A Nanotechnology Face-Lift for MCPs

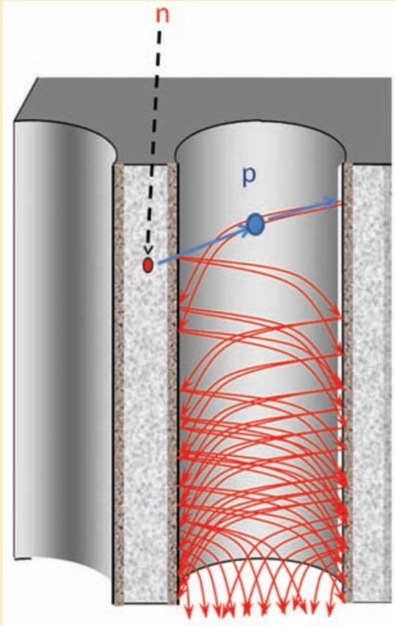
Semiconductor technology allows use of new materials.

BY KEN STENTON, ARRADIANCE INC.

Although microchannel plate (MCP) electron multiplier technology has been around for about 50 years, advances in performance have been very slow. Today, because of advanced semiconductor deposition techniques, however, it holds promise for applications in homeland security, where it could be used to enhance detection of special nuclear materials. MCPs, which have long relied on lead glass substrates, have now been freed to be manufactured from a wide range of substrate materials, including silicon, ceramic – even plastic.

Detecting nuclear materials is significant in preventing their being smuggled across borders. Most deployed neutron detection systems rely on detecting "thermalized" neutrons. The problem with this approach is that, to be detected, neutrons must be slowed down, which requires many centimeters of cumbersome material surrounding the detector. Also, once the neutrons are slowed, their original energy and direction cannot be detected, rendering identification of special nuclear material more difficult.

Arradiance Inc. of Sudbury, Mass., has developed a method that combines the low-noise, and high-temporal and -spatial resolution of microchannel plates with the neutron-stopping power of hydrogen-rich plastic substrates. The technology uses atomic layer deposition to add emissive and resistive thin films to the plastic MCP substrates, resulting in a device that can be fully optimized for neutron detection through dissociated optimization of the substrate and the electrically active functional films.



When a neutron hits a plastic microchannel plate, it interacts with hydrogen, resulting in a recoil proton entering one of its adjacent pores. The proton then hits the walls of the pore, causing a cascade of secondary electrons. The resultant electron signal is then easily detectable.

Timing resolution

The new technology incorporates thin-film materials and low-temperature processes to create hydrogen-rich plastic microchannel structures with conductive and high secondary electron emissive films, thus enabling high-gain detectors. The timing resolution of this neutron detection – <10 ns – is limited only by the depth of neutron absorption and the speed of propagation through the device.

Successful passive special nuclear material detection requires high efficiency in the presence of large background gamma radiation. Plastic MCPs are less sensitive to gamma radiation than are those made of traditional lead glass. More advanced imaging capabilities also may be achieved by taking advantage of the potential of the MCP structure to achieve <100-μm pore spacing.

It also may be possible to determine the special nuclear material source location through directional, active neutron irradiation. Active interrogation with a pulsed neutron beam can use a time-of-flight method. This is enabled by the timing accuracy of the plastic MCP, which can detect neutron energy with high resolution through the time-of-flight technique. The high timing resolution also allows efficient discrimination between the neutrons generated in a fusion chain within special nuclear materials and the diffuse background radiation. Extending this methodology, it also may be possible to measure the spectral distribution of emitted neutrons.

As more industries move into the nanoworld, measurement resolution and efficiency are more critical, and the demand for more sensitive signal-to-noise detectors becomes greater. The MCP technology advances have potential in this area because of sufficient sensitivity combined with high temporal and spatial resolution.

Meet the author

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