Highly Sensitive Grating-Coupled Bloch Surface Wave Resonance Bio-sensors via Azimuthal Interrogation

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Introduction: Bloch surface waves (BSWs) are electromagnetic excitation modes that exist at the interface of truncated dielectric multilayer structures and a homogeneous medium. They can be excited either by prism coupling or grating coupling.

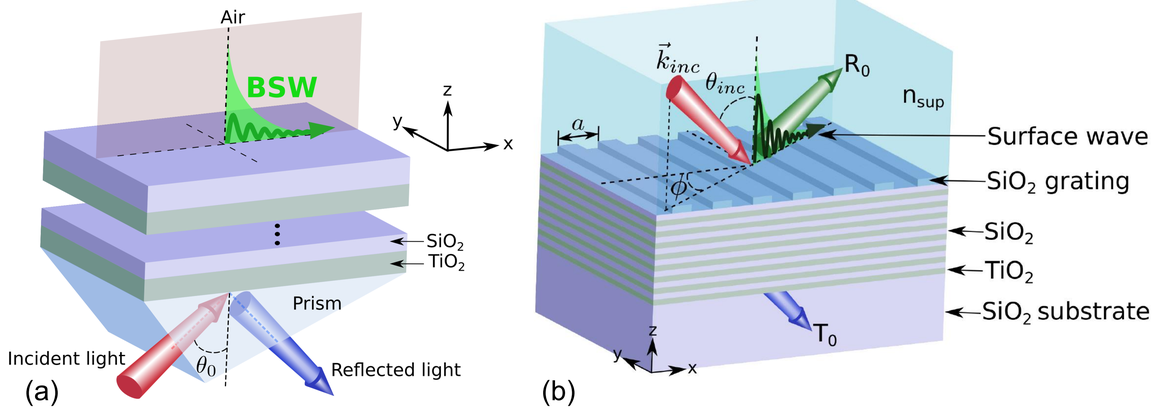


Figure 1. Schematic of Bloch surface wave excitation. (a) Prism-coupling (b) Grating coupling

Advantages of grating coupling:

1. Does not require a bulky prism.
2. Enables azimuthal interrogation.

Computational Methods: The RF module solves the Maxwell's vector wave equation

$$\nabla \times \mu_r^{-1}\left(\nabla \times \vec{E}\right) - k_0^2\left(\varepsilon_r - \frac{j\sigma}{\omega\varepsilon_0}\right)\vec{E} = \vec{0}.$$

For $\mu_r = 1$, $\varepsilon_r = n^2$, and $\sigma = 0$, it reduces to

$$\nabla \times \left(\nabla \times \vec{E}\right) - k_0^2 n^2 \vec{E} = \vec{0}.$$

The incident wavevector has component magnitudes

$$k_x = k_0 sin(\theta_{inc}) cos(\varphi),$$
$$k_y = k_0 sin(\theta_{inc}) sin(\varphi),$$
$$k_z = k_0 cos(\theta_{inc}).$$

The problem is modeled using Floquet boundary conditions on the sides of the domain and Port boundary conditions at the top and bottom.

Reflectivity Maps

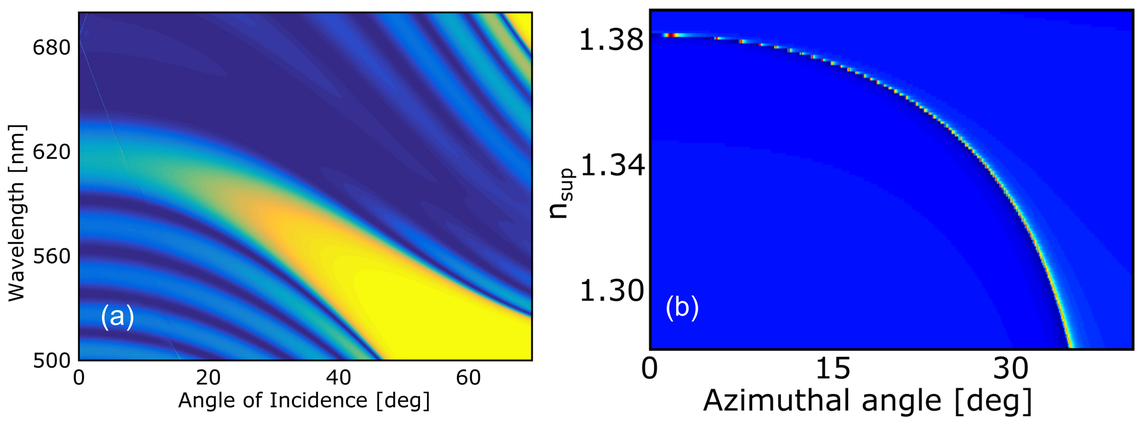
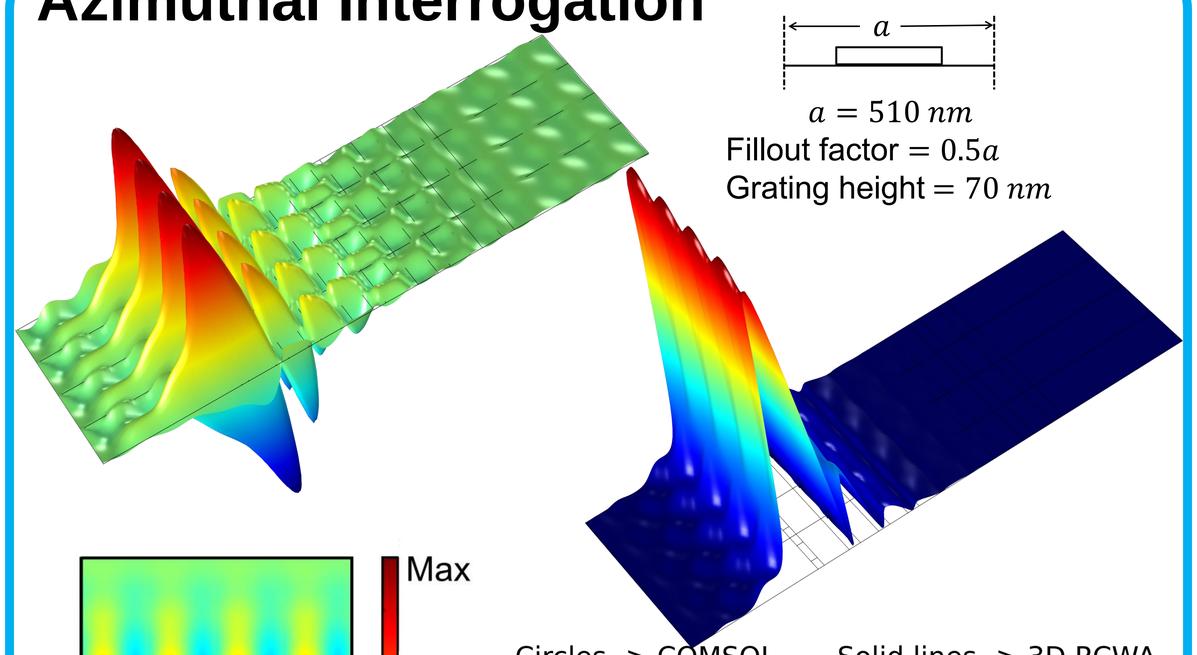
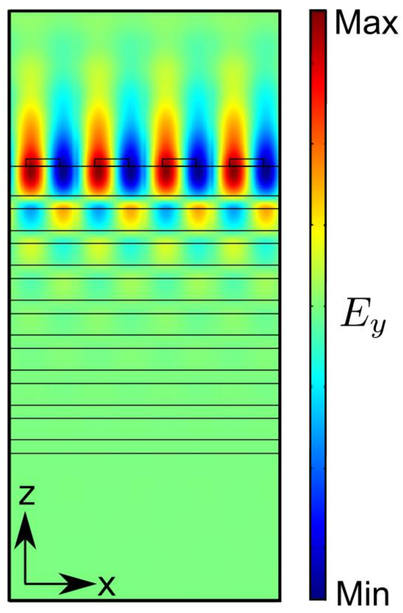


Figure 3. Reflectivity maps of a 16 layered TiO_2-SiO_2 dielectric multilayer, with a grating profile on the surface layer. (a) as a function of wavelength and incident angle for $\varphi = 0^0$ (b) as a function of superstrate refractive index and azimuthal angle for $\lambda = 632.8\,nm$ and $\theta = 5.4^0$.

Azimuthal Interrogation





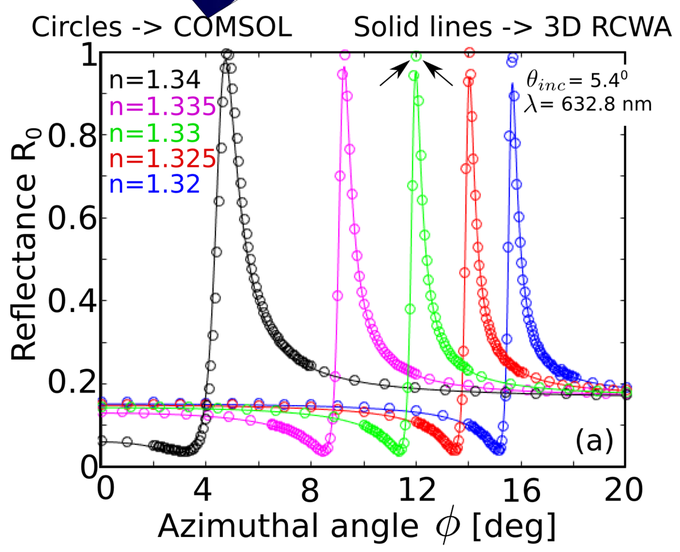


Figure 3. Grating coupled Bloch Surface wave via azimuthal interrogation. Refractive index sensitivity is enhanced compared to conventional angular interrogation.

References:

1. W. M. Robertson and M. S. May, Appl. Phys. Lett., **74**, 1800 – 1803, (1999).
2. G. Ruffato, G. Zacco and F. Romanato (2012 Dr. Ki Young Kim(Ed.), InTech, DOI: 10.5772/51044.