Waveguide-mode Sensors with a Waveguide Layer Nanostructured by Dynamic Oblique Deposition

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Recently, so-called waveguide-mode sensors, which consist of multilayer of dielectric/absorptive/glass substrate as shown in Fig. 1 (left), are attracting much attention from viewpoints of applications to the molecular detection. In order to enhance the sensitivity, open pores much smaller that the wavelength are introduced into the waveguide layers so that their effective refractive index changes depending on that of the surrounding fluid. The cost effective processes to create nanopores with high uniformity and repro- ducibility are strongly required. Obliquely deposited oxide films with nanocolumnar structures are the possible candidates for the waveguide layer in the waveguide-mode sensors, because their nanostructure can be tailored by the deposition geometry. However, the refractive index of the oxide nanocolumns-fluid composite has not yet been well understood. In this work, we investigate the refractive index of the SiO_2 nanocolumns-fluid composite and discuss the application to the waveguide-mode sensors.

The multilayers to measure the refractive index of the SiO_2 nanocolumns-fluid composite were prepared by dynamic oblique deposition technique. On a glass substrate, a Si layer as the absorptive layer was deposited by e-beam evaporation up to <240 nm thick from surface normal. A nanocolumnar SiO_2 layer was deposited at a deposition angle of 67° by e-beam evaporation up to a thickness of about 700 nm. The substrate was rotated rapidly during the deposition. A SEM image of a resulting film is indicated in Fig. 1 (right).

The reflectance measured in the different fluid as a function of angle of incidence shows sharp minima as shown in Fig. 2. The effective refractive indices of the SiO_2 layer estimated from the positions of the minima depend strongly on the surrounding fluid and are 1.283 (in air), 1.407 (in H_2O) and 1.424 (in C_2H_5OH). Due to big changes in the effective refractive indices, the position of the reflectance minima is sensitive to the refractive index of the fluid. Consequently, the nanocolumnar oxide films are quite useful for the waveguide layer in the waveguide-mode sensors.

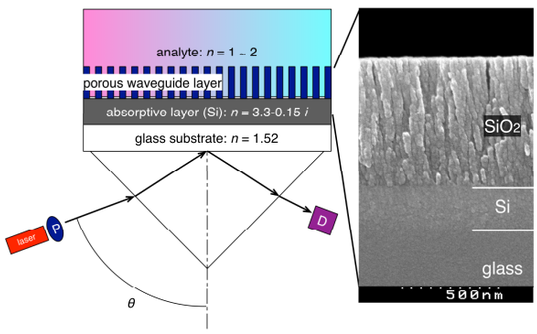

Fig. 1. Schematic configuration of a waveguide-mode sensor (left) and the SEM image of the cross section of porous waveguide layer (SiO_2)/absorptive layer (Si)/glass substrate.

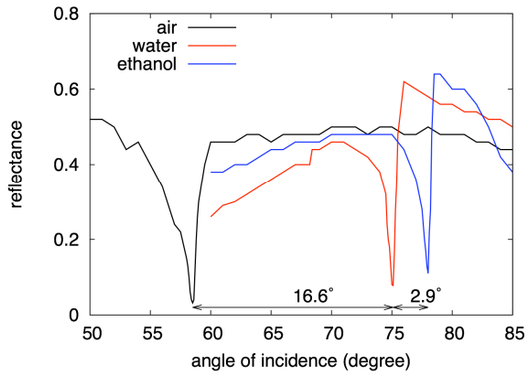

Fig. 2. Reflectance for a sample immersed in air, water and ethanol as a function of angle of incidence.