Plasmonic nanotube hyperbolic metamaterial with ultra-high refractive index sensitivity

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In the past decade, noble metals-based plasmonic metamaterials have been extensively researched and employed in fields such as optical filtering, biosensing, thermoelectric acquisition and photodetection, which mostly benefits from the localized or non-localized plasmonic resonance modes of metallic nanostructure arrays that form the plasmonic metamaterials. In this work, we propose a significantly sensitive refractive index sensor based on gold nanotube hyperbolic metamaterial. Effective dielectric tensor components of the gold nanotube array are numerically obtained by the Maxwell-Garnett effective medium theory for shell-liked structure, in which we demonstrate the k-space hyperbolic dispertion relation from visible to near-infrared regime. In order to theoretically verify the sensing capability of the gold nanotube array-based hyperbolic metamaterial, we design an attenuated total reflectance (ATR) configuration to calculate the reflectance spectrum utilizing the transfer matrix method (TMM). In our simulation model, the plasmonic hyperbolic metamaterial is equivalent to a extremely anisotropic media layer with one component of the permittivity tensor negative to the other two. The results show that four distinctive reflection dips with narrow bandwidths representing for the high-k bulk plasmonic resonance modes are achieved in the near-infrared wavelength range. Moreover, the four dips have significant shift as the refractive index of superstrate changes slightly. Ultra-high sensitivities of 16,700 nm/RIU and 43,300 nm/RIU which exceed that of localized-plasmon based schemes by two orders of magnitude are obtained at the resonance wavelengths of 1448 nm and 2324 nm, respectively. Meanwhile, the figure of merit (FOM) for the two modes reaches 198 and 620, respectively. Given the outstanding refractive index sensing capability, we believe that the proposed gold nanotube hyperbolic metamaterial has potential application in the fields of label-free biosensing and spectroscopy.

Biography

Tao Wang has completed his PhD at the age of 25 years from the key laboratory of laser technology, Huazhong University of Science and Technology, P. R. China. He is the Professor of Huazhong University of Science and Technology. He has published more than 55 papers in reputed journals and has been serving as an Member of SPIE from January 1997 and the Chinese Optical Society from 1990. His research interests include Optoelectronic Devices and Integration, Biological Optical Sensing, Information Optics and Photonics Technologies, Nonlinear Optics and Applications, Nanophotonics, Nanostructures and Nanometrology

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