Tamm Plasmon Sensors

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1. Introduction

A plasmon state that could be excited at the boundary of photonic crystal and metal is recently theoretically estimated [1] and experimentally testified [2]. The propagation constant dispersion of TP lies within the light corn. Consequently, no coupling system is required to excite the plasmon mode. Due to the characteristic of Tamm plasmon, optical sensors based on TP have been studied for chemical, biomedical, environmental monitoring lately. The ordinary Tamm plasmon structure is constituted by dielectric layers with high and low refractive index alternately to form the dielectric Bragg reflector (DBR) and with a sharp optical response within the photonic bandgap of DBR. The electric field of TP is enhanced at Au-DBR interface and decay to DBR and metals.

In this work, the Tamm plasmon optical sensors with design of cell gaps are proposed. The enhanced electric fields are concentrated in the cell gap. [3] The simulation and experiment results show the wavelength shifts because Tamm Plasmon resonance is sensitive to the refractive index change of medium inside cell gaps. Therefore, the cell gap Tamm plasmon device could be a high sensitive biochemical sensor.

2. Results and Discussions

Fig.1a shows schematic diagrams of the TP structure used in this work. For the DBR structure, it is multilayers formed of eight pairs of tantalum pentoxide (Ta_2O_5) and silicon dioxide layers (SiO_2) with the center wavelength at 650 nm. In the experiment setup, gold is deposited on the other substrate with curvatures to form the subwavelength gaps between metal and DBR.

For normal incidence, experiment and simulation reflectance spectra are showed in Fig .2. It can be clear seen, when the media in gaps are changed from air to water, the resonant wavelengths of optical Tamm states are red-shifted from 681nm to 745nm. Based on the results, optical Tamm states could be used to sensor applications with the advantage in low cost and compact device.

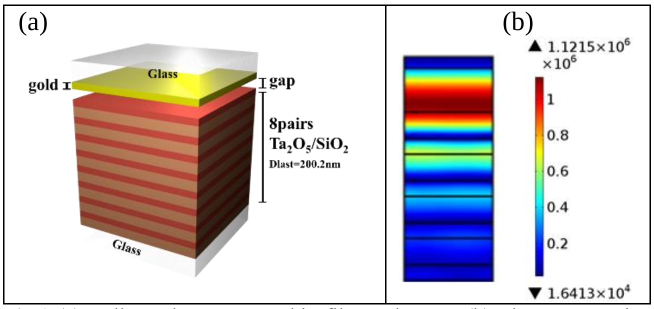

Fig.1 (a) Cell gap between Au thin film and DBR. (b) The cross-section normalized electric field.

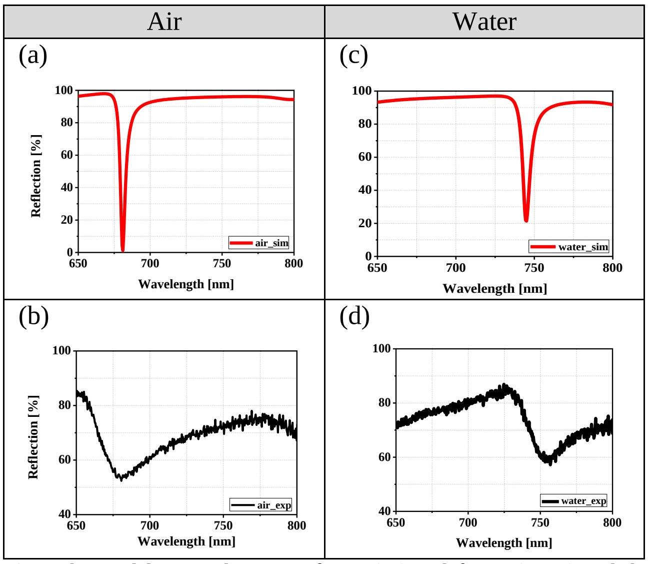

Fig.2 The modeling results are in fig.2a (air) and fig.2c (water) and the measurement results are in fig.2b (air) and fig.2d (water).

3. Conclusions

In conclusion, a novel design of sensors by using TP with small cell gaps are presented. The Tamm Plasmon devices with small gaps could help to trap light and with high sensitivity. In Future, it can be potentially applied to biochemical sensors with integrated microfluidic channels as biochip systems.

4. Acknowledgements

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