Metamaterials to Improve Terahertz-wave Real-Time Imaging System

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Metamaterial with split ring resonator (SRR) array is proposed to improve the performance for the real-time terahertz (THz)-wave imaging system based on the frequency up-conversion with nonlinear crystal. The SRR works as a micro-antenna to collect the incident THz wave and confine the electric field into the capacitor area at its resonance, where the enhanced electric field reinforces the conversion efficiency on the nonlinear crystal, resulting in improving the detection signals with the image.

THz-wave source and detector have enabled the THz spectroscopy, THz image system to be realized in laboratory or recently in commercial. Among the THz image techniques, the real-time THz imaging is desired in many applications, such as the quality control in manufacturing, security checking at the airport. The real-time THz imaging demonstrated in reference [1] shows promise for the technical transformation to the industry. However, the wavelength-conversion efficiency at the DAST crystal is low, which further limits the image quality and resolution.

In this report, we propose metamaterials with SRR array to improve the THz-wave real-time image performance. At resonant frequency, each SRR works as an antenna pixel to confine the electric field of the THz wave into a localized area, such as the center of the SRR lattice that with the gap (capacitor) between the two metallic patterns as shown in Fig. 1 from the COMSOL simulation. The SRR has a lattice of 100μm*100μm at sub wavelength, which does not cause limitation to the image resolution. On the other hand, it would improve the minimum resoluble object through reinforcing the detection signal by the electric field enhancement. The SRR structure design requires a high quality (Q) factor of resonance to obtain a strong enhanced field, which is usually accompanied with the trapped mode of the resonator, such as the one shown in Fig. 1. An effective area with the enhanced field is another point to get the efficient nonlinear conversion. There is trade-off between the two points, which is under consideration.

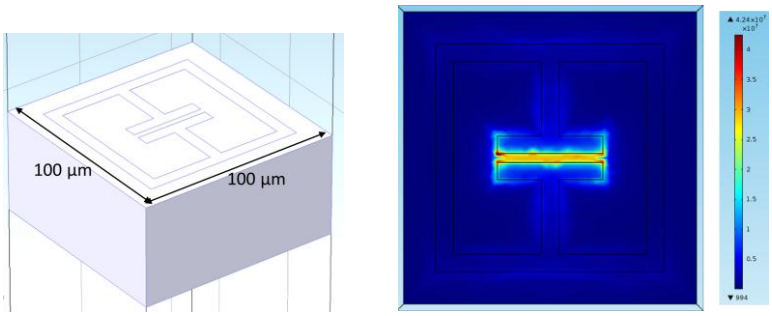

Fig. 1 Electric field distribution on the substrate surface of the metamaterial unit cell at its resonance.

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Reference: [1] S. Fan, et al., Optics Express, Vol. 23, No. 6, 7611-7618, (2015 Mar).