Gas Visualization Based on Localized Surface Plasmon Resonance of Gold Nanoparticle Films

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***Abstract*—Localized surface plasmon resonance (LSPR) of metal nanoparticles (MNPs) causes strong light absorption and scattering, and the intensity changes are corresponding to refractive index of medium. Our research demonstrates that the spatial distribution of a gas flow can be visualized by observation of transmitted/scattered light of a LSPR-film which consists of two-dimensional arrangement of gold nanoparticles (AuNPs). In this study, to improve the visualization ability of LSPR-films, AuNPs are prepared under different conditions of annealing temperature and re-sputtering times. The LSPR character and gas responding ability are investigated. The results show that LSPR-film with annealing temperature 200°C and 3 times of sputtering shows the best performance. The film has ability to visualize the gas flow of ethanol with a concentration of 400ppm. It is suggested that high visualization ability can be achieved by controlling the distance of neighboring nanoparticles.**

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I. INTRODUCTION

Human's senses are impossible to see spatial distribution of gases. Because of this, spatial distribution of gases and the flow can't be intuitively comprehended and the detection of gas sources is very difficult. The visualization of gases is helpful for us to understand the gas distribution in environment. The simple gas-visualization will bring the effective coping method to disasters, crimes and accidents. The gas-visualization device should have the abilities such as fast response, reversibility and high spatial resolution.

The sensor for real time gas-visualization needs to have fast response, fast recovery and high spatial resolution. However, conventional gas sensors have not enough visualization ability. It is necessary to new method to detect gas distribution visually.

The principle of localized surface plasmon resonance (LSPR) sensor is based on that the plasmon resonance is highly sensitive to the refractive index, a change in refractive index results in a change in transmittance/scattering of the light. The LSPR sensor response doesn't need chemical reactions, so that the most notable features of the LSPR gas sensors are fast response and fast recovery[1]. LSPR gas sensors are suitable for real time visualization of gas space. Because the responding ability of LSPR-film is sensitive to the size and neighboring distance of AuNPs, the LSPR character of AuNPs film with different nanostructure and their application for gas visualization are investigated in this study.

II. LSPR GAS-VISUALIZATION METHODOLOGY

The LSPR is the resonance reaction of electron oscillations to light in metal nanoparticles (MNPs). The specific electric field of light in UV-vis spectral range is strongly absorbed or scattered by the LSPR phenomena[1-3]. The change in intensity of transmittance/scattering light is related to the refractive index of medium, so that the existence of gases which have different refractive index from air can be detected by observation of light[4]. The schematic of the ideal gas-visualization sensor is shown in Fig. 1. Gases can be visualized by observation of light using LSPR-film which consists of two-dimensional array of AuNPs. The investigation of transmitted/scattered light brings the information of gas distribution and gas sources. Fig. 2 shows the gas-visualization images and the time response which were taken in previous our research. Ethanol gas is blown from the nozzle shown in lower-right of visualization images. The area in which gray value largely changes corresponds to the existence area of gases on the LSPR-film because it is considered that difference between refractive index of ethanol gases and air causes large changes

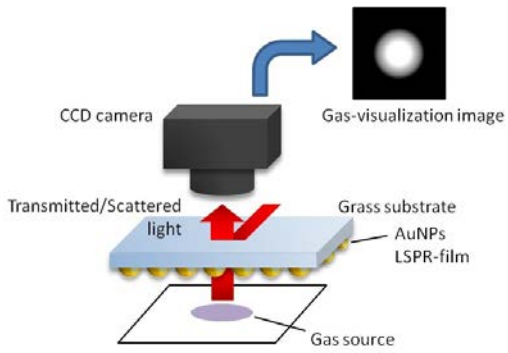

Fig. 1. Schematic of the ideal LSPR gas-visualization sensor. CCD camera observes transmitted/scattered light from the LSPR-film made on a grass substrate. The distribution of gases is shown as large gray value of the gas-visualization image

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