Subwavelength wire array metamaterial THz cavities

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Abstract—**We demonstrate THz radiation field concentration in subwavelength cavities in wire-array metamaterials. The resonant cavity modes are observed in the far-field and near-field.**

I. INTRODUCTION

DEMONSTRATIONS of waveguiding and confinment on the subwavelength scale using metamaterials have resulted in flexible functionalities such as sub-diffraction imaging[1] and subwavelength waveguides[2] among others. In this paper, we present THz confinement in subwavelength cavities using wire array metamaterials.

The wire array metamaterial consists of ~450 indium wires embedded in Zeonex polymer (n = 1.52), and was fabricated using fibre drawing methods[1]. The samples used in this work were discs of such metamaterial 250-400 µm thick and 1 mm in diameter. The wires were oriented along the thickness of the disc (250-400 µm long), with a diameter of 20 µm, spaced 50 µm apart. The wires support resonances at frequencies for which an integer number of half-wavelengths correspond to the wires' length – the Fabry-Perot resonances of the disc. High transmission is observed for these frequencies, whilst low transmission is observed for frequencies above them.

A defect is introduced in the sample to obtain the subwavelength cavity, by etching selected wires with hydrochloric acid to shorten them by 10%. These wires support resonances at 10% higher frequencies than the remainder of the array, and thus transmit frequencies that the remainder of the array does not, confining the radiation at those frequencies to those wires alone. The samples were characterized using both far-field and near-field THz-TDS measurements.

II. RESULTS

Figure 1 shows the transmission curves of a sample with and without the defect, obtained from the far-field measurements. The sample thickness is close to 375 µm, hence the second resonance is seen near 0.5 THz. The resonance of the subwavelength cavity appears at 0.56 THz. Fig. 2 shows a microscope image and a near field image of a second, 275 µm thick sample with three wire defects. At the second resonance of the shorter defect wires, 0.76 THz, the modes are seen localized on these wires. The FWHM of the field confined to an individual wire is 13 times smaller than the wavelength in the polymer host, giving a cavity volume of $\lambda^3/400$ relative to the free space wavelength. Further details, and results on sub-wavelength waveguides will be presented at the conference.

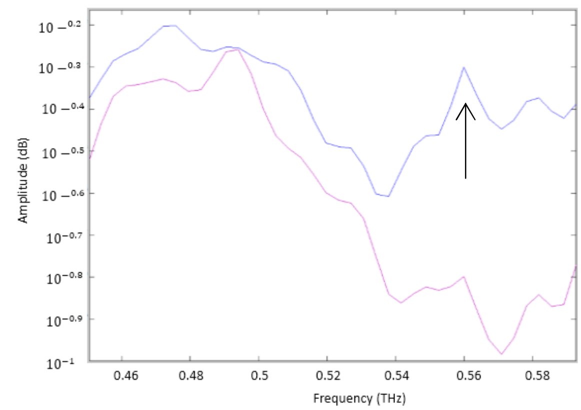

Fig. 1. Transmission of sample without defect (magenta) and with a defect (blue). The resonance frequency of the defect mode is around 0.56 THz indicated by the arrow.

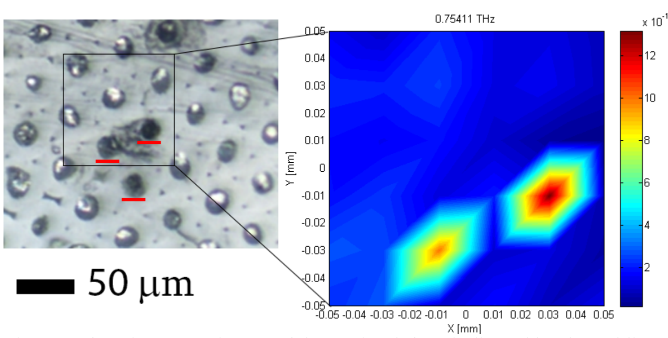

Fig. 2. Left: Microscope image of the 3 wire defect, indicated by the red lines. Right: Near field THz image of 2 wire defects at the resonant frequency of the defects 0.76 THz.

III. SUMMARY

We experimentally observed the resonances of sub-wavelength cavities in wire-array metamaterials. Using near-field imaging, we observed the cavity mode fields and estimate a cavity volume of $\lambda^3/400$.

REFERENCES

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