Experimental realization of double-sided perfect metamaterial absorber through stochastic design process at terahertz gap

Huang, Tsung-Yu [1,*], Tseng, Ching-Wei [1,*], Yeh, Ting-Tso[1], Tahsin Akalin[2] and Yen, Ta-Jen [1,3,a)]
[1]Department of Material Science and Engineering, National Tsing Hua University, Hsinchu, Taiwan, R.O.C
[2]IEMN, Lille 1 University, France
[2]Department of Materials Science Center For Nanotechnology, Materials Science, and Microsystems, National Tsing Hua University, Hsinchu 30013, Taiwan, R.O.C.
[*]These two authors contributed to this work equally
[a)]Author to whom correspondence should be addressed. Electronic mail: tjyen@mx.nthu.edu.tw

Abstract—**We design a double-sided perfect absorber at 2.4 THz within the terahertz gap to enable light absorption at the bidirectional directions, which is impossible for the traditional metamaterial-based perfect absorbers due to the employment of a metallic ground plane dedicated to reduce transmission. Here, the double-sided perfect absorber is fabricated on a $\lambda_0/6$-thick polyethylene terephthalate (PET) substrate of $\varepsilon_r = 3.05\times(1+0.08i)$ sandwiched by the two identical randomized metallic patterns, which provide equalized permittivity and permeability to match the impedance of free space and enormous imaginary part of refractive index to trap the light, evidenced by the retrieval method.**

I. INTRODUCTION

Metamaterials possess unprecedented optical properties and could be operated within microwave, infrared and visible region due to scalability of metamaterials. In recent decades, researches in terahertz (THz) gap (0.1 to 3 THz; far-infrared) have attracted tremendous attention because metamaterials could achieve strong electric and magnetic responses which are weak in materials in nature within THz gap. Through utilizing metamaterials, various novel phenomena based on strong electric response, magnetic response or both could be applied in THz devices, such as superlens, electromagnetic cloaking, slowing light systems and perfect absorbers. Among these fancy applications, perfect absorbers have been widely developed recently owing to extensive practical applications by perfect absorbers, including radar absorbent devices, lining of anechoic chambers, bolometers, screens for electromagnetic interference and spatial light modulators .

In 1952, a microwave absorber, Salisbury screen [1], was invented by American engineer Winfield Salisbury. Such absorber consists of a metallic ground plane, a loss-free dielectric layer with precisely assigned thickness and a thin lossy screen. The principle of Salisbury screen is to match the impedance between free space and absorber itself through quarter-wave antireflection interference. With metallic ground plane minimizing the transmittance and lossy screen suppressing reflectance due to destructive interference, a perfect absorber could be achieved. Even though Salisbury screen absorber could reach highly efficient absorbance, the performance relies on thickness of spacer which increases the size of absorbers and restricts the practical applications based on Salisbury screen.

In view of the aforementioned drawback, perfect metamaterial absorbers (PMA) are proposed recent years [2, 3]. But the ground planes and customized patterned ground planes are need. Ground plane would limit PMA operating in unidirectional illumination, and customized patterned ground planes would takes people's time to search the optimized patterns out. As a result, a double-sided perfect absorber is development-needed to expand the applications of THz absorber.

II. RESULTS

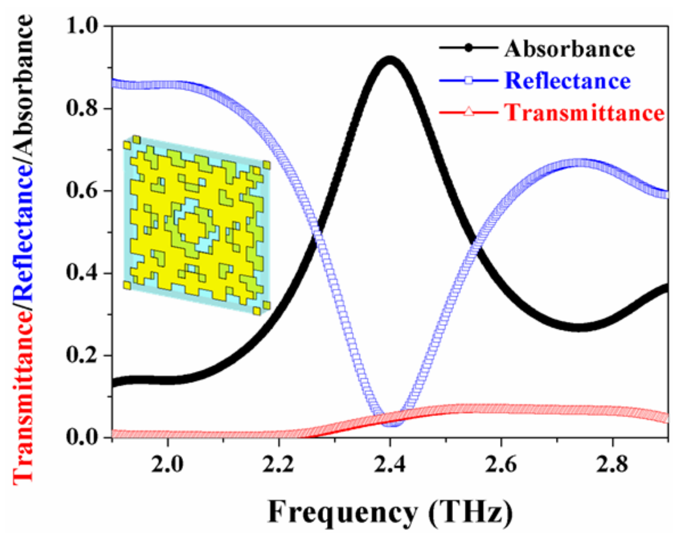

Fig. 1. The inset shows schematic view of the double-sided perfect absorber with the metallic patterns developed through stochastic process. Simulated reflectance, transmittance and absorbance of the double-sided perfect absorber on a flexible PET thin film with 12-μm-thick. The corresponding absorbance approaches to 0.917 at 1.74 THz.

III. SUMMARY

We have stochastically developed metamaterial patterns to successfully demonstrate a double-sided perfect absorber at 2.4 THz to trap light at the two opposite directions with the absorbance of up to 0.917 by matching the impedance between free space and the device and providing equivalent great imaginary part of index, respectively. The double-sided is with the thickness of $\lambda_0/6$ that can be further reduced by employing thinner rigid substrate such as a silicon thin film.

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