Design of Polarization-Dependent Reflectarray for Terahertz Waves

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Abstract: A reflectarray is designed for polarization-dependent beam deflection at 1 THz. Each unit cell is composed of two sets of dipole resonators, corresponding to orthogonal polarizations. The orthogonal dipoles are arranged in two interlaced triangular-lattice arrays. One subarray containing multiple unit cells provides a gradient phase response to complete a 2pi phase cycle over its length. This design demonstrates that it is possible to separate the polarization components of an incident beam by deflecting them into two different directions in a given plane. Numerical results predict successful implementation of the principle with available materials and within realistic manufacturing tolerances for operation at a frequency of 1 THz.

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Adelaide Applied Electromagnetics

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Abstract

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Introduction:

Terahertz technology for communication:

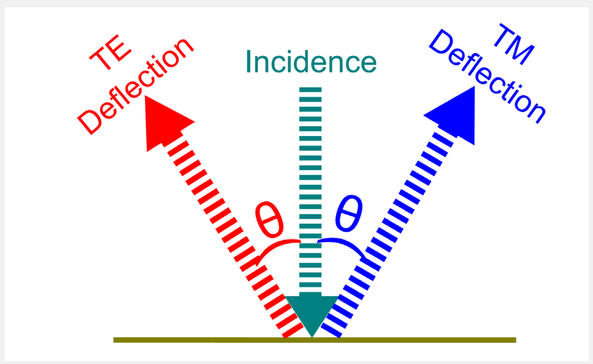
- Higher frequencies than conventional microwave radiation
- Penetrability into various objects opaque to optical beams

Reflectarray for dual reflection:

- High efficiency; ability to manipulate the reflection direction
- Dual reflections with rectangular patches and crossed dipoles

Objective:

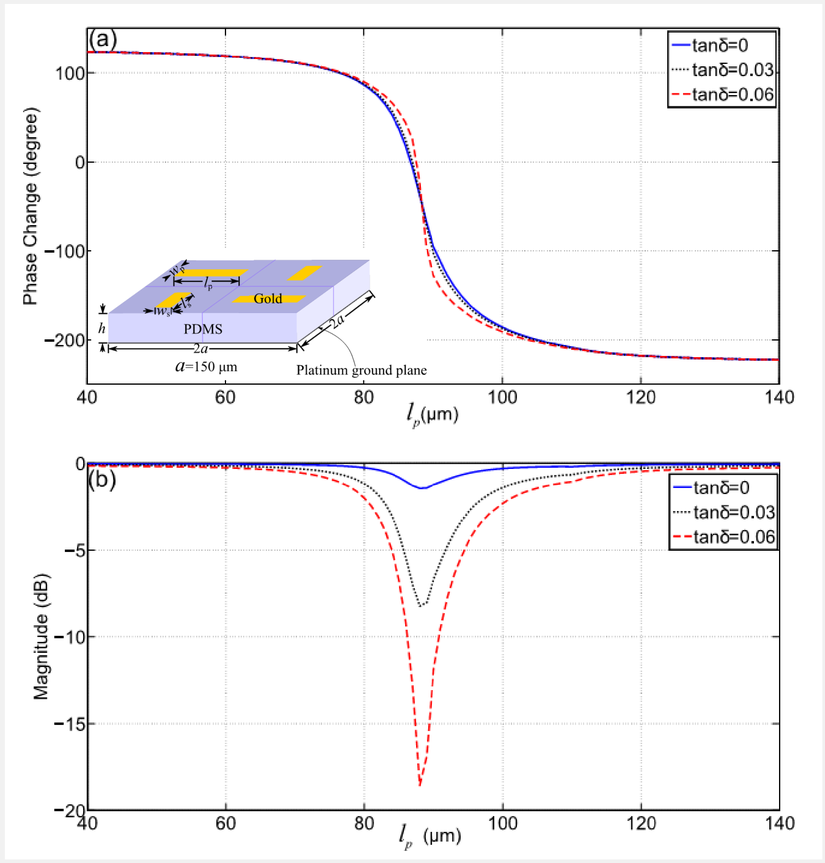
The aim is to design and realise a terahertz reflectarray for beam splitting, by deflecting the two polarisation components of an incident beam into different directions.



Reflective Unit cell:

The unit cell:

- Two sets of orthogonally interlaced triangular-lattice dipoles
- Three layers: gold dipoles, PDMS substrate, platinum ground plane
- Operating frequency: 1 THz
- Parameters: $\varepsilon_{rPDMS} = 2.23,\ 2a = 300\,\mu\text{m},\ h = 20\,\mu\text{m}, \tan\delta_{PDMS} = 0$

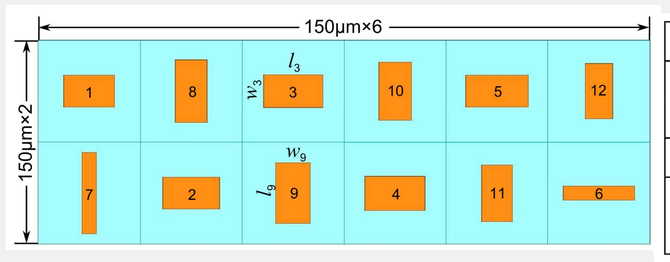


Simulated reflection coefficients for 2D uniform infinite arrays with different PDMS loss tangent.

Subarray with Lossless PDMS & Simulations

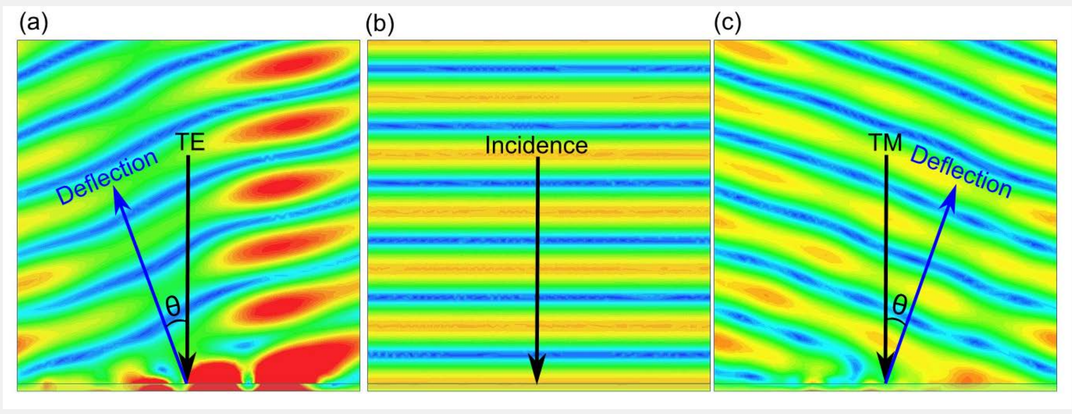
Deflection angle:

$$\Delta\phi = \pm 60^\circ,\ \lambda_0 = 300\,\mu\text{m},\ a = 150\,\mu\text{m},\quad \sin\theta = \frac{\Delta\phi\lambda_0}{2\pi a},\ \Rightarrow\ \theta \approx \pm 19.5^\circ.$$



	1	2	3	4	5	6
l_p	75	84	87	89	92	105
w_p	47	47	48	50	47	21
	7	8	9	10	11	12
l_s	120	92	89	85	83	81
w_s	21	47	51	48	45	40

Layout of a subarray made of 12 dipoles and the dimensions of each dipole.

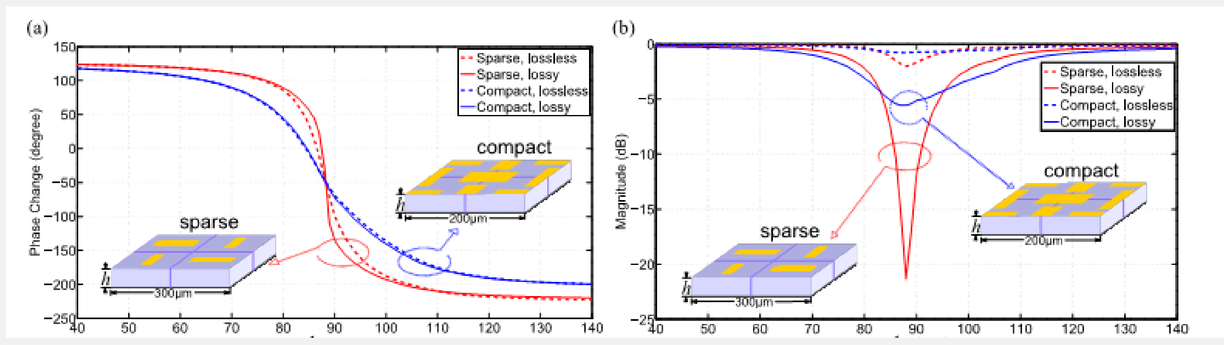


Instantaneous scattered field from the reflectarray with lossless substrate at 1 THz. When the incident wave (b) is normal to the surface of the reflectarray, the TE and TM polarized wave are deflected into two different directions with the designed angles shown in (a) and (c), respectively.

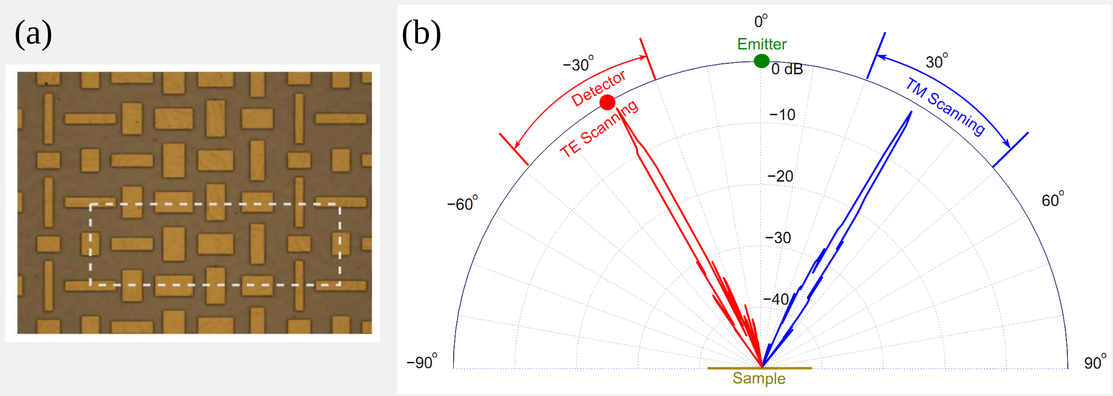
Improved Configuration & Measurement Results

Improvements:

- Lossy PDMS substrate for practical application
- Compact the sparse configuration for higher efficiency and less stringent fabrication tolerance
- Deflection angle: ±30°
- Parameters: $\varepsilon_{rPDMS} = 2.23,\ 2a = 200\,\mu\text{m},\ h = 20\,\mu\text{m}, \tan\delta_{PDMS} = 0.06$



Simulated reflection coefficients for 2D uniform infinite interlaced triangular-lattice dipole arrays with compact (blue dash and solid lines) and sparse (red dash and solid lines) configurations.



(a)Microscopy image for a small part of the reflectarray. (b) Measured radiation patterns for the TE (red line) and TM (blue line) polarizations of the reflectarray. The normal incident wave can be efficiently deflected into two different directions with the properties of polarization dependence.

Conclusion:

A terahertz reflectarray for polarization-dependent deflection has been proposed and fabricated. The simulated and measured results verify that the reflectarray can deflect the incident waves with different polarizations into desired directions, depending on the polarization of the incident waves..

Tiaoming Niu received B. S. and M. S. degrees in information science and engineering from the Lanzhou University, China, in 2003 and 2011, respectively. In 2003-2008 she worked in China Telecom as an engineer. In 2011 she joined the school of electrical and electronic engineering at the University of Adelaide for her Ph. D study. She is currently involving in the research of terahertz reflectarrays and metamaterials.