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Accelerating palladium nanowire hydrogen sensors using engineered nanofiltration layers

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BRIEF DESCRIPTION

Researchers at UCI have developed a method for enhancing existing hydrogen gas sensors, leading to as much as a 20-fold improvement in sensor response and recovery times.

FULL DESCRIPTION

In the push toward utilizing hydrogen gas (H₂) as a clean energy alternative, the ability to rapidly detect minute quantities of leaked H₂ has become increasingly important due to its high combustibility at concentrations >4% volume in air. According to the US Department of Energy, H₂ sensors should have rapid response times, detecting 1% volume of H₂ within one minute. Many commercial H₂ sensors are chemiresistors, which display an increase in resistance upon adsorption of certain gases. Though sensor architecture has evolved over the years, palladium (Pd) has remained one of the most commonly studied sensor materials due to its high H₂ sensitivity, simple preparation, and operability at room temperature. In particular, Pd nanowires (NWs) have demonstrated remarkable sensitivity to the presence of H₂ due to their high surface area, which increases the number of H₂ adsorption sites. Despite these advantages, Pd NWs have found limited application in actual hydrogen sensors due to their affinity for other air-based species, including oxygen and nitrogen, which dramatically limit the ability of the NWs to detect H₂.

To combat this lack of H₂ selectivity, researchers at UCI have developed a protective filter layer that is easily added to Pd NWs. The filter layer is based on a common metal organic framework motif, whose pore sizes (0.34 nm) allow for the diffusion of H₂ (0.289 nm) through the layer, while simultaneously blocking the larger oxygen (0.345 nm) and nitrogen (0.364 nm) molecules. Such functionalized Pd NWs display an improved response and recovery time, able to detect 1% H₂ within 7s compared to the 164 s response time of bare Pd NWs.

SUGGESTED USES

For the rapid and selective detection of molecular hydrogen gas.

ADVANTAGES

- » Simple, inexpensive fabrication: This method is an amendment to existing palladium nanowire fabrication methods, which rely on standard lithographic procedures. The nanowire functionalization, which boosts hydrogen sensing response time, is completely solution-based.
- » Rapid response: The resulting functionalized palladium nanowires exhibit significantly faster response and recovery times compared to bare wires.
- » High selectivity: Unlike other common palladium-based sensors, the functionalized ones are selective to hydrogen alone, preventing interaction with other larger air molecules.

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	11,913,929	02/27/2024	2018-067

Additional Patent Pending

STATE OF DEVELOPMENT

Functionalized Pd NWs have been fabricated and used to detect a range of concentrations of H₂ (0.1-1%).

