High-sensitive terahertz biosensor from a thin metamaterial

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***Abstract*— we demonstrate a high-sensitive and multi-frequency THz measurement on the biomolecules based on a flexible metamaterial. The sensitivity of our proposed biosensor is finally achieved to be around 0.132 GHz/nm that is much higher than other reported results. The tumor molecules are coated on the metamaterial, and a very large frequency shift is observed, which implies its application in disease detection.**

I. INTRODUCTION

TERAHERTZ corresponds to the rotation and vibration of biomolecules. Due to its high penetration and low photon energy for biological tissues, it is very attractive as nondestructive biomedical and biological imaging tools. The conventional method is to measure the THz spectrum of the biomolecules, However, the sensitivity of this method is low because the power of THz source is low. To improve the sensitivity, the resonance structure is used which is allowed to the get the information at only one frequency. In this paper, we proposed an electromagnetically-induced transparency (EIT) –like structure, which resonates at several frequencies. Therefore, we not only keep the high sensitivity of the resonance structure, but also get the information of THz spectrum.

II. RESULTS

We demonstrate here a highly-sensitive THz biosensor based on bull's-eye-shaped metamaterial, which exhibits multiple EIT-like peaks. These resonance peaks can offer not only the high detection sensitivity but also the spectral characteristics of the molecules. The essence of the chosen metamaterial consists of planar array of five concentric gold rings that is periodically patterned on flexible polyimide (PI) substrate. We first study the influence of the substrate thickness of the THz biosensor. In this case, the PI film is covered on the thin metamaterial to simulate the biomolecules. The EM simulation shows the frequency change increases as the PI thickness increases. As the thickness is larger than 8μm, the change of frequency saturates. Since the sensitivity is proportional to the frequency change. This saturation means that sensitivity of biosensor will keep unchanged. We also make a series of samples and measure the THz transmission. Good agreement is obtained between the simulation and experiments. Considering the success rate of sample fabrication and detection sensitivity, we choose the thickness of 10 μm in the following study. Then the influences of sample parameters, including thickness and refractive index, have been investigated to study the THz biosensor. The sensitivity of our proposed biosensor is finally achieved to be around 0.132 GHz/nm that is much higher than other reported result [1].

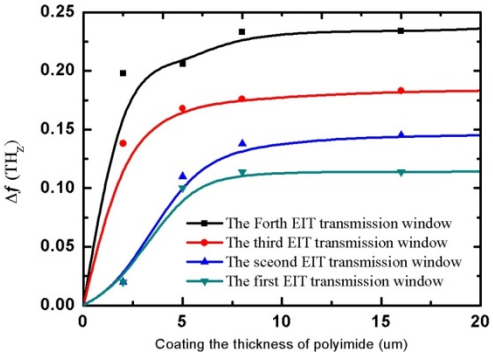

Fig.1 the frequency change vs the coating thickness for different resonance peaks. The coating material is PI.

The transmission spectra of our proposed THz metamaterial were measured by THz time domain spectroscopy (TDS) system, and were utilized to detect several kinds of samples. Here, we reported three different kinds, including coating PI film, one layer tumor cell and specific biorecognition of biomolecule [2,3]. The frequency shifts for EIT peaks could be achieved from about 10 GHz to as much as the order of 200 GHz, which implies that our propose acts well for detection of disease.

III. SUMMARY

We make EIT-like structure with a very thin substrate as a biosensor. The simulation and experiments show the sensitivity can reach 0.132 GHz/nm, that is much higher than the previous report. Our measurement also can offer the information of THz spectrum.

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