

## Calorimetric Gas Sensors with Catalytic Decomposition of H<sub>2</sub>O<sub>2</sub> by MnO<sub>2</sub> Based on Heat Flux Sensors

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**Abstract:** In the presented work, the first research attempt was made to create an H<sub>2</sub>O<sub>2</sub> gas sensor based on heat flux sensors (HFS). We proceeded from the fact that H<sub>2</sub>O<sub>2</sub> gas sensors already exist [1] that operate on the principle of the difference in registered temperatures: one sensor measures the temperature of the H<sub>2</sub>O<sub>2</sub> gas, and the other sensor measures the temperature of the catalyst (MnO<sub>2</sub>), on which the exothermic reaction of H<sub>2</sub>O<sub>2</sub> decomposition with heat release occurs. The temperature difference determines the concentration of H<sub>2</sub>O<sub>2</sub> gas. We fabricated an experimental sample of HFS [2-4] using a 10-meter-long, glass-insulated, single-crystal tin-doped bismuth microwire (outer diameter: 20 μm; core diameter: 4 μm). A key factor in this process was the ability to grow the microwire as a single crystal, achieved through a laser-assisted recrystallization technique performed under a strong electric field. The microwire was coiled into a flat spiral and mounted onto a thin copper disk. This sample demonstrated high sensitivity to heat flow, reaching up to 10<sup>-2</sup> V/W, with a time constant of approximately 0.2 seconds. Polycrystalline bismuth films with thicknesses ranging from 2 to 5 μm were deposited onto mica substrates using a vacuum thermal evaporation technique. Experimental samples of HFS were then fabricated by recrystallizing these films under laser heating in a strong electric field. The MnO<sub>2</sub> catalyst (in powder form or as a film on a thin ( $d=20\text{ }\mu\text{m}$ ) stainless steel substrate) was applied to one side of the HFS, fabricated based on glass-insulated Bi microwire and on Bi films. When such a sensor is placed in an H<sub>2</sub>O<sub>2</sub> gas stream, according to the exothermic decomposition reaction, the catalyst heats up, which leads to a heat flux through the HFS and, consequently, to the appearance of a voltage at the sensor output, the magnitude of which was proportional to the H<sub>2</sub>O<sub>2</sub> gas concentration. When the fabricated sensors based on Bi microwire and Bi films were placed over a 60 % H<sub>2</sub>O<sub>2</sub> solution at room temperature, the output voltage of the sensors was 130 μV and 7 μV, respectively, and decreased as the H<sub>2</sub>O<sub>2</sub> concentration decreased.

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**Keywords:** Calorimetric gas sensors, MnO<sub>2</sub>, Heat flux sensor, Glass-insulated Bi single-crystal microwire, Bi single-crystal film.

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