

## Polymer Single-Nanowire Optical Sensor

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Although nanowires have attracted much interest in sensing applications, polymer single nanowires for optical sensing, which promises greater versatility and superior performances, remains unexplored. To date, most of these single nanowire devices have been focused on the electrical conductance change when exposed to the species. However, optical detection are highly desired owing to its advantages, such as fast response, immunity to electromagnetic interference, safe operation in explosive or combustive atmosphere, the possibility of remote monitoring through optical fibers.

Researchers in Zhejiang University, China, reported a novel approach to polymer single-nanowire optical sensors. The compact and flexible sensing scheme demonstrated may be attractive for very fast detection in physical, chemical, and biological applications with high sensitivity and small footprint.

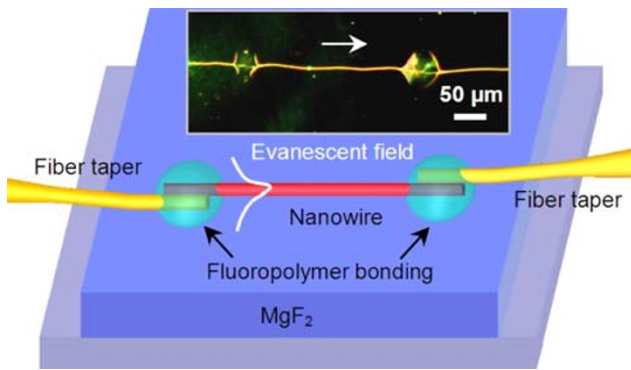
Fuxing Gu and Professor Limin Tong who leads the Nanophotonics group at the Zhejiang University in China, together with coauthors from Department of Chemistry at Zhejiang University, report their most recent findings in an article titled “Polymer Single-Nanowire Optical Sensors” published online on August 2, 2008 in the journal *Nano Letters*.

“When a weak stream of light is guided along a properly functionalized polymer nanowire, the light output is strongly and instantly dependent on the surrounding of the nanowire, making it ideal for high-sensitivity sensing with ultrafast response.” Prof. Tong explained the basic idea. “Polymer single nanowires for gas optical sensing are of great scientific interest and technological significance” Gu explains to Nanospotlight. “To use polymer single nanowires as optical gas sensors, two major challenges must be

overcome: the fabrication of polymer single nanowires that are optically sensitive to specific specimens, and efficiently launching light into and picking signals up from the nanowire. First, we draw nanowires from polymer solutions doped or blended with functional materials that act as sensitive elements. Secondly, we employ an evanescent coupling technique for high-efficient optical launching and collection.”

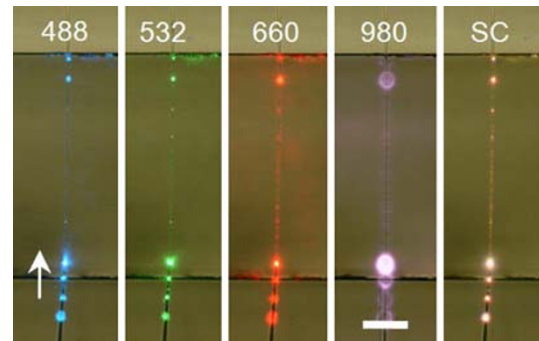
“When we use a polyacrylamide (PAM) nanowire (Fig. 1) for relative humidity (RH) sensing, we got a response time as short as 30 ms, which are over 10 times faster than those of existing RH sensors” says Gu. Poly-aniline blended with polystyrene was used to detect NO<sub>2</sub> at concentrations as low as 0.1 ppm with fast response, good reversibility, and fast recovery time at room temperature. Bromothymol blue (a pH indicator)-doped poly(methyl methacrylate) nanowires were used to detect NH<sub>3</sub> down to 3 ppm level with fast response.

“The remarkably fast response of the sensor can be attributed to the small diameter and large surface-to-volume ratio of the nanowire that enable rapid diffusion or evaporation of the water molecules, as well as fast signal collection using optical approach.” Gu explains. The seamless combination of the functionalized polymer single nanowire with optical scheme demonstrated here presents high versatility and flexibility for gas sensing, and may open new opportunities for both polymer nanowires and optical sensors. “The optical scheme extends the sensing element from conductive polymer nanowires for electric detection to broader categories, since a majority of polymer nanowires, no matter they are electric conductive or not, provide low optical waveguiding losses (Fig. 2) within visible or near infrared spectral range. Moreover, compared



**Fig. 1** PAM single-nanowire humidity sensor—Schematic illustration of the sensor. Inset, optical microscope image of a  $\text{MgF}_2$ -supported 410-nm-diameter PAM nanowire with a 532-nm-wavelength light launched from left side. The *white arrow* indicates the direction of light propagation

with other materials, polymers are much more hospitable to a variety of dopants.” says Prof. Tong. “We are now working to use polymer single nanowires for biological sensing integrated with microchip, and investigating



**Fig. 2** Waveguiding polymer single nanowire—optical micrographs of a 300-nm-diameter PMMA nanowire guiding a broadband supercontinuum (denoted as SC) and monochromatic lasers with wavelengths of 488, 532, 660, and 980 nm, respectively. Scale bar, 50  $\mu\text{m}$ . The *white arrow* indicates the direction of light propagation

optoelectronics and nonlinear effects in polymer single nanowires for nanoscale devices.”

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