Nanotechnology helps scientists make bendy sensors for hydrogen vehicles

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In recent years, Americans have been intrigued by the promise of hydrogen-powered vehicles. But experts have judged that several technology problems must be resolved before they are more than a novelty.

Recently, scientists at the U.S. Department of Energy's Argonne National Laboratory have used their insights into nanomaterials to create bendy hydrogen sensors, which are at the heart of hydrogen fuel cells used in hydrogen vehicles.

In comparison to previously designed hydrogen sensors, which are rigid and use expensive, pure palladium, the new sensors are bendy and use single-walled carbon nanotubes (SWNTs) to improve efficiency and reduce cost. The development of these hydrogen sensors will help to ensure economical, environmental and societal safety, as the nation is realizing the potential for a more hydrogen-based economy.

Yugang Sun and H. Hau Wang, researchers in Argonne's Center for Nanoscale Materials and Materials Science Division, respectively, fabricated the new sensing devices using a two-step process separated by high and low temperatures. First, at around 900 degrees C, researchers grow SWNTs on a silicon substrate using chemical vapor deposition. Then, researchers transfer the SWNTs onto a plastic substrate at temperatures lower than 150 degrees C using a technique called dry transfer printing.

This precise process is what allows the film of nanotubes to form on the plastic, after which the palladium nanoparticles can be deposited on the SWNTs to make the sensors. The palladium nanoparticles play an important role in increasing the interaction between hydrogen and the SWNTs to enhance the change of resistance of the device when it is exposed to hydrogen molecules.

According to Sun, these sensors exhibit excellent sensing performance in terms of high sensitivity, fast response time and quick recovery, and the use of plastic sheets reduces their overall weight and increases their mechanical flexibility and shock resistance. The sensors are also able to be wrapped around curved surfaces, and this proves useful in many applications, notably in vehicles, aircraft and portable electronics.

“The leakage of hydrogen caused by tiny pinholes in the pipe of a space shuttle, for example, could not be easily detected by individual rigid detectors because the locations of pinholes are not predetermined,” said Sun. “However, laminating a dense array of flexible sensors on the surfaces of the pipe can detect any hydrogen leakage prior to diffusion to alert control units to take action.”

Flexible hydrogen sensors show a change of 75 percent in their resistance when exposed to hydrogen at a concentration of 0.05 percent in air. The devices can detect the presence of 1 percent hydrogen at room temperature in 3 seconds. Even after bending—with a bending radius of approximately 7.5 mm—and relaxing 2,000 times, the devices still perform with as much effectiveness.

Source: Argonne National Laboratory