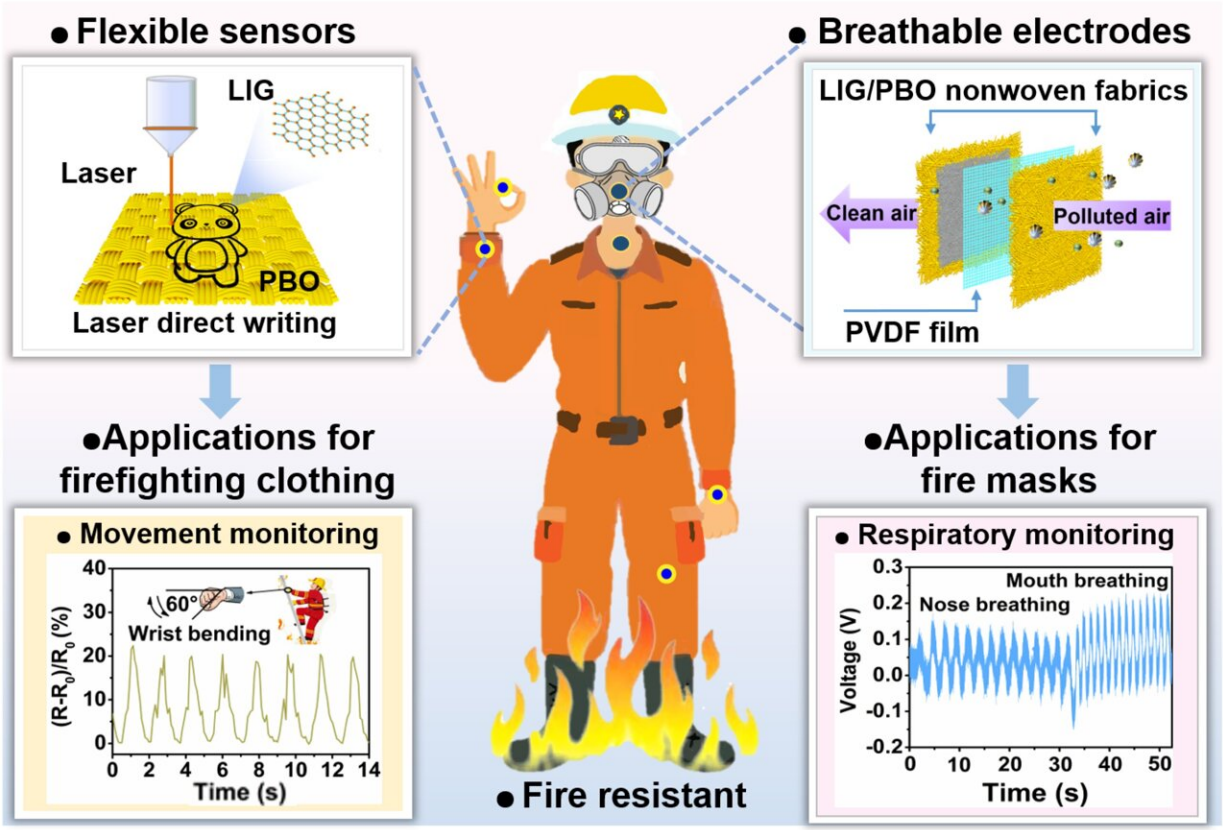
Flexible, wearable electronics woven into gear can reduce firefighters' rate of injury and mortality

January 17 2023



Scientists from multiple institutions address the challenges and limitations of current fire-fighting gear by introducing wearable, breathable sensors and electrodes to better serve firefighters. Credit: Nano Research, Tsinghua University Press

Firefighting may look vastly different in the future thanks to intelligent fire suits and masks developed by multiple research institutions in China.

Researchers published results showing breathable electrodes woven into fabric used in fire suits have proven to be stable at temperatures over 520ºC. At these temperatures, the fabric is found to be essentially non-combustible with high rates of thermal protection time.

The study was published on January 12, 2023 in *Nano Research*.

The results show the efficacy and practicality of Janus graphene/poly(p-phenylene benzobisoxazole)—or PBO—woven fabric in making firefighting "smarter" with the main goal being to manufacture products on an industrial scale that are flame-retardant but also intelligent enough to warn the firefighter of increased risks while traversing the flames.

"Conventional firefighting clothing and fire masks can ensure firemen's safety to a certain extent," said Wei Fan, professor and researcher at the School of Textile Science and Engineering at Xi'an Polytechnic University. "However, the fire scene often changes quickly, sometimes leaving firefighters trapped in the fire for failing to judge the risks in time. In these situations, firefighters also need to be rescued."

The key here is the use of Janus graphene/PBO, woven fabrics. PBO fibers offer better strength and fire protection than other similar fibers, such as Kevlar. The PBO fibers are first woven into a fabric that is then irradiated using a CO_2 infrared laser. From here, the fabric becomes the Janus graphene/PBO hybrid that is the focus of the study.

The mask also utilizes a top and bottom layer of Janus graphene/PBO with a piezoelectric layer in between that acts as a way to convert mechanical pressures to electricity, and vice versa.

"The mask has a good smoke particle filtration effect, and the filtration efficiency of $PM_{2.5}$ and $PM_{3.0}$ reaches 95% and 100%, respectively. Meanwhile, the mask has good wearing comfort as its respiratory resistance (46.8 Pa) is lower than 49 Pa of commercial masks. Besides, the mask is sensitive to the speed and intensity of human breathing, which can dynamically monitor the health of the firemen," said Fan.

Flame-retardant electronics featured in these fire suits are flexible, heat resistant, and quick to make and low-cost, which makes scaling for industrial production a tangible achievement. This makes it more likely that future firefighting suits and masks will be able to effectively use this technology. Quick, effective responses can also reduce economic losses attributed to fires.

"The graphene/PBO woven fabrics-based sensors exhibit good repeatability and stability in human motion monitoring and NO_2 gas detection, the main toxic gas in fires, which can be applied to firefighting suits to help firefighters effectively avoiding danger," Fan said. Being able to detect sharp increases in NO_2 gas can help firefighters change course in an instant if needed and could be a lifesaving addition to firefighter gear.

Major improvements can be made in the firefighting field to better protect the firefighters by taking advantage of graphene/PBO woven and nonwoven fabrics. Widescale use of this technology can help the researchers reach their ultimate goal of reducing mortality and injury to those who risk their lives fighting fires.

More information: Yu Luo et al, Laser-induced Janus graphene/poly(p-phenylene benzobisoxazole) fabrics with intrinsic flame retardancy as flexible sensors and breathable electrodes for fire-fighting field, *Nano Research* (2023). DOI: 10.1007/s12274-023-5382-y

Provided by Tsinghua University Press