4-3 Development of New Monitoring Technology for the Utilization of Hydrogen as a Clean Energy Source

— Optical Hydrogen Sensors Using Gasochromic Phenomenon —

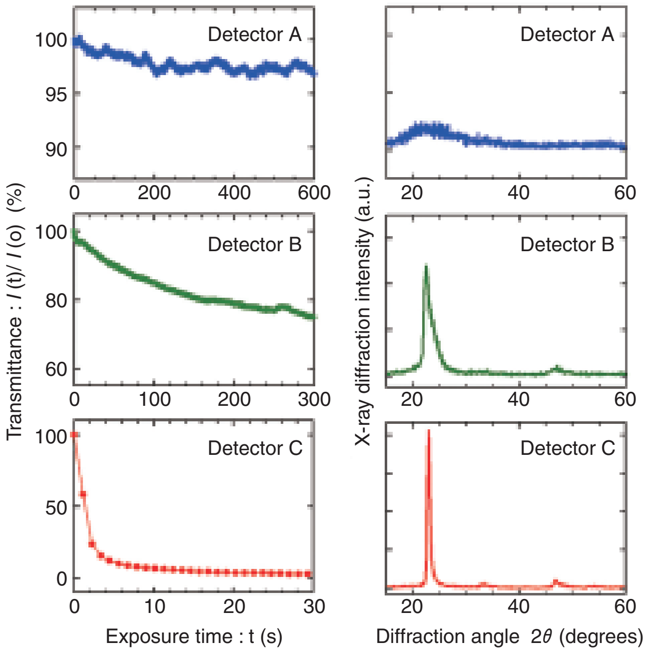

Fig.4-8 Response for hydrogen and structure of the tungsten oxide in the detectors
The transmittance of 630 nm light in the detector decreases with time, during the exposure of 1 % hydrogen. The response in Detector A is slow, but that in Detector C is fast. The tungsten oxide in Detector A has an amorphous pattern, and those in Detector B and C have X-ray diffraction peaks. The crystal of the tungsten oxide in Detector C orients to the (001) monoclinic plane.

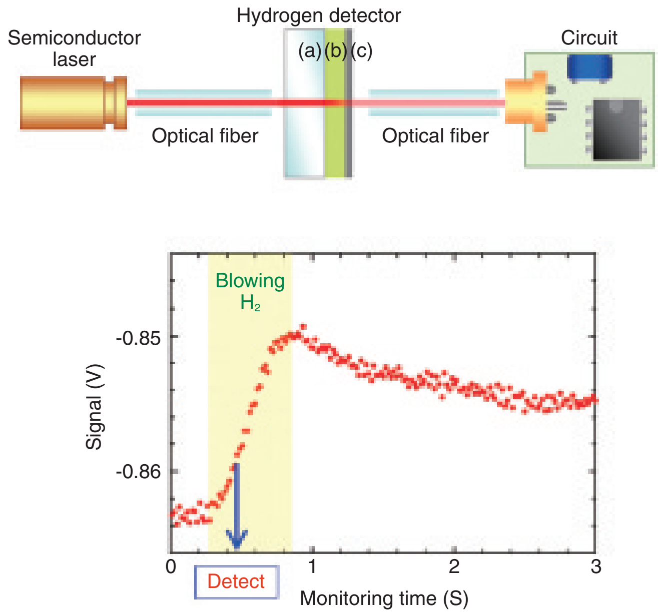

Fig.4-9 Developed optical hydrogen sensor
The detector consists of (a) quartz glass substrate, (b) oriented tungsten oxide film, and (c) palladium coating. The intensity of 650 nm light transmitted from the detector is converted into a voltage signal by the circuit at the end of the optical fiber. Received signals when 1 % hydrogen is blow on the detector are shown. Hydrogen can be recognized from a received signal which is more than double intensity of the noise width.

The concentration of lower explosive limit (LEL) in hydrogen (H_2) is 4 vol.% at room temperature in ambient air. Therefore, the development of technology to detect a leak of H_2 with low cost, but reliably and safely, is required for the production, the storage, the transport, and the use of H_2. Optical hydrogen sensors without an electric current and a heating in the detector have been proposed as safer and cheaper sensors. The detector consists of transparent substrate, a coloration layer of tungsten oxide thin film, and catalyst layer of palladium. Leakage of H_2 is detected by decrease in the intensity of transmitted light from the detector, using the gasochromic phenomenon that tungsten oxide changes color from yellow to blue when it adsorbs H_2 catalyzed by palladium. The detection time is required to be the less than 1 second in the standard which is proposed by U.S. Department of Energy (DOE). But the coloration rate of tungsten oxide for H_2 is usually slow, on the order of minutes. In this study, the tungsten oxide thin films with rapid coloration rate were investigated. It was found that the response in the detector using oriented crystal tungsten oxide is faster, as shown in Fig.4-8. A sensor was constructed with the detector inserted between conventional optical fibers. It was verified that the sensor can detect 1 % H_2 in ambient air within 1 second, as shown in Fig.4-9. Using the optical fiber networks, the sensor can be applied to a centralized monitoring system for large pipe layouts or complex plants of production and storages.

Reference

Takano, K. et al., High Sensitive Gasochromic Hydrogen Sensors using Tungsten Oxide Thin Films, Transaction of the Material Research Society of Japan, vol.31, no.1, 2006, p.223-226.