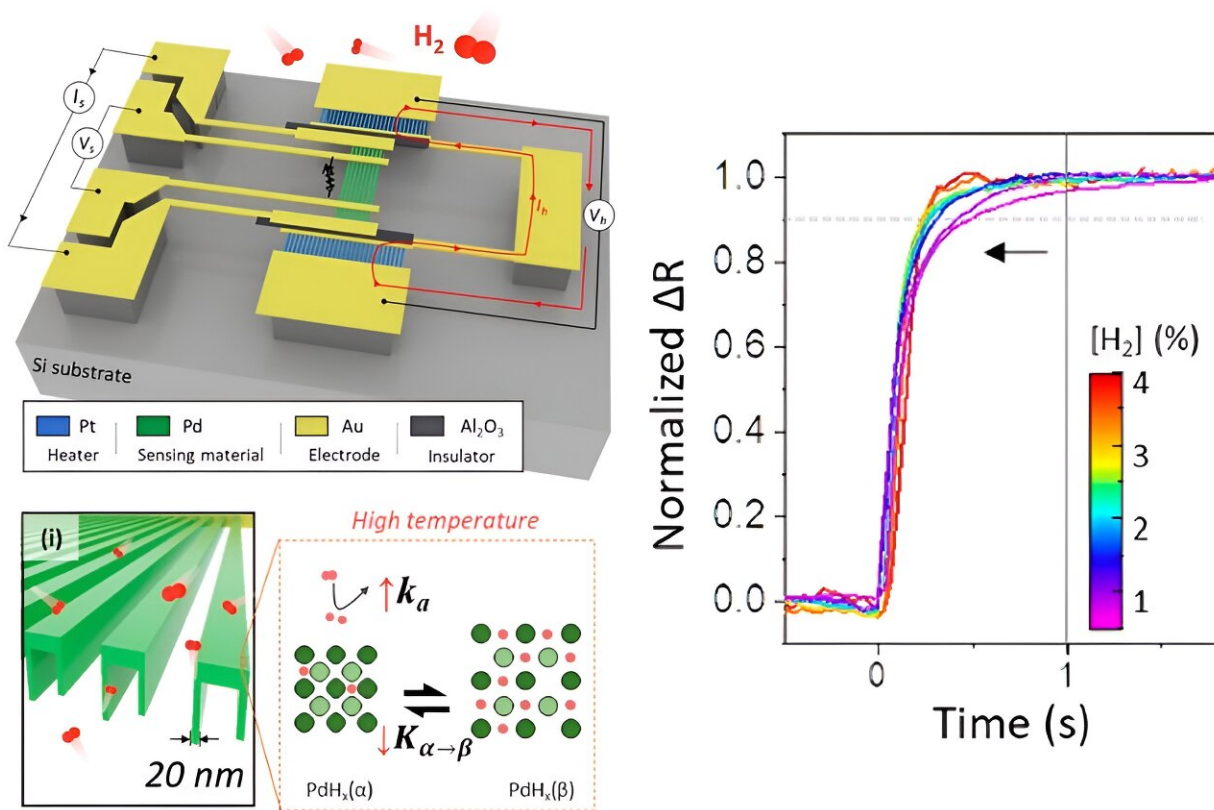


Scientists develop ultrafast hydrogen leak detection

January 26 2024



(Left) The conceptual drawing of the structure of the coplanar heater-integrated hydrogen sensor. Pd nanowire is stably suspended in the air even with its thickness of 20 nm. (Right) A graph of hydrogen sensor performance operating within 0.6 seconds for hydrogen at a concentration of 0.1 to 4%. Credit: *ACS Nano* (2023). DOI: 10.1021/acsnano.3c06806

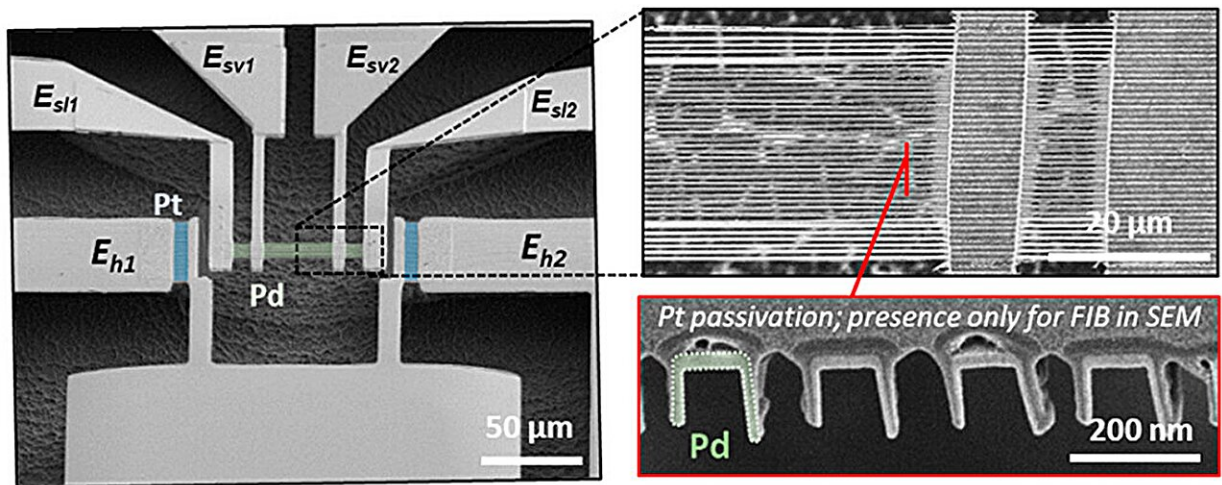
As the spread of eco-friendly hydrogen cars increases, the importance of hydrogen sensors is also on the rise. In particular, achieving technology to detect hydrogen leaks within one second remains a challenging task. Accordingly, the development of the world's first hydrogen sensor that meets the performance standards of the U.S. Department of Energy has become a hot topic.

A team at KAIST led by Dr. Min-Seung Jo from Professor Jun-Bo Yoon's team in the Department of Electrical and Electronic Engineering has successfully achieved all of its desired performance indicators, meeting globally recognized standards through collaboration with the Electromagnetic Energy Materials Research Team at Hyundai Motor Company's Basic Materials Research Center and Professor Min-Ho Seo of Pusan National University.

On January 10, the research group announced that the world's first hydrogen sensor with a speed of less than 0.6 seconds had been developed.

In order to secure hydrogen detection technology that is faster and more stable than existing commercialized hydrogen sensors, the KAIST team began developing a next-generation hydrogen sensor in 2021 together with Hyundai Motor Company. They succeeded after two years of development. The research is [published](#) in *ACS Nano*.

Existing hydrogen sensor research has mainly focused on sensing materials, such as catalytic treatments or the alloying of palladium (Pd) materials, which are widely used in hydrogen sensors. Although these studies showed excellent performance with certain performance indicators, they did not meet all of the desired performance indicators, and commercialization was limited due to the difficulty of batch processing.



Electron microscopy of the coplanar heater-integrated hydrogen sensor. (Left) photo of the entire device. (Top right) Pd nanowire suspended in the air. (Bottom right) Cross section of Pd nanowire. Credit: *ACS Nano* (2023). DOI: 10.1021/acsnano.3c06806

To overcome this, the research team developed a sensor that satisfied all of the performance indicators by combining independent micro/nano structure design and processing technology based on pure palladium materials.

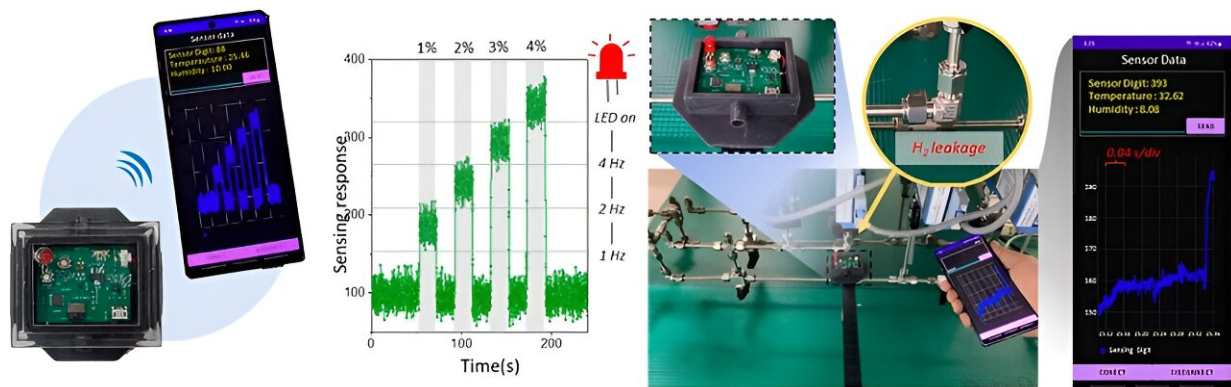
In addition, considering future mass production, pure metal materials with fewer material restrictions were used instead of synthetic materials, and a next-generation hydrogen sensor was developed that could be mass-produced based on a semiconductor batch process.

The developed device is a differential coplanar device in which the heater and sensing materials are integrated side by side on the same plane to overcome the uneven temperature distribution of existing gas sensors, in which the heater, insulating layer, and sensing materials are

stacked vertically.

The palladium nanomaterial, which is a sensing material, has a completely floating structure and is exposed to air from beneath, maximizing the reaction area with a gas to ensure a fast reaction speed. In addition, the palladium sensing material operates at a uniform temperature throughout the entire area. The research team was able to secure a fast operation speed, wide sensing concentration, and temperature/humidity insensitivity by accurately controlling temperature-sensitive sensing performance.

The team packaged the fabricated device with a Bluetooth module to create an integrated system that wirelessly detects hydrogen leaks within one second. Unlike existing high-performance optical hydrogen sensors, this one is highly portable and can be used in a variety of applications where hydrogen energy is used.



(Left) Real-time hydrogen detection results from the coplanar heater-integrated hydrogen sensor integrated and packaged in wireless communication and an app for mobile phone. (Middle) LED blinking cycle control in accordance with the hydrogen concentration level. (Right) Results of performance confirmation of the detection within 1 second in a real-time hydrogen leak demo. Credit: ACS Nano (2023). DOI: 10.1021/acsnano.3c06806

Dr. Min-Seung Jo, who led the research, said, "The results of this research are of significant value as they not only operate at high speeds by exceeding the performance limits of existing hydrogen sensors, but also secure the reliability and stability necessary for actual use, and can be used in various places such as automobiles, hydrogen charging stations, and homes."

He also revealed his future plans, saying, "Through the commercialization of this hydrogen sensor technology, I would like to contribute to advancing the safe and eco-friendly use of [hydrogen energy](#)."

The research team is currently working with Hyundai Motor Company to manufacture the device on a wafer scale and then mount it on a vehicle module to further verify detection and durability performance.

More information: Min-Seung Jo et al, Ultrafast (~ 0.6 s), Robust, and Highly Linear Hydrogen Detection up to 10% Using Fully Suspended Pure Pd Nanowire, *ACS Nano* (2023). [DOI: 10.1021/acsnano.3c06806](https://doi.org/10.1021/acsnano.3c06806)

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