Highly Sensitive Grating-Coupled Bloch Surface Wave Resonance Biosensor Via Azimuthal Interrogation

V. Koju[1], W. M. Robertson[1]

[1]Middle Tennessee State University, Murfreesboro, TN, USA

Abstract

Bloch surface waves (BSWs) are electromagnetic excitation modes that exist at the interface of truncated dielectric multilayer structures and a homogeneous medium. Although BSWs are intrinsically present at such interfaces, they cannot be directly excited by light incident from the homogeneous medium due to their non-radiative and evanescent nature [1]. The use of a grating coupler or a prism mitigates this inability by providing an additional momentum to the free-space wave vector required to satisfy the phase matching condition with the BSW wave vector. Here we present a new highly sensitive sensing technique based on grating-coupled Bloch surface wave resonance (GCBSWR) via azimuthal control.

Since GCBSWR bio-sensors do not require a bulky prism to couple light into BSWs, they are strong candidates for nanoscale bio-sensors. But conventional GCBSWR bio-sensors, based on either wavelength or angular interrogation, are observed to be less sensitive compared to prism-coupled Bloch surface wave resonance (PCBSWR) bio-sensors [2]. However, due to their inhomogeneous surface architecture, GCBSWR bio-sensors can be interrogated by rotating the grating platform azimuthally. We exploit this ability to improve the sensing capability of GCBSWR bio-sensors.

We demonstrate computationally, using RF Module of COMSOL Multiphysics® software, that the proposed azimuthal angle interrogation technique highly enhances the sensitivity of GCBSWR bio-sensors. For our study we use a sixteen layered TiO2-SiO2 multilayer with SiO2 gratings on the top sensing platform. We fix the wavelength and incident angle of the incoming light, and sweep over the azimuthal angle to simulate the sensitivity as a function of changing refractive index of the sensing layer. Figure 1 shows the reflectivity as a function of azimuthal angle for different analyte-layer refractive indices. The results from COMSOL Multiphysics are compared with that from a three-dimensional scattering matrix based rigorous coupled wave analysis method. An example of the electric field of BSW excited at the azimuthal angle of around 16 degrees for the analyte-layer refractive index of 1.32 is illustrated in Figure 2.

Reference

[1] W. M. Robertson and M. S. May, "Surface electromagnetic wave excitation on one-dimensional photonic band-gap arrays," Appl. Phys. Lett., 74, 1800 – 1803, (1999).

[2] G. Ruffato et al., "Innovative Exploitation of Grating-Coupled Surface Plasmon Resonance for Sensing," Plasmonics - Principles and Applications, Dr. Ki Young Kim(Ed.), InTech, DOI: 10.5772/51044 (2012).

Figures used in the abstract

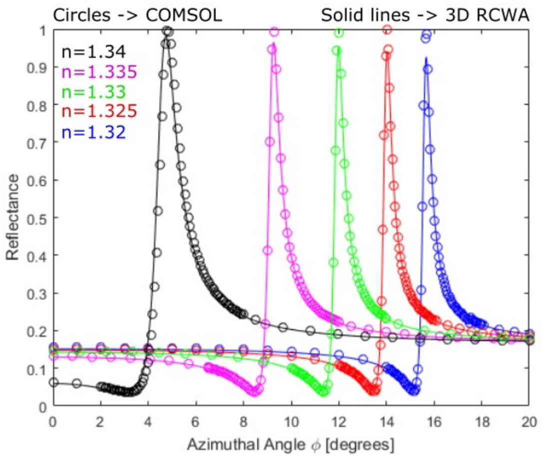

Figure 1: Reflectivity curves as a function of azimuthal angle for different analyte-layer refractive indices. The wavelength of operation and incident angle are 632.8 nm and 5.4 degrees respectively.

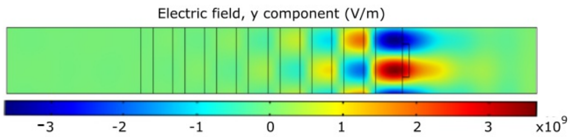

Figure 2: Electric filed profile of Bloch surface wave corresponding to the tip of the blue curve in Figure 1.