

# Fast, Large-Area, Wide-Bandgap UV Photodetector for Cherenkov Light Detection

This detector can be used for monitoring fires, microbial sterilization/disinfection processing, and spectrophotometry analysis.

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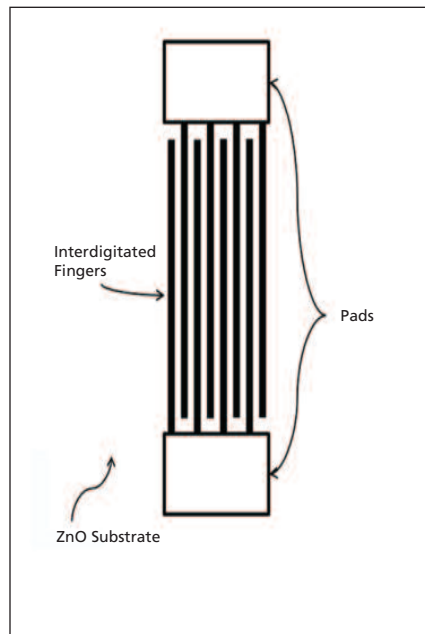
Due to limited resources available for power and space for payloads, miniaturizing and integrating instrumentation is a high priority for addressing the challenges of manned and unmanned deep space missions to high Earth orbit (HEO), near Earth objects (NEOs), Lunar and Martian orbits and surfaces, and outer planetary systems, as well as improvements to high-altitude aircraft safety. New, robust, and compact detectors allow future instrumentation packages more options in satisfying specific mission goals.

A solid-state ultraviolet (UV) detector was developed with a theoretical fast response time and large detection area intended for application to Cherenkov detectors. The detector is based on the wide-bandgap semiconductor zinc oxide (ZnO), which in a bridge circuit can detect small, fast pulses of UV light like those required for Cherenkov detectors. The goal is to replace the role of photomultiplier tubes in Cherenkov detectors with these solid-state devices, saving on size, weight, and required power.

For improving detection geometry, a spherical detector to measure high atomic number and energy (HZE) ions from any direction has been patented as part of a larger space radiation detector system. The detector will require the development of solid-state UV photodetectors fast enough (2 ns response time or better) to detect the shockwave of Cherenkov light emitted as the ions pass through a quartz, sapphire, or acrylic ball. The detector must be small enough to fit in the detector system structure, but have an active area large enough to capture enough Cherenkov light from the sphere.

The detector is fabricated on bulk single-crystal undoped ZnO. Inter-

digitated finger electrodes and contact pads are patterned via photolithography, and formed by sputtered metal of silver, platinum, or other high-conductivity metal.



Schematic of the UV Photodetector.

The detector is operated as a resistive sensor, such as an RTD (resistance temperature detector) or strain gauge with a supplied voltage/current, and monitoring resulting current/voltage. A common embodiment is as part of a bridge circuit where a supplied voltage is divided between the detector and a dummy resistor, in parallel with two other resistors of similar values of the detector and dummy resistor. Directly observing the difference of the voltage drop of the detector and its parallel resistor, a UV light measurement can be

made. The preferred embodiment is in half-bridge configuration where the dummy resistor is another interdigitated finger electrode pattern on the same ZnO substrate, but coated with a UV blocking material.

When exposed to UV light (or any light of sufficient energy), the electrons in valence bands of the semiconductor absorb sufficient energy to jump into the conductive band and freely move about the semiconductor. Unless defined by an electric field, the motions of these electrons are random, and will lose enough energy to fall back into a valence band. An applied electric field thus directs the drift of the conductive electrons, and the addition of conductive electrons by the absorption of UV light reduces the resistance of the semiconductor.

The main feature of the detector is the simplicity of design with the large area and the fast response time necessary for detecting Cherenkov light in radiation detectors. The sensor can be fabricated using standard microfabrication processes without doping, allowing extended use in space without loss of sensitivity. The response time is dependent on electrode spacing, but the wavelength is not, allowing the detector to be fabricated to tolerances specific to mission requirements.

*This work was done by John D. Wrbanek and Susan Y. Wrbanek of Glenn Research Center. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-19040-1.*