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Fabrication and characterization of transparent metallic electrodes in the terahertz domain

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The demand for transparent electrodes keeps increasing as new generations of electronic devices appear, including solar cells and touch screens. Indium tin oxide (ITO) is the most promising transparent electrode material to date [1] although there are several limitations when using ITO. Firstly, it is a brittle material and therefore flexible devices such as electronic paper would be hard to achieve. Secondly, the continuous increase in the price of indium due to limited availability worldwide makes its use unsustainable in the future.

Our work is motivated by early work [2] showing that an optically opaque layer with a negative permittivity can be perfectly transparent when sandwiched between two carefully designed metamaterial layers. Here we present a method to achieve a transparent metallic electrode deposited on a substrate. By placing a composite layer consisting of dielectric and metallic stripes (AB layer) on top of the metallic electrode (C layer) (see Fig. 1(a)) we found that the backscattering from the metallic film (C layer) can be almost perfectly canceled, leading to transparency of the whole structure. We fabricated the transparent metallic electrodes and characterized them by the use of the T-Ray 4000 terahertz time-domain spectroscopy system. The physics behind the cancellation of the scattering from the target opaque layer requires carefully chosen geometrical parameters of the metamaterial layers, AB and C, (see Fig. 1(b)). Figure 1(c) displays the transmittance through the whole sample normalized to that through the silicon substrate. The transmittance through the C layer mesh is quite low for the frequency range 0.2 - 0.8 THz, reaching its maximum of approximately 0.45 at 0.8 THz. By placing the AB mesh on top of the C layer separated by 12.5 μm silica, the ABC device achieves almost a perfect transmittance at 0.57 THz. Moreover, in the frequency range 0.3 - 0.6 THz the ABC device has still higher transmittance than the C layer alone. Our experimental results match nicely with the full-wave simulations (solid lines, Fig. 1(c)) [3].

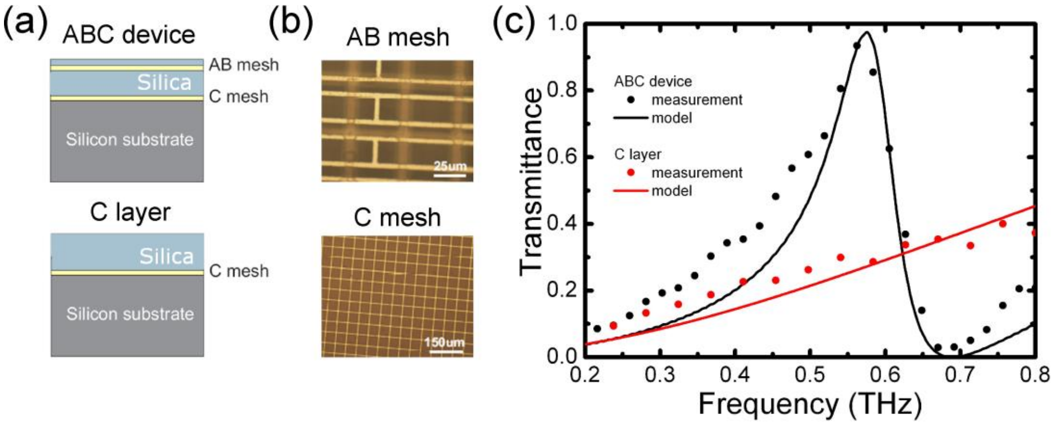

Fig. 1 (a) Illustration of cross-sections of ABC device and C layer samples. (b) Optical images of AB and C meshes. (c) Measured transmittance (dots) through the ABC device (black) and C mesh (red) and numerical results (solid lines).

References

[1] R. B. H. Tahar, T. Ban, Y. Ohva and Y. Takahashi, App. Phys., **83**, 2631-2645(1998).

[2] L. Zhou, W. Wen, C. T. Chan, and P. Sheng, Phys. Rev. Lett., **94**, 243905(2005).

[3] R. Malureanu, M. Zalkovskij, Z. Song, C. Gritti, A. Andryieuski *et al.*, Opt. Express, **20**, 22770 (2012).