THz nano-imaging of conductivity inhomogeneity in CVD-grown graphene

Henrik Bødker Lassen[1], Mohsen Ahmadi[2], Zhipei Sun[2,5], Peter Bøggild[3,4], Edmund Kelleher[1] and Peter Uhd Jepsen[1,4]
[1]*DTU Fotonik, Technical University of Denmark, Ørsteds Plads 343, DK-2800 Kgs. Lyngby, Denmark*
[2]*Department of Electronics and Nanoengineering, Aalto University, Tietotie 3, FI-02150, Finland*
[3]*DTU Physics, Technical University of Denmark, Fysikvej 309, DK-2800 Kgs. Lyngby, Denmark*
[4]*Centre for Nanostructured Graphene (CNG), Technical University of Denmark, Ørsteds Plads 345C, DK-2800 Kgs. Lyngby, Denmark*
[5]*QTF Centre of Excellence, Department of Applied Physics, Aalto University, FI-00076, Finland*
edkel@fotonik.dtu.dk, puje@fotonik.dtu.dk

It is well established that the nanoscale structure, including crystalline domain size distribution and impurities, of graphene is a deciding factor for its electronic properties. Conventional THz spectroscopy is a standard metrology for characterization of sheet conductivity and its underlying parameters [1]. Until now, only indirect information about the nanoscale conductivity of graphene has been available due to the large mismatch between length scales of domain sizes and probe dimensions.

Earlier reports on nanoscale conductivity of graphene indicate very little sensitivity to local conductivity in THz s-SNOM measurements due to its near-unity near-field reflectivity [2]. Here, we demonstrate THz time-domain spectroscopy with a commercial s-SNOM system (Neaspec) for nanoscale mapping of CVD-grown monolayer graphene (Fig. 1(a) shows the topology measured by AFM). We directly observe deeply sub-wavelength features, including edges and inclusions, in the spatially resolved THz scattering signal with 30 nm resolution (Fig. 1(b), inset shows the approach curve). We suggest these characteristics of the graphene layer are correlated with a non-uniform surface conductivity on the length scale of tens to hundreds of nanometres. Figure 1(c) shows the spectrally resolved scattering signal along the line indicated in Fig. 1(a). We will discuss the conversion of this signal into a spatially resolved sheet conductivity map and the relation between local and macroscopic conductivity in CVD-grown graphene, as well as models used to describe conductivity in materials with domain sizes approaching the mean free path of the conductive electrons.

References

[1] P. R. Whelan *et al.* 2D Materials **8** (2021) 022003.
[2] J. Zhang *et al.* ACS Photonics **5** (2018), 2645.

Figures

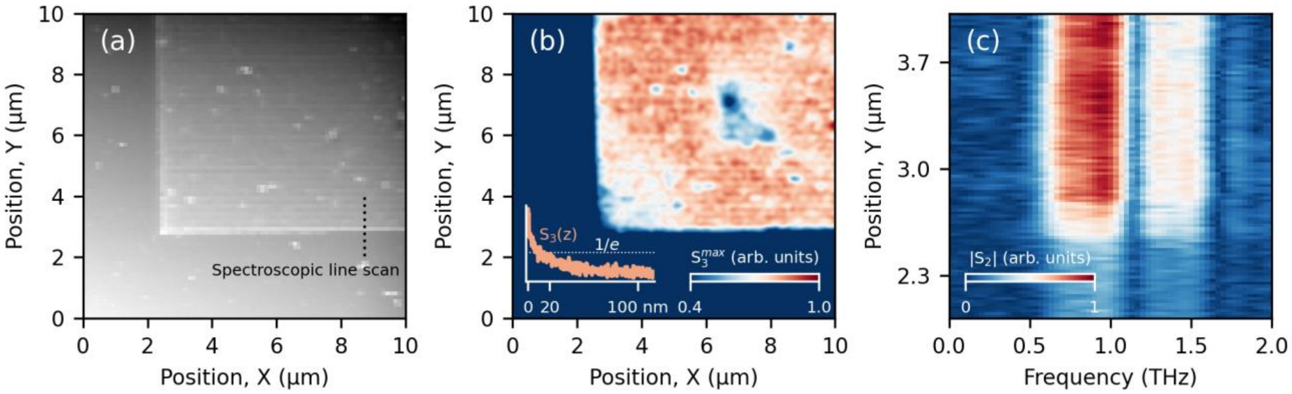

Figure 1: (a) Topology (AFM) of the single-layer graphene. (b) Amplitude of scattered THz signal (3rd harmonic of AFM tapping frequency) with approach curve in the inset. (c) Spectrally resolved scattering signal (2nd harmonic of AFM tapping frequency) along the line indicated in (a).