Ultra-broadband terahertz perfect absorber

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***Abstract*—We propose three kinds of ultra-broadband terahertz (THz) perfect absorbers by fabricating gratings on heavily boron-doped silicon substrate. By optimizing the doping density, the absorption bandwidths are 1 THz, 1.5 THz, and 2.0 THz, respectively, with absorbance above 95%. The fundamental principles are mainly attributed to the antireflection effects, the grating diffractions and the air gap-mode resonance.**

I. INTRODUCTION

Recently, THz perfect absorber has attracted great interest, due to its wide applications in spectrum imaging system, sensor, thermal emitter, etc. In the past few years, single-frequency and multi-frequency THz absorbers are realized based on meta-based resonance structure [1-2]. Until recently, a broadband, polarization-insensitive THz absorber is obtained in Ref [3] by integrating multiple (five layers) parallel plate waveguides in one unit cell and merging together their resonance bands. However, this kind of broadband THz absorber is suffered from the difficulties of either alignment or fabrication, resulting in the impracticality in practical application. Therefore, a simple-structured broadband perfect absorber is also one critical problem that needs to be solved urgently.

II. RESULTS

Here, we report three kind of ultra-broadband THz perfect absorbers based on heavily boron-doped silicon with carrier density of N=1.6×10^{16} cm^{-3} [4-6]. Figure. 1(a_1) shows the SEM image of the square grating fabricated on the heavily boron-doped silicon substrate. In the low frequency regime, the grating array can be considered as an effective medium coating on the substrate, resulting in the anti-reflection effect between the incident and the reflected THz waves. In the high frequency regime, the [±1, 0]-order grating diffraction is contributed to the absorption. So, both the antireflection effects and the [±1, 0]-order grating diffraction are combined with each other, leading to the wideband THz perfect absorber with absorption bandwidths of 1.0 THz (for absorptivity ≥ 95%) (see Fig. 1(a_2)). The second dumbbell-shaped ultra-broadband THz perfect absorber is depicted in Fig. 2(a1). Three resonance peaks (in Fig. 1(b_2)) are corresponding to the anti-reflection effects, the [±1, 0]-order grating diffraction and the [0, ±1]-order grating diffraction, respectively. All of these three resonance peaks are jointed into the ultra-broadband THz perfect absorber (the absorption bandwidths is 1.5 THz for absorptivity ≥ 95%). Fig. 1(a_3) shows the double-layered grating array etched on the heavily boron-doped silicon substrate. Air gap mode resonance, the first-order grating diffraction, and the second-order grating diffraction are all excited in the double-layered doped-silicon grating structure. These three resonance peaks are broadened and combined into each other, resulting in the ultra-broadband THz absorber with absorption bandwidths of 2.0 THz (for absorptivity ≥ 95%), as shown in Fig. 1(b_3).

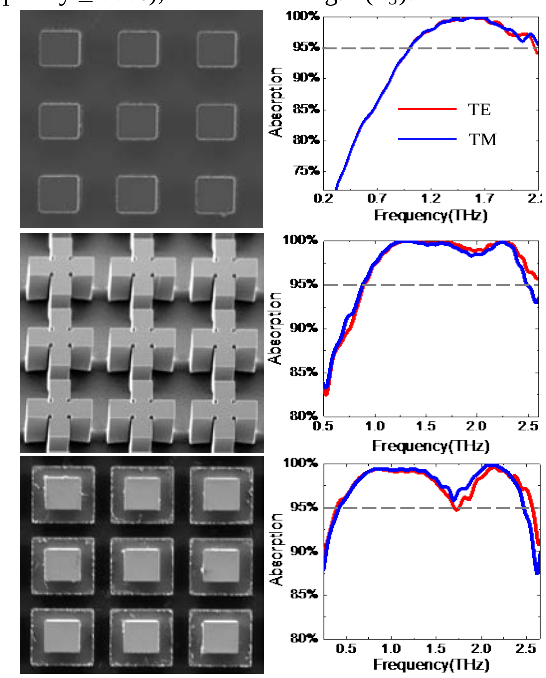

Fig. 1. (a_1-c_1)SEM of the fabricated samples corresponds to square grating array (a_1), dumbbell-shaped grating array (b_1), and double-layered grating array (c_1). (a_2-c_2) Measured results correspond to (a_1-c_1). Red line and blue line are corresponding to TE and TM incident THz waves, respectively.

III. SUMMARY

We have reported three ultra-broadband THz absorbers based on doped-silicon-based doubled-layered gratings. By associating the gap-mode resonance, the grating diffractions, and the antireflection effects, ultra-broadband THz absorbers with nearly 1.0 THz, 1.5 THz, and 2.0 THz absorption bandwidths were obtained in three kinds of grating arrays.

IV. REFERENCES

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