Liquid Crystal Control of Surface Plasmon Resonance Sensor Based on Nanorods

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Surface plasmon resonance occurs as a result of resonant interaction of incident light wave at a specific incident angle (resonance angle) with the surface plasmon. The surface plasmon is a charge density oscillation arising in the metal film at the interface with dielectric. The resonance angle is very sensitive to refractive index change of the medium surrounding the metal film. Thus, surface plasmon resonance can be used as a tool for investigating chemical and biological structures adjoined with the metal film [1].

We consider a nanorod-mediated surface plasmon resonance sensor [2] and investigate the influence of its different structural parameters on the sensitivity enhancement. For this purpose we study a five-layer system depicted on figure. The system includes the following elements: a glass prism (layer 1), liquid crystal (layer 2), a thin metal film (layer 3), a layer of aligned nanorods array (layer 4), and a sensing layer, which can be air or the target analyte (layer 5).

The theoretical modeling accounts for two anisotropic layers (liquid crystal layer and layer of metallic nanorods). It is based on five-layer Fresnel equations and the Maxwell-Garnett type effective medium theory [3,4]. The effective medium theory is adopted to treat the nanorods and the voids between them as a layer with an effective dielectric constant. For simplicity it is assumed that the voids are made of the same material as the sensing layer.

We investigate the reflectance of the system in the environment with the refractive indices of 1.00 and 1.33 as a function of the light beam incidence angle. The nanorod-mediated surface plasmon resonance is studied depending on the nanorod tilt angle, concentration, length and diameter of nanorods, orientational state and thickness of the liquid crystal film. It is shown that by controlling the orientational state of liquid crystal layer one can increase the sensitivity of the system. Our results may be used for designing a new type of surface plasmon resonance sensor.

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References:

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