Tuning of multipole meta-atom response

Moritz Wenclawiak, Karl Unterrainer and Juraj Darmo
Photonics Institute, Vienna University of Technology, Vienna, Austria

TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Motivation

The meta-atom, as the basic block of artificially created materials - metamaterials, is a human built material system with specific interaction with electromagnetic waves. Its main characteristic thereby features:

- dimension shorter than the interacting wavelength
- control over electromagnetic response of a structure
- tuning optical transmission properties
- influencing the polarization direction of the impinging radiation
- accessing intersubband transistion in quantum heterostructures

Changing the topology of the used meta-atoms leads therefore to the control over:

- resonance frequency, - linewidth and absorption strength

S-shaped meta-atom

The multipole approach [1, 2] is based on a combination of single dipoles with resonance frequency f_0. They are coupled via a conductive connection (coupling constant σ). Capacitive coupling can be controlled via variation of the distance between the meta-atoms in the measured array.

- L-shaped meta-atom
- mode-splitting into two eigen-modes
- S-shaped meta-atom
- two conductively coupled L-meta-atoms

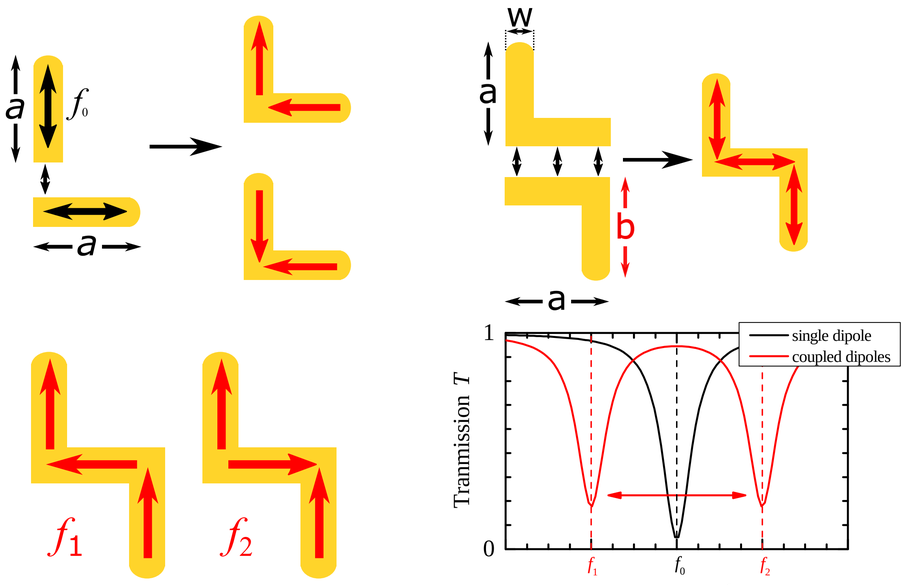

Figure 1: Coupling of the dipoles to the S-shaped meta-atom with possible modes and mode-splitting.

References

[1] J. Petschulat *et al. Phys. Rev. A*, 78(043811), 2008.

[2] J. Petschulat *et al. Phys. Rev. B*, 82(075102), 2010.

Contact Information

Adress Gusshausstr. 27-29, A - 1040 Vienna, Austria
Email moritz.wenclawiak@tuwien.ac.at
Phone +43 1 / 58801 - 38773
Web http://www.thzlabs.at
http://www.photonik.tuwien.ac.at

THz time-domain-spectroscopy

- time resolved measurement of electric field and phase
- sample S consists of an array of meta-atoms with a constant array spacing to reduce capacitive coupling effects

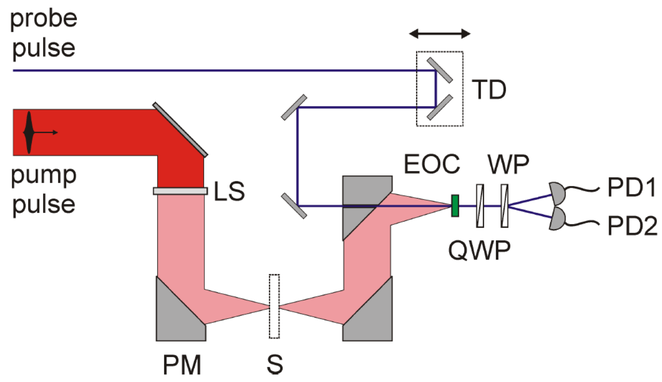

Figure 2: Time-domain-spectroscopy setup

Transmission spectra

The transmission spectra are measured with a time-domain-spectroscopy (TDS) setup. The pulsed terahertz (THz) radiation is generated by a large area photoconductive antenna driven by a conventional femtosecond fiber laser. The pulses are linearly polarized.

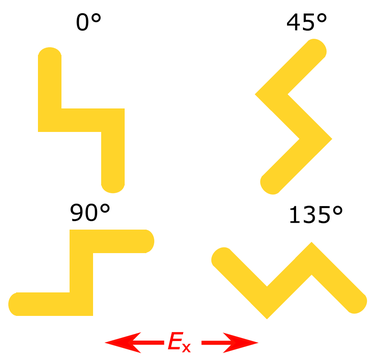

Figure 3: Polarization angles Φ

- mode selection via polarization angle Φ
- introducing an asymmetry via parameter $r = \frac{a}{b}$
- access to "new" mode

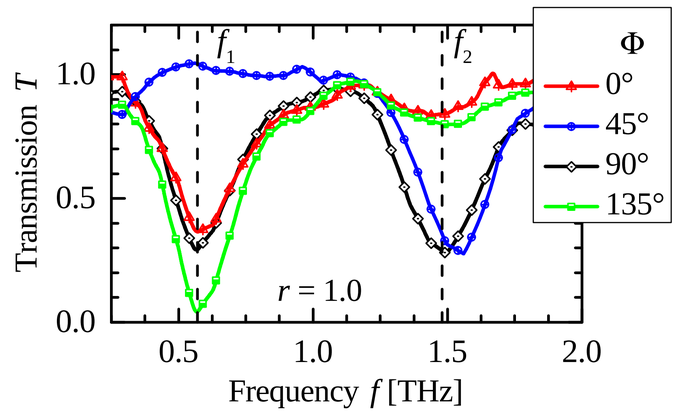

Figure 4: Change of polarization

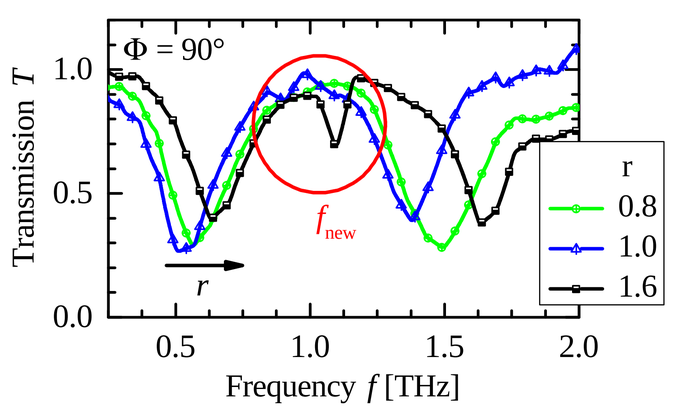

Figure 5: Change of arm ratio r

Comparison to analytical model

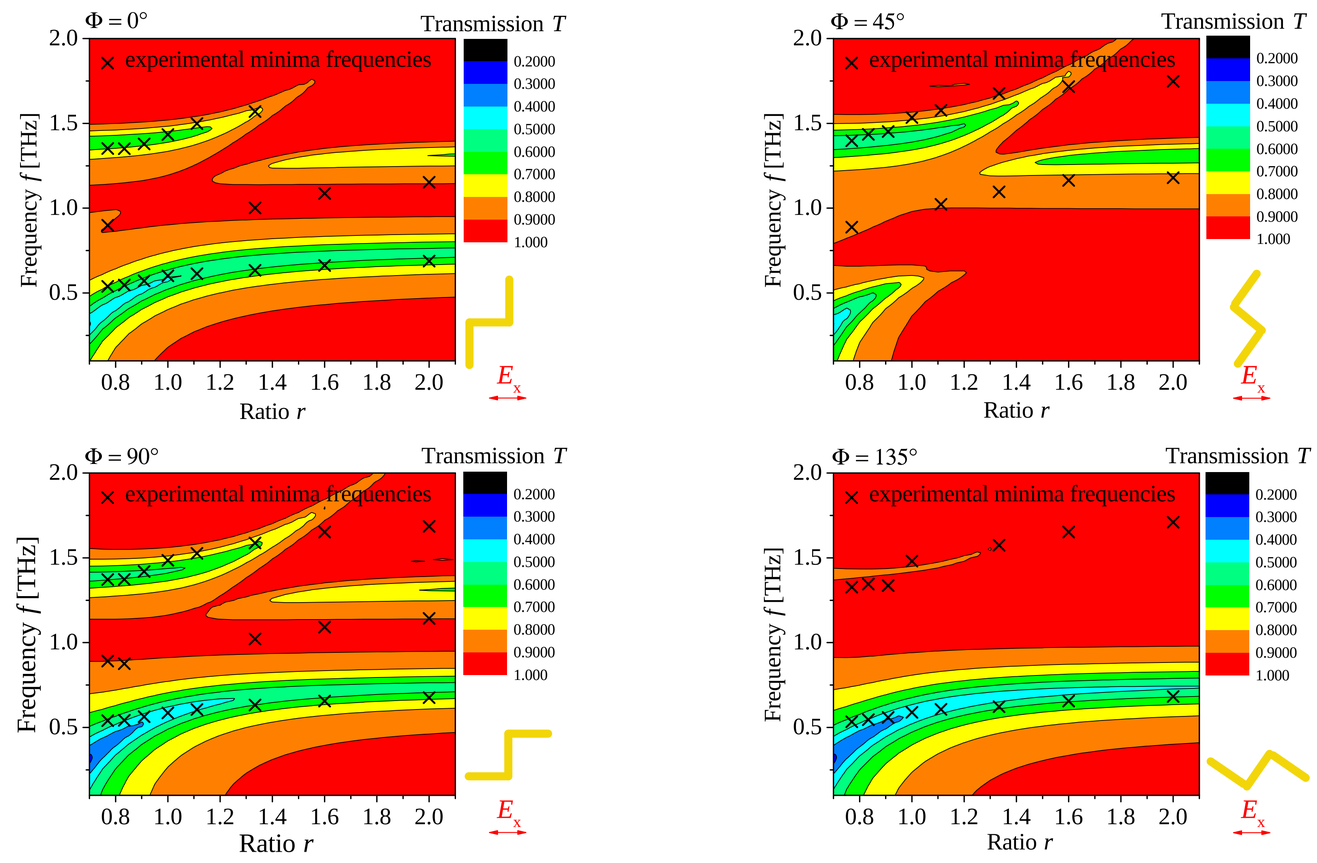

Figure 6: Experimental data compared to analytical calculations.

Acknowledgements

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