Original research article

Porous silicon based CO₂ sensors with high sensitivity

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ABSTRACT

Porous silicon (PS) has been an attractive material for bio-chemical sensors. Pore volume and surface area of the porous silicon are key parameters for the sensor applications. Its large surface area for the applications and compatibility with silicon-based technologies has been the driving force for this technology development. The carbon dioxide (CO₂) gas is one of the most important greenhouse gases that cause global warming and air pollution. For this reason, detection of CO₂ gas in living environment is essential. In this study, luminescence and electrical properties of the PS under different carbon dioxide levels and detection mechanisms were investigated. PS are fabricated by anodic etching in hydrofluoric acid based solution in a double anodization cell. The surface bond configurations and structural properties of PS were monitored by Fourier Transmission Infrared Spectroscopy (FTIR) and Scanning Electron Microscopy (SEM), respectively. The experimental results suggested that the PS surface very sensitive to CO₂ gas and can be used for CO₂ sensing.

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1. Introduction

Carbon dioxide (CO₂) detecting is required and important in many fields such as clean energy technologies, agricultural production, food industry, health care and chemical industry [1,2]. CO₂ gas is also one of the most important of greenhouses gases to produce global warming. Sensing and classification of harmful chemicals to protect human health and the environment is essential [3]. With concerns for air quality, CO₂ monitoring is becoming more important. While CO₂ is not an air pollutant, it can have an undesirable effect on us when levels exceed a determined level. When the level rise, we tend to get sleepy and have difficulty focusing, and some people even develop headaches. For this reason, it is important for our living areas to have CO₂ monitored to stay at an under determined harmful level. Sensing studies of harmful chemicals in the air with PS are still an intensively studied subject [1–4]. Over the last two decades, porous silicon has been shown to be very effective for the production of integrated gas/vapor sensors with the low-cost process and room temperature operation [1–7]. Its high surface to volume ratio, up to 10⁷ times larger than bulk materials, provides a strong interaction between material surface and gas molecules and allows high sensitivity of detection to be achieved for CO₂ sensing [5].

Optical and electrical approaches have been established to be valuable for the detection of gas species and organic vapors using porous silicon based sensors [8]. The changes in optical and electrical properties of the porous silicon with the specific gas/vapor species have been showed through quantitative monitoring of the variation of different parameters (e.g., photoluminescence spectrum; reflected, transmitted, and diffracted optical power; capacitance; current; resistance; etc.) as a function of the gas/vapor concentration [7–13].

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