

Previous work in TFT-based detectors was not able to reliably detect alpha particles due to their low sensitivity. ASU's new active pixel sensor design achieves higher gain, and so sensitivity, by cascading multiple low-gain common source amplification stages in an open loop configuration. The cascading technique was developed to overcome the low gain of previous TFT pixel amplifiers, which used only a single amplification stage.

"The total gain of the new multistage amplifier now grows geometrically with each additional stage, enabling the small charge or incident voltage pulse, consistent with the ionising event created by a single alpha particle strike, to be amplified to a level readily detectable using conventional peripheral CMOS readout electronics," said Kunnen.

Flexible technology

The ASU team has now shifted its focus to tiling the current pixel design into a larger area detection array, and integration of the disparate layers into a unified detection system. Once larger area sensors with integrated capture diodes have been demonstrated to effectively detect thermal neutrons, the team plan to move on to field trials to inspect for SNM.

This technology can also be applied to applications requiring the detection of small discrete charges and signal levels using TFT-based sensors manufactured using flat panel display technology. In fact, the neutron detector work is part of an on-going effort at ASU to apply flexible flat panel display technology to large area sensor applications

more generally. This effort has already seen publications from the FEDC group in areas including flexible digital x-ray radiography panels and flexible ISFET biosensor arrays.

More information: "TFT-based, multi-stage, active pixel sensor for alpha particle detection." G. Kunnen; J. Smith; H. Chung; D. Allee. *Electronics Letters*, Volume 50, Issue 9, 24 April 2014, p. 705 – 706. DOI: 10.1049/el.2014.0259 , Print ISSN 0013-5194, Online ISSN 1350-911X

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