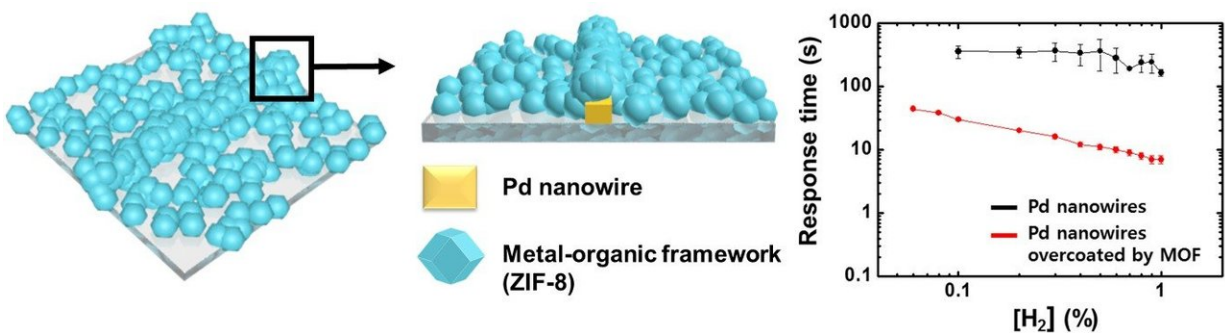


Ultra-fast and ultra-sensitive hydrogen sensor

September 29 2017



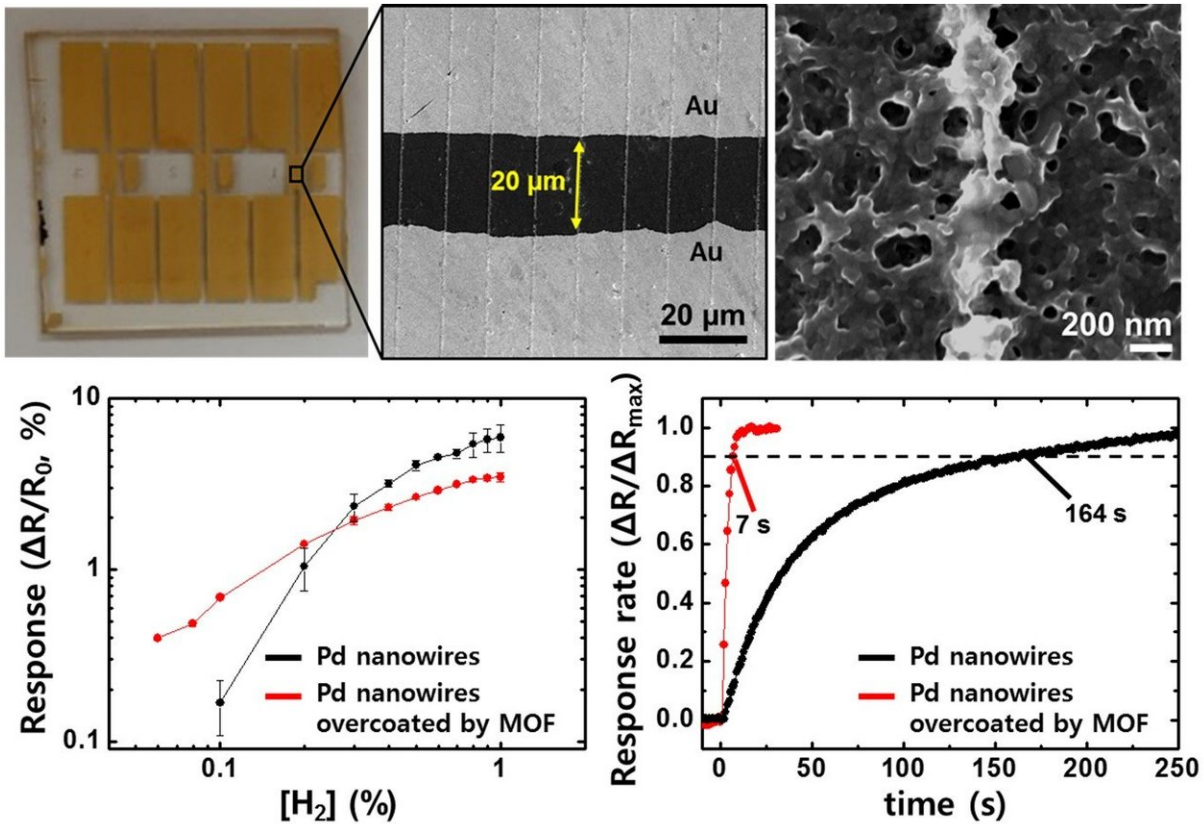
Representative image of this paper published in *ACS Nano* on Sept. 26. Credit: KAIST

A KAIST team made an ultra-fast hydrogen sensor that can detect hydrogen gas levels under 1% in less than seven seconds. The sensor also can detect hundreds of parts per million levels of hydrogen gas within 60 seconds at room temperature.

A research group under Professor Il-Doo Kim in the Department of Materials Science and Engineering at KAIST, in collaboration with Professor Reginald M. Penner of the University of California-Irvine, has developed an ultra-fast [hydrogen gas](#) detection system based on a palladium (Pd) nanowire array coated with a metal-organic framework (MOF).

Hydrogen has been regarded as an eco-friendly next-generation energy source. However, it is a flammable gas that can explode even with a small spark. For safety, the lower explosion limit for hydrogen gas is 4 vol% so [sensors](#) should be able to detect the colorless and odorless hydrogen molecule quickly. The importance of sensors capable of rapidly detecting colorless and odorless hydrogen gas has been emphasized in recent guidelines issued by the U.S. Department of Energy. According to the guidelines, hydrogen sensors should detect 1 vol% of hydrogen in air in less than 60 seconds for adequate response and recovery times.

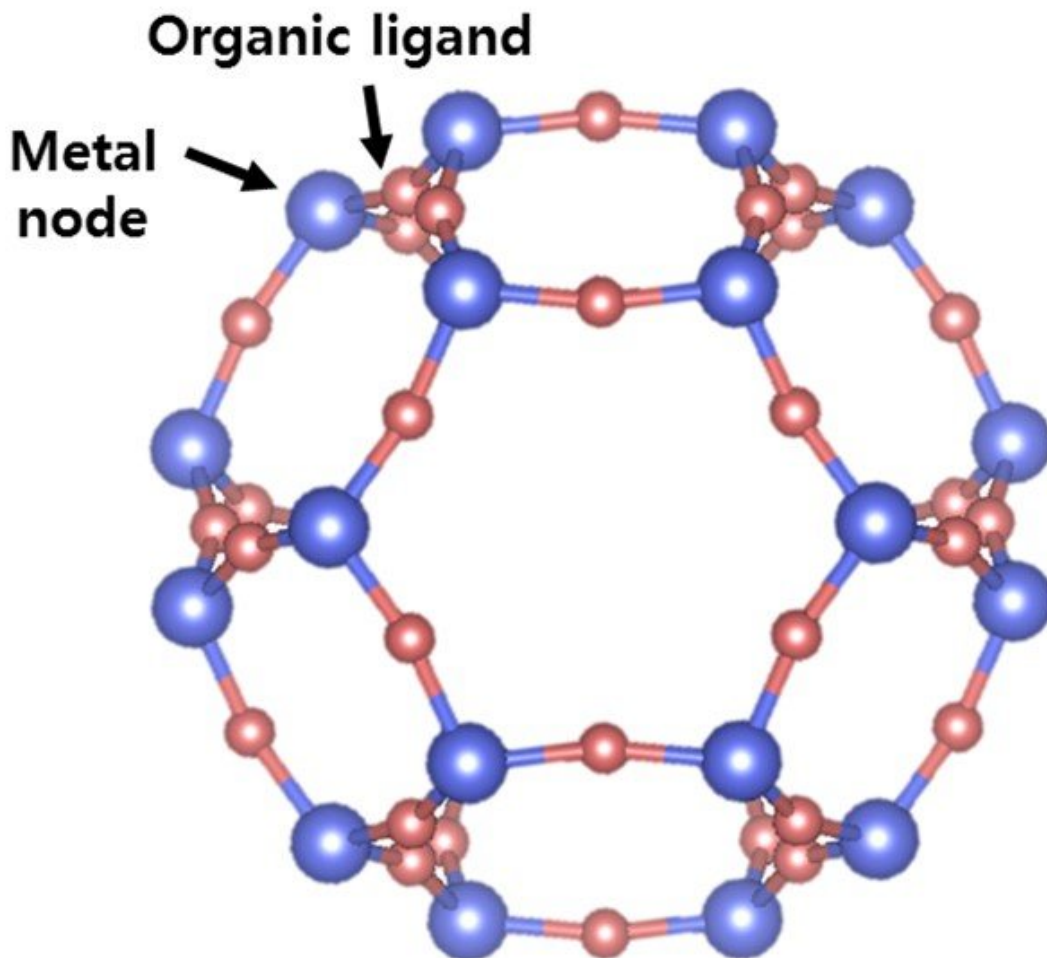
To overcome the limitations of Pd-based hydrogen sensors, the research team introduced a MOF layer on top of a Pd nanowire array. Lithographically patterned Pd nanowires were simply overcoated with a Zn-based zeolite imidazole framework (ZIF-8) layer composed of Zn ions and organic ligands. ZIF-8 film is easily coated on Pd nanowires by simple dipping (for 2-6 hours) in a methanol solution including Zn (NO₃)₂·6H₂O and 2-methylimidazole.



Images of Pd nanowire array-based hydrogen sensors, scanning electron microscopy image of a Pd nanowire covered by a metal-organic framework layer, and the hydrogen sensing properties of the sensors. Credit: KAIST

As synthesized ZIF-8 is a highly porous material composed of a number of micro-pores of 0.34 nm and 1.16 nm, hydrogen gas with a kinetic diameter of 0.289 nm can easily penetrate inside the ZIF-8 membrane, while large molecules (> 0.34 nm) are effectively screened by the MOF filter. Thus, the ZIF-8 filter on the Pd nanowires allows the predominant penetration of [hydrogen molecules](#), leading to the acceleration of Pd-based H₂ sensors with a 20-fold faster recovery and response speed compared to pristine Pd [nanowires](#) at [room temperature](#).

Professor Kim expects that the ultra-fast hydrogen sensor can be useful for the prevention of explosion accidents caused by the leakage of [hydrogen](#) gas. In addition, he expects that other harmful gases in the air can be accurately detected through effective nano-filtration by using of a variety of MOF layers.



Schematic illustration of a metal-organic framework (MOF). The MOF, consisting of metal ions and organic ligands, is a highly porous material with a ultrahigh surface area. The various structures of MOFs can be synthesized depending on the kinds of metal ions and organic ligands. Credit: KAIST

This study was carried out by Ph.D. candidate Won-Tae Koo (first author), Professor Kim (co-corresponding author), and Professor Penner (co-corresponding author). The study has been published in the online edition of *ACS Applied Materials and Interfaces*, as the cover-featured image for the September issue.

More information: Ji-Soo Jang et al, Hollow Pd-Ag Composite Nanowires for Fast Responding and Transparent Hydrogen Sensors, *ACS Applied Materials & Interfaces* (2017). [DOI: 10.1021/acsami.7b10908](https://doi.org/10.1021/acsami.7b10908)

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