TRANSMITTED-TYPE GUIDED-MODE RESONANCE SENSOR USING COUPLED GRATINGS

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Abstract. Transmitted-type guided-mode resonance (GMR) sensor based on the coupled gratings (CGs) and the corresponding Fabry-Pérot-like (FP-like) model for evaluating the resonance peaks are presented. The estimated locations of the FP-like resonance obtained by this theoretical model are well agreed with those of the exact results. Good sensing properties of the CGs sensor can be maintained, regardless of whether the two grating membranes are laterally aligned or not. The sensitivity of the CGs sensor is immune to the variation of the refractive index (RI) of the substrate, and it can be improved by selecting higher order FP-like mode.

Optical device based on the guided-mode resonance (GMR) effect has been a growing field of interest due to its narrowband spectral filtering property and low sideband. Optical sensors based on the GMR effect are of increasing importance due to their simple structures with versatile sensing characteristics. Various GMR designs based on 1D and 2D periodic structures have been proposed to improve the performance for sensing applications, examples of present-day uses include optical pressure sensor [1], multiwavelength GMR sensor [2, 3], intensity-resolved GMR sensors[4], and polymer GMR sensor[5].

We proposed a transmitted-type sensor based on the GMR transmission filter using the coupled gratings (CGs). This kind of sensor consists of two identical grating membranes with a gap for analyte, and a Fabry-Pérot-like (FP-like) model is proposed to analyze the tunable transmission characteristics of the CGs sensor. It is shown that a narrow FP-like channel with high transmissivity occurs in the opaque background of the CGs, and its location is shifted linearly with the variation of the RI of the gaseous analyte. Good sensing properties are immune to the lateral shift and the refractive index (RI) of the substrate. The stronger couplings between the two grating membranes can be used to improve the sensitivity. By selecting higher order FP-like mode such as m = 4, the sensitivity of the CGs sensor can be improved to 748 nm/RIU with the FOM of 374[6].

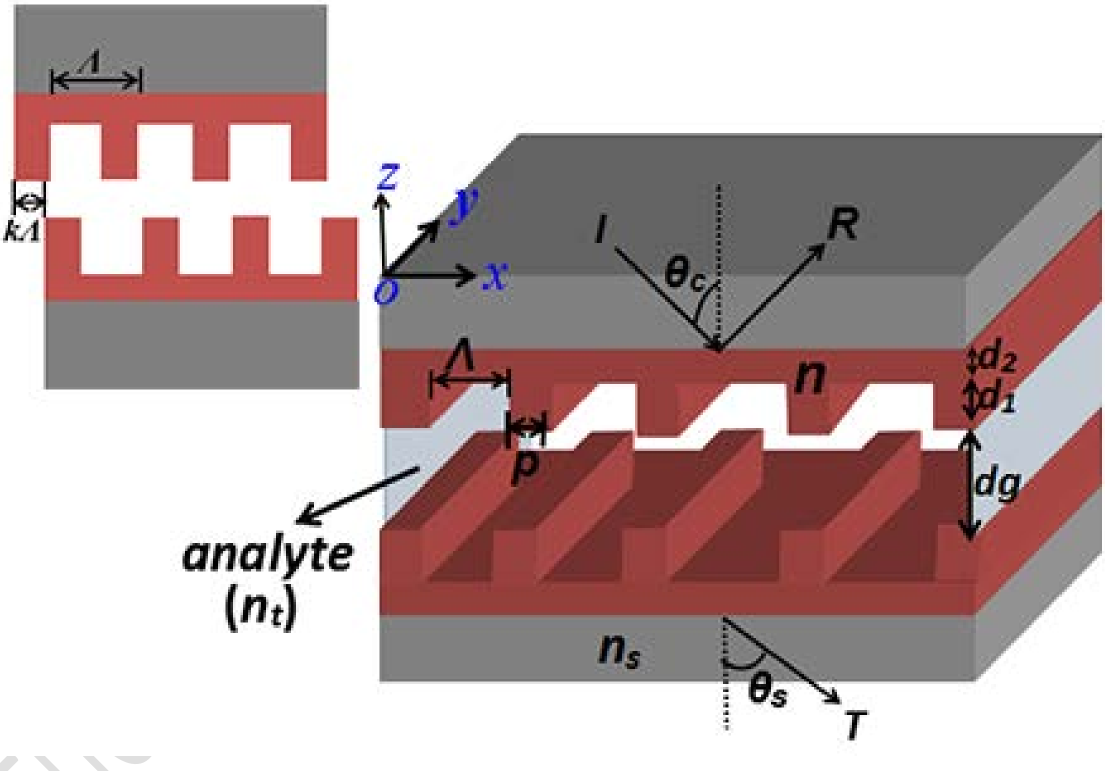

Fig. 1. Schematic diagram of the CGs sensor under the TE-polarized plane wave illumination, k=0 corresponds to the aligned condition

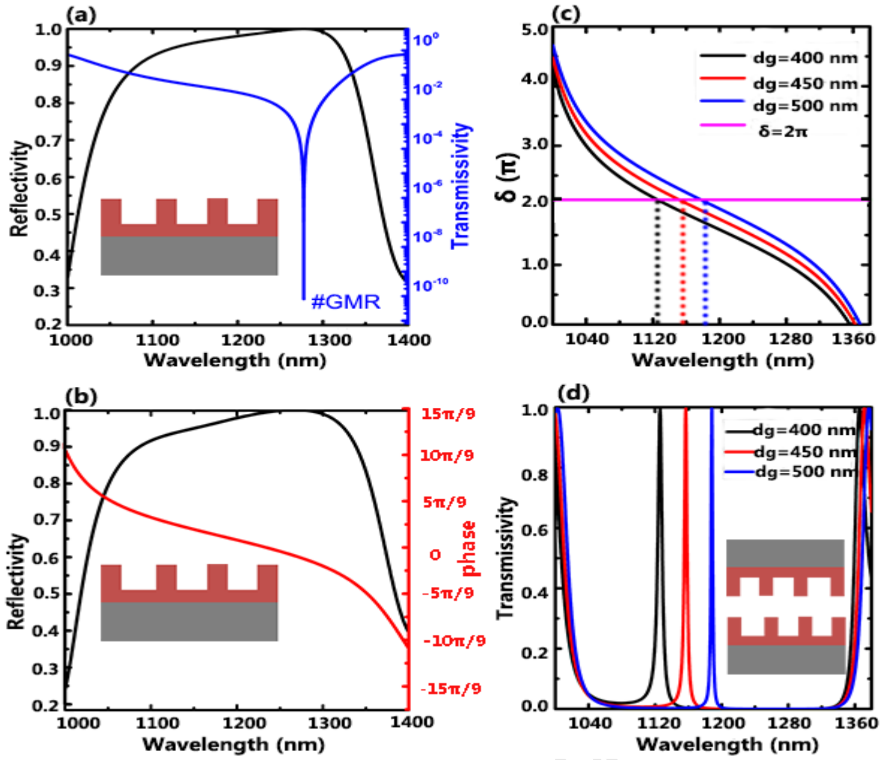

Fig. 2. (a) Spectral response of the single grating membrane. (b) Reflection response and reflection phase of the single grating membrane. (c) Transmission peaks of the CGs sensor estimated by using the FP-like model for different gap thickness. (d) Transmission response of the CGs sensor for different gap thickness

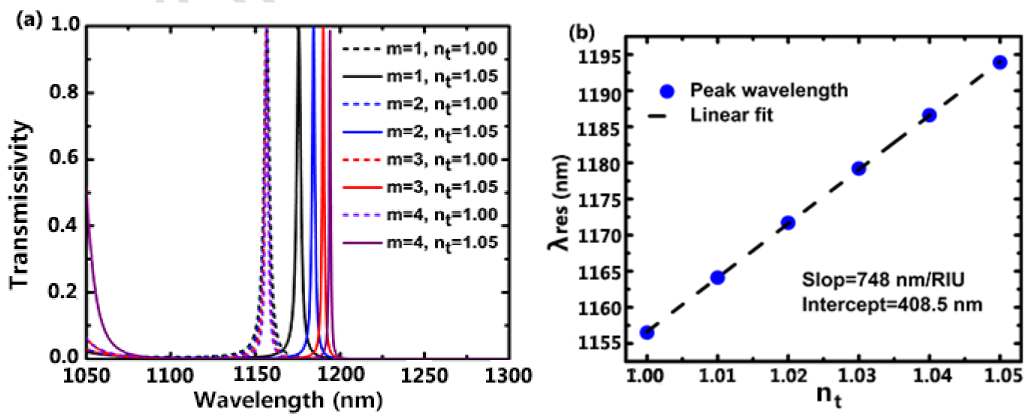

Fig. 3. (a) Transmission spectra of the CGs sensor as function of the RI of the analyte for different modes. (b) Spectral position of the resonant peak as a function of the RI of the analyte with m = 4

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