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News and opinions

Nanowires promise self-powered UV detectors

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Ultraviolet photodetectors (UV PDs) are widely used in flame detectors, pollutant monitoring, water purification, and personal protection devices. Semiconductor films, nanowires, and nanoparticles have been used to produce devices that are responsive, fast, and sensitive. The drawback, however, has been that most devices rely on an external power source. Self-powered UV PDs, by contrast, could offer cost and energy savings, as well as opening the way to device miniaturization.

Now researchers from Georgia Institute of Technology, South China Normal University, and Beijing Institute of Nanoenergy and Nanosystems have created a self-powered UV PD using pyroelectric ZnO nanowires [Dong et al., *Nano Today* (2019), https://doi.org/10.1016/j.nantod.2019.100798].

"For most reported UV PDs, their excellent detection performance or even normal operation relies on an external power supply. This has long been an obstacle to meeting industrial requirements of cost-saving, energy efficiency, and size minimization," explains Xingfu Wang, who led the research effort with Zhong Lin Wang.

The devices, which comprise 40–70 nm diameter n-type ZnO nanowires grown on p-type Si substrates with indium-tin-oxide (ITO) and copper electrodes, form a p-n junction that functions as a UV PD. When exposed to UV light, the pyroelectric effect induces a polarization potential in the semiconductor nanowire, which can modulate charge carrier separation and transport.

At room temperature, without UV illumination, the p-Si/n-ZnO sensor devices maintain a steady current. When exposed to UV light, the temperature of the ZnO nanowire suddenly increases and the pyroelectric effect generates a polarization potential along the length of the wire (Fig. 1). This, in turn, creates positive charge in the top electrode and negative charge in the bottom electrode. As the nanowire gradually cools back to room temperature, the pyroelectric effect disappears and the output returns to its original level.

At lower temperatures, the response of the nanowire UV PDs is improved, because the temperature change and, therefore, the pyroelectric effect, is more pronounced. At the lowest temperature the researchers explored (77 K), the device response to UV exposure

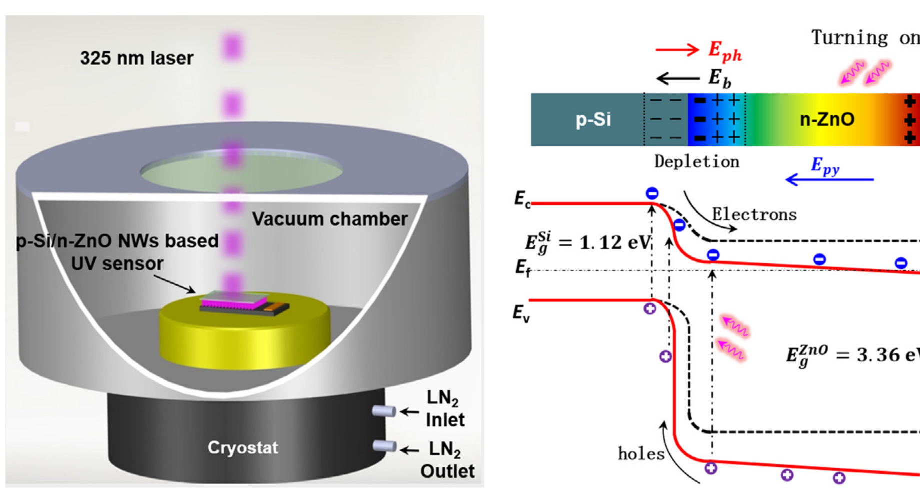

Fig. 1. Schematic diagram of the experimental set-up and device structure of self-powered p-Si/n-ZnO UV sensors (left); energy-band diagram of p-Si/n-ZnO heterojunction at the moment of turning on UV light (right).

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is improved by over 1300 %, compared with 530 % at room temperature. Even at higher temperatures, up to 85 °C, the UV detector is still functional.

“Although self-powered UV PDs based on the photovoltaic effect have been demonstrated previously, the junction quality and photo-absorption of the materials limited the photo-sensing performances,” points out Xingfu Wang. “The pyro-phototronic effect in p-Si/n-ZnO nanowire heterostructure UV PDs demonstrated in our work could represent a solution to overcome this issue.”

The researchers believe the results indicate that pyroelectric ZnO nanowire-based devices could ultimately offer a pathway towards high-performance, energy efficient, self-powered UV detection and ultrafast optoelectronic communication.

“In order to further enrich their functionalities and expand their potential applications, [we are now working on] alternative substrates with good flexibility and visible-light transparency,” Xingfu Wang told *Nano Today*.