SAND2014-20326C

THz surface waves on graphene bow-tie antennas

**Oleg Mitrofanov[1,2], Wenlong Yu,[3] Yuxuan Jiang,[3] Igal Brener,[2,4]
Wei Pan,[4] Claire Berger,[3,5] Walter A. de Heer,[3] and Zhigang Jiang[3]**

[1] *University College London, London, UK*
[2] *Center for Integrated Nanotechnologies, Sandia National Laboratories, Albuquerque, NM, USA*
[3] *School of Physics, Georgia Institute of Technology, Atlanta, GA, USA*
[4] *Sandia National Laboratories, Albuquerque, NM, USA*
[5] *CNRS/Institut Néel, Grenoble, France*

Graphene holds potential for THz applications as a material, properties of which can be modified through the position of the Fermi level. For example, transparency of its atomically thin layer can be reduced from ~100% down to ~70% at THz frequencies, making graphene attractive for active and passive THz devices. The Fermi level also affects properties of surface plasmons in graphene, enabling tuneable sub-wavelength scale THz devices, such as graphene ribbon arrays. To this day, however, surface plasmons in graphene remain poorly investigated at THz frequencies.

We developed a near-field scanning probe method, in which surface waves are detected using an integrated sub-wavelength aperture THz near-field probe [1]. This method shows that multilayer graphene patterns support excitation and propagation of surface waves, similar to metallic layers [2]. Propagation of surface waves can be observed in time using the THz time-domain spectroscopy technique.

While the multilayer graphene exhibits a stronger effect on THz waves, a monolayer graphene, is expected to provide a higher quality material with a more uniform response over large areas, required for THz devices. We demonstrate here that despite a relatively high transparency of the monolayer epitaxial graphene, THz surface waves are excited on its surface. We investigate lithographically-defined graphene bow-tie antenna on SiC. Figure 1 shows that upon the excitation of a graphene bow-tie antenna by a THz pulse, surface waves are detected within the bow-tie area. Excited at the bow-tie edges, the surface waves form an interference pattern [Fig. 1(c)].

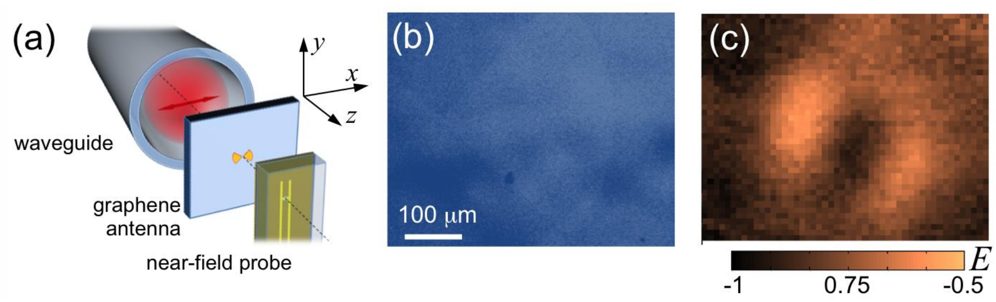

Fig. 1. (a) Schematic diagram of near-field imaging system for probing THz waves on a graphene antenna. Optical (b) and THz (c) images of the same region of the bow-tie.

References

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

[2] O. Mitrofanov *et al.*, Appl. Phys. Lett. **103,** 111105 (2013)