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Subwavelength fiber: Enhanced THz Magnetic Source

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Abstract—We experimentally demonstrate that an enhanced THz magnetic source can be achieved by placing a sub-wavelength fiber in front of a sub-wavelength aperture. This hybrid system can be considered a unit cell of metasurfaces for THz wave manipulation and can also be scaled to optical frequencies opening up avenues for developing fiber based optical devices such as nanoantenna and laser.

I. INTRODUCTION

FROM antenna theory we know that for radio waves one can easily create an electric dipole antenna by using a couple of straight wires, or magnetic dipole antenna by making a subwavelength loop from a conducting material. At higher frequencies, including THz and optics, realization of magnetic dipole antennas becomes difficult, both because of the reduced sizes of the antennas as well as difficulty associated with feeding such antennas. In additions, metals are no longer good conductors at higher frequencies, therefore different approaches are needed in order to create antennas. This is why there is a significant interest for studying the possibilities for wave manipulation by subwavelength dielectric structures [1]. At optical frequencies, it has been shown that dielectric nanostructures lead to strong light localization when excited by a plane wave or a dipole emitter due to excitation of Mie resonances [1-3]. These resonances have strong electric and/or magnetic responses that can be harnessed in designing micro/nano-antennas and metadevices.

Here, we experimentally demonstrate an enhanced magnetic dipole source for THz radiation. We show that by placing a subwavelength fiber in front of an aperture, which acts as magnetic dipole (MD), can lead into more than an order of magnitude enhancement of radiated power [4].

II. RESULTS AND DISCUSSION

The schematic of our hybrid system (sub-wavelength aperture and fiber) is shown in Fig. 1(a). It is shown that a subwavelength aperture can be approximated with a MD source provided that the diameter is less than 0.3λ [4]. Using numerical modelling (CST microwave studio), we confirm that a $300\mu\text{m}$ aperture excited with a x -polarized plane wave acts as a y -oriented MD in THz [4]. Moreover, we have shown that maximum transmission of the hybrid system occurs when the fiber diameter is similar to that of the aperture [4]. For experiments, we have used a THz-TDS system with an H-shape antenna as emitter and a near-field microprobe tip as detector. Figure 1(b) shows the measured normalized integrated power (solid lines) over the green plane in Fig 1(a)

for aperture only, and two different orientation of coupled system. The transmitted power in the coupled systems is enhanced below 0.36 THz with peak positions at 0.15 and 0.23 THz. This enhancement is due excitation of Mie resonances in the fiber cross section, which leads into more than an order of magnitude enhancement in the forward emission. This hybrid system (Fig. 1(a)) is equivalent of a double fiber and MD source due to presence of metallic plate. The details of numerical calculations, experimental measurements, enhancements ratio and equivalent system will be presented.

Fig. 1. (a) Schematic of the hybrid system. (b) Normalized integrated power: experiment (solid lines) and numerical simulation (dashed lines). The insets show the normalized field intensity at 0.3 THz.

REFERENCES

- [1]. Kivshar *et al.* "Meta-optics with Mie resonances," *Opt. Photonics News* **28**, 24-31, 2017.
- [2]. Mitrofanov *et al.* "Near-field probing of Mie resonances in single TiO_2 microspheres at terahertz frequencies," *Opt. Express* **22**, 23034, 2014.
- [3]. Atakaramians *et al.* "Strong magnetic response of optical nanofibers," *ACS Photonics* **3** (6), 972-978, 2016.
- [4]. Atakaramians *et al.* "Enhanced terahertz magnetic dipole response by subwavelength fiber," *APL-Photonics* **3**, 051701, 2018.