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Metasurfaces for Terahertz Waves Polarization Control

A.V. Lavrinenko[1], R. Malureanu[1], M. Zalkovskij[1], S. Zhukovsky[1],
A. Andryieuski[1], P.U. Jepsen[1], D. N. Chigrin[2], Z. Y. Song[3], Q. He[3], L. Zhou[3]

[1]Department of Photonics Engineering, Technical University of Denmark Oersteds plads, Bld. 343, DK-2800, Kgs. Lyngby, Denmark
[2]RWTH Aachen University, Aachen, 52074 Germany
[3]Physics Department, Fudan University, Shanghai 200433, China

email:
alav@fotonik.dtu.dk;
rmal@fotonik.dtu.dk;
mzal@fotonik.dtu.dk;
sezh@fotonik.dtu.dk;
andra@fotonik.dtu.dk;
puje@fotonik.dtu.dk;
dmitry.chigrin@googlemail.com;
qionghe@fudan.edu.cn;
sls@fudan.edu.cn;
phzhou@fudan.edu.cn

Mailing address: Prof. Lavrinenko A. V., DTU Fotonik, Technical University of Denmark, Oersteds pl. Bld.343, Kongens Lyngby, DK-2800, Denmark

Phone/Fax: +45 45256392/+45 4593 6581

Corresponding/Presenting Author: Andrei V. Lavrinenko

Session: SC2: **THz Metamaterials: Fundamentals and Applications**

Invited

Metamaterials as the design concept and umbrella name have demonstrated a broad range of useful properties in different ranges of frequencies. The main advantage of the metamaterial-based devices is the possibility to broaden both passive and active photonic component functionalities. While in the visible, near infrared or microwave regimes these issues in principle have strong alternatives via a conventional optics or electromagnetic approaches, at terahertz (THz) frequencies metamaterials are often considered as being the unique solution for the encountered problems. Several approaches involving metamaterials-based THz components have been proposed and show good potential for applications [1,2]. Especially fruitful appears to be two-dimensional metamaterials or metasurfaces due to fabrication simplifications and practically the same as bulk metamaterials functionalities.

In the talk we will focus on employment of THz metasurfaces as polarizers and polarization converters, absorbers and conducting layers with enhanced transmittance, dichroic and chiral reconfigurable systems, waveplates and broadband filters.

As the unified approach we employ the transmission line theory providing a needed level of the generalization. We demonstrate its applicability in optical problems by analyzing the theoretical limits of a metasurface converter with orthogonal linear eigenpolarizations that allows for linear-to-elliptical polarization transformation with any desired ellipticity and ellipse orientation. Our analysis reveals that the maximal conversion efficiency with a single metamaterial surface is 50 % in transmission and up to 90% in reflection. However, a double layer transmission converter and a single layer with a metallic mirror can have 100% polarization conversion efficiency. We tested our conclusions numerically reaching the designated limits of efficiency using a simple metamaterial design and checking them against the numbers reported in literature.

The metasurfaces performance was characterized by exemplifying them with free-standing membranes patterned with a grid of air slits perforated in a uniform large area (up to several cm^2) 2μm-thick Ni film. Depending on arrangement of both slits and their sizes different optical properties of such metasurface can be acquired. We demonstrate linear polarization filtering with the parallel slits dimmers, and more complex chiral behaviour of dimers, when non-equal slits are non-parallel. In particular, strong optical activity and circular polarization conversion are reported.

[1] M. Rahm, J. S. Li, and W. Padilla, J. Infrared Millim Terahertz Waves 34, 1–27 (2013).

[2] H. O. Moser, C. Rockstuhl, “3D THz metamaterials from micro/nanomanufacturing,” Laser Photon. Rev. **6,** 219-244 (2012).