Dielectric Huygens Metagrating-Based Optical Biosesor

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Abstract: We propose a novel concept for optical biosensing with enhanced sensitivity and robustness to source intensity. We designed and engineered the dielectric Huygens' metagrating based diffraction sensor in a way which allows to efficiently deflect the beam with 68% light transmission in -1st diffraction order and negligible light transmission in 0th diffraction order (Figure 1). The proposed diffraction sensor showed a maximum sensitivity of -478 RIU^{-1} at the analyte refractive index (RI) change of 1.33 to 1.34, while the conventional blazed grating shows the maximum sensitivity of -18.4 RIU^{-1}, which is 26 times lower than our Huygens' metagrating based diffraction sensor. Furthermore, the proposed sensor shows the average sensitivity of -71.3 RIU^{-1}, in the broad refractive index range of 1.33 to 1.43. We also investigated the influence of the deflection angle on refractive-index sensing performance of our sensor against the conventional blazed grating-based diffraction sensor where our sensor demonstrated one order of magnitude higher sensitivity compared to the blazed grating. Due to high sensitivity with a broad detection range, the proposed sensor will be a suitable candidate for the detection of biomarkers and gas detection for diabetes, multiple sclerosis monitoring and beyond

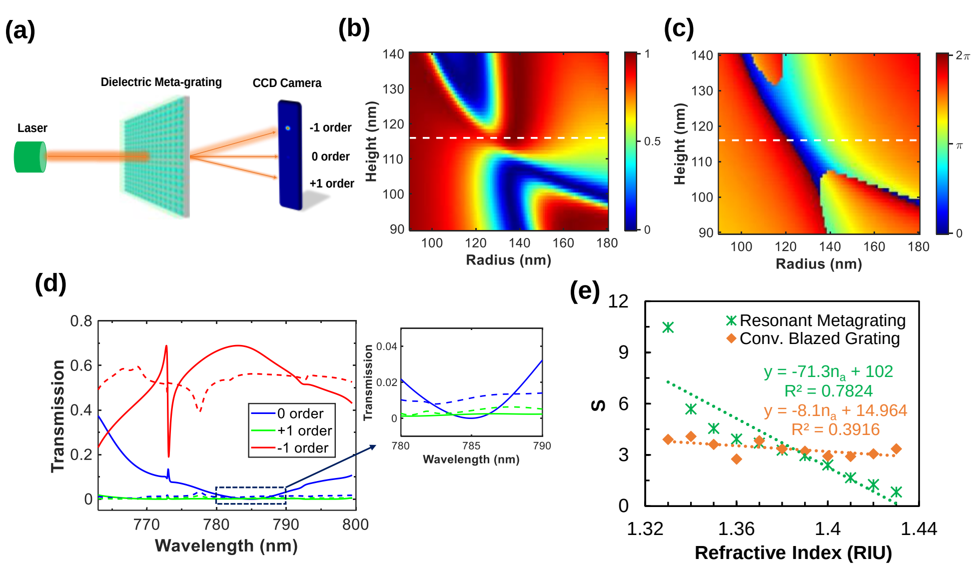

Figure 1: (a) Schematic of dielectric Huygens' diffraction grating, where the supercell contains with nine nanodisks. Numerically calculated (b) transmission and (c) phase profile for a variation of the nanodisk radius 90 nm to 180 nm and height variation from 90 nm to 140 nm at a constant period of p = 475 nm for silicon-nanodisk metasurfaces embedded in a homogeneous medium with n = 1.33. The white-shaded line indicates the overlap of electric and magnetic resonances (h = 116 nm) at 785 nm wavelength. (d) Numerically calculated transmission spectra of 0, +1 and -1 diffraction orders for conventional blazed grating (dashed lines) and Huygens' metagrating (solid lines), and (e) Linear fitting of signal intensity as a function of analyte RI.