A flexible and conformal THz coding metamaterial

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***Abstract*—Control of terahertz (THz, 1 THz=10^{12} Hz) wave is still a big challenge in the THz community. We present here a flexible coding metamaterial, which is composed of "0" and "1"elements, i.e., 1-bit coding case, to shape the reflection and scattering of THz wave. The far-field patterns can be varied by adjusting the digital sequence. We also demonstrate a low-reflection-and–scattering metamaterial, which show a reflectivity less than -10 dB in a wide THz range. Since this metamaterial is made of flexible substrate, it can be conformal to the object, which indicates a widespread application.**

I. INTRODUCTION

TERAHERTZ (THz) wave region has several important advantages. It can clearly offer better angular resolution for a given antenna diameter than do microwaves. Compared with infrared wave, it has a larger penetration capability, for example, THz wave can easily go through smog. Due to its great potential application, the control of THz wave becomes very attractive in the THz community for design and fabrication of THz devices. Metamaterial, a kind of artificially periodic structure, can realize a broader range of effective permittivity and permeability, which cannot be achieved by the nature material. This leads to the prediction and demonstration of a series of novel physical phenomena, such as negative refractive index of the material, a zero index of refraction, invisibility cloaks and superlens. Since this metamaterial is based on the effective medium theory, we call them "analog metamaterial".

Inspired by the digital electronics, digital metamaterial is recently proposed and demonstrated. In this metamaterial, two types of unit cells are set as "0" and "1" bits, respectively. They are used to construct the metamaterial with the desired electromagnetic parameters and functions. This new methodology will simplify the design and fabrication of the metamaterial and devices.

In this paper, we design a coding metamaterial working at THz. The reflective characteristic can be tuned by varying the coding sequences. We also design and fabricate a low reflection and scattering metamaterial, which is flexible and capable to be conformal to the object.

II. RESULTS

A THz coding metamaterial is shown in Fig.1a (above). It is a three-layer structure, which is composed of a metasurface, a polyimide (PI) layer and a ground plane. "0" and "1"bits are set to be a unit covered by a metallic ring and without covering on the PI layer, respectively. The difference of angle of reflective wave is about 180 degree from 0.8 to 1.4 THz for these two bits. By adjusting the coding sequence, the reflective beams can vary from two to three beams. The coding sequence shown in Fig.1a is a low reflection and scattering metamaterial. Fig.1b depicts the simulation and results. Under the incidence angle of 13 degree, the reflection below -10 dB is from 0.8 to 1.4 THz, a very wide frequency range. Our measurements also show that this characteristic can keep up to the incident angle of 40 degree. Due to the symmetric structure, the reflection is also polarization insensitive. Due to the flexibility of our metamaterial, we can wrap the coding metamaterial around a metallic cylinder. The measured results have a similar behavior compared with the flat case.

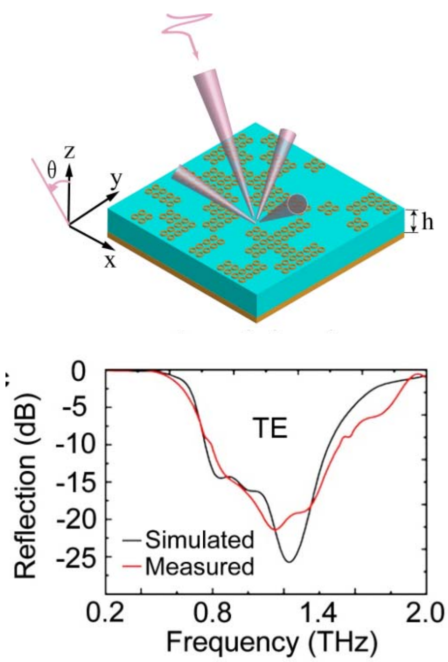

Fig.1 (above) Schematic of a 1-bit coding metamaterial; (below) Simulated (black lines) and measured (red lines) reflection spectra under the incidence angle of 13° for TE polarization

III. SUMMARY

In conclusion, we have proposed a flexible and conformal coding metamaterial at THz. It shows a wideband and low reflection behavior, which demonstrates a very nice example for the application of the digital metamaterial and pave an avenue to THz electronics.

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