Self-ordered nanoporous silica films applied to surface photo voltage type NO\textsubscript{x} gas sensor

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Nitrogen oxides (NO\textsubscript{x}) generated by combustion are harmful to human’s health, and all the nations have regulated their concentrations in the environment. Therefore, development of a highly sensitive, highly responsive, and portable device for monitoring these gases are urgently required. The surface photo voltage (SPV) semiconductor characterization technique has great potential for satisfying the requirements of such gas sensors. The SPV system sensitively detects variation in surface voltage, which is effected by physical adsorption and chemical interaction between the target gases and the sensitive layer. The capacitance of the insulator layer depends on the gas adsorption performance, and improvement of gas adsorption performance leads directly to enhancement of SPV gas sensor characteristics.

The large surface area created by nanosize pores in self-order nanoporous materials enables improvement in the gas adsorption properties of SPV devices. This paper reports possible application of the self-ordered hexagonal and cubic-like self-order nanoporous silica films to SPV type NO\textsubscript{x} gas sensor, the film being synthesized by the spin coating method and by use of nonionictype triblock copolymer (PEO-PPO-PEO) surfactant as a template. The NO\textsubscript{x} gas sensors are based on the SPV characterization system. The self-order nanoporous silica film is assembled as a gas adsorption insulator layer of the MIS structure based on the SPV characterization system.

The SPV sensor system is fabricated from the MIS structure of semiconductors. Specifically, n-Si with SiO\textsubscript{2} and SiN\textsubscript{4} layers is used as a substrate. Hexagonal silica film by P123 (EO\textsubscript{20}-PO\textsubscript{70}-EO\textsubscript{20}) or cubic-like silica film by F127 (EO\textsubscript{100}-PO\textsubscript{65}-EO\textsubscript{100}) is prepared on the SiN\textsubscript{4} layer of the substrate as a gas adsorption insulator layer. Consequently, the self-order nanoporous silica combined MIS structure of the SPV sensor is constituted of Au/ hexagonal or cubic-like self-order nanoporous silica/ SiN\textsubscript{4}/ SiO\textsubscript{2}/ n-Si/ Al (SPV-hex or SPV-cub). The sensing properties of each SPV device were estimated under NO (100ppm, 100sccm) and NO\textsubscript{2} (50ppm, 100sccm) gas exposure conditions.

Figure 1 shows the Current-Bias voltage curves (CB curve) of SPV-hex and SPV-cub measured at room temperature under standard air (100sccm) conditions and under NO\textsubscript{x} conditions. These SPV samples exhibit clear bias shift and by NO\textsubscript{x} adsorption in nanoporous films and indicate the dependence on nano-structures. The bias shift differences between exposure gases in each device are also observed in each figure. This result is strongly influenced dielectric constants of exposure gases.

![Figure 1](image1.png)

Figure 1. Current-Bias Voltage Curve of SPV-hex and SPV-cub under air and NO condition.

![Figure 2](image2.png)

Figure 2. Current-Bias Voltage Curve of SPV-hex and SPV-cub under air and NO\textsubscript{2} condition.