On the Excitation of a Higher-Order Mode in the Kretschmann-Type SPR Waveguide Sensor in the Terahertz Region

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As the core width of the Kretschmann-type surface plasmon resonance (SPR) waveguide sensor [1] is increasesed, the resonance gets stronger and the frequency response becomes steeper. However, there is a possibility that higher-order modes may propagate in the waveguide. In this article, the characteristics of the Kretschmann-type SPR waveguide sensor with first-order mode excitation are analyzed using the frequency-dependent FDTD method.

The structure of the sensor is shown in Fig. 1. SiO_2 is used for the core and polyethylene is used for the cladding, with relative permittivities of 1.94^2 and 1.5^2, respectively. The angle of incidence of the waveguide is set to $\theta = 45°$, and the core width is chosen as $w = 100$ μm. An InSb layer with a thickness of $t = 2.0$ μm is added as the sensing region, and water is placed outside as the sample. The relative permittivities of InSb and water are treated using the Drude model [2] and the two-pole Debye model [3], respectively. For the analysis of dispersive media, the recursive convolution method based on the trapezoidal rule is used for the FDTD method [4]. The spatial grid size is set to $\Delta z = \Delta x = 0.5$ μm, and the temperature is set to 300 K.

The frequency responses of the sensor when exciting the fundamental and first-order modes are shown in Fig. 2. Compared to the fundamental mode, the first-order mode case exhibits a peak shift toward the higher frequency side and an increase in output power. This may degrade the sensing accuracy. As a result, it is necessary to minimize the higher-order mode components in the incident wave of the sensor.

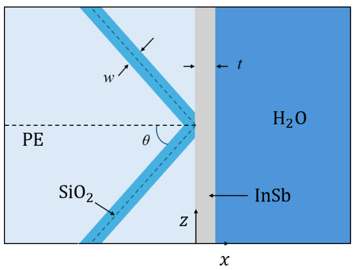

Figure 1. Kretschmann-type SPR waveguide sensor

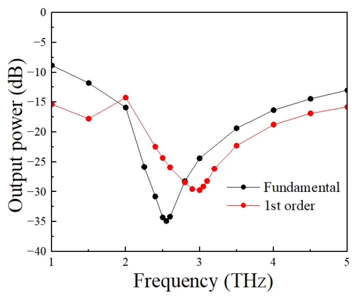

Figure 2. Frequency response

References

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