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Near-field spectroscopy and imaging of Mie resonances in single TiO_2 microspheres

Oleg Mitrofanov[1,2], Filip Dominec,[3] Petr Kužel,[3] John L. Reno,[2,4] Igal Brener,[2,4] U-Chan Chung,[5] Cathy Elissalde,[5] Mario Maglione,[5] and Patrick Mounaix[5]

[3]

[1] *University College London, London, UK*

[2] *Center for Integrated Nanotechnologies, Sandia National Laboratories, Albuquerque, NM, USA*

[3] *Academy of Sciences of the Czech Republic, Czech Republic*

[4] *Sandia National Laboratories, Albuquerque, NM, USA*

[5] *ICMCB, Univ. Bordeaux, CNRS, France*

[6] *LOMA, Univ. Bordeaux, CNRS, France*

Sub-wavelength size dielectric resonators have attracted much interest recently as elements with effective magnetic response that can be used in metamaterials. This magnetic response occurs in a high-permittivity, sub-wavelength size dielectric particle as a result of the lowest order resonance, known as the 1st Mie mode or the magnetic dipole (MD) mode. At THz frequencies, there is a range of high-permittivity materials (with ε >100), which can provide isotropic alternatives to split-ring resonators. Such resonators however present a difficult problem for experimental investigations due to their sub-wavelength size.

Here, we demonstrate a THz near-field method for spectroscopy and mapping of Mie resonances in single sub-wavelength size (~λ/10) resonators. We investigate the magnetic dipole and electric dipole modes in single TiO_2 micro-spheres using THz near-field microscopy and a sub-wavelength aperture probe [1]. We exploit the effect of the resonator on transmission of a plane wave through a sub-wavelength size aperture. The transmission spectrum exhibits clear signatures for the MD as well as electric dipole modes [2]. The experimental results agree with numerical simulations. In addition, the spectral signature of the MD mode in this measurement can be described analytically as a Fano resonance. The near-field mapping of the field near the resonator displays the spatial mode signatures and reveals the effect of mode degeneracy lifting in elliptical resonators.

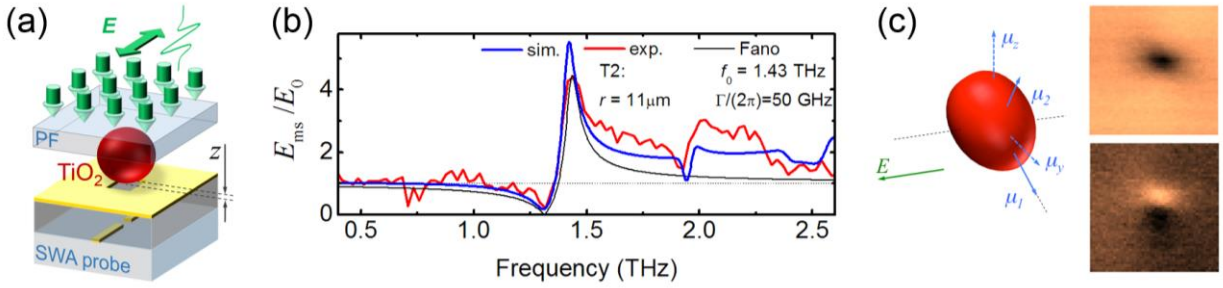

Fig. 1. (a) Schematic diagram of the experiment. (b) Amplitude spectra of a 11μm radius TiO_2 micro-sphere (experiment, numerical simulations and an analytical model). (c) Mode-splitting in an elliptical TiO_2 resonator: schematic diagram and 100x100μm THz near-field images (E_x).

References

[1] A. J. Macfaden *et al.*, Appl. Phys. Lett. **104,** 011110 (2014)

[2] O. Mitrofanov *et al.*, Opt. Express **22,** 23034 (2014)