Non-destructive, large-area electrical characterization of graphene: a new light on defects

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We overview recent progress in fast, non-destructive large-area mapping techniques based on terahertz time domain spectroscopy (THz-TDS) and micro-four point probes [1] allowing spatial analysis of electrical continuity, carrier mobility and carrier density across up to 4'' graphene films (see Fig. 1), as well as insights into the scattering dynamics. At low frequencies (0.1-1.5 THz) the real part of the complex conductivity derived from the THz transmittance can be approximated to the DC conductivity, with the spatial resolution limited by the THz wavelength of 0.2-3.0 mm [1]. The conductivity maps obtained with THz-TDS are in close agreement with scanning micro four point probe measurements. Transferring graphene to substrates with a THz-transparent) backgate, allows the field effect conductance and thus carrier mobility and density to be mapped as well. A deeper insight into the scattering dynamics is achieved by ultra-broadband THz-TDS up to 15 THz. While the complex conductivity of graphene grown on single crystal Cu(111) and transferred with a reusable-catalyst transfer process [2] is perfectly fitted by Drude model (isotropic scattering), graphene grown on commercial Cu foil and transferred by sacrificial Cu etching could only be described by assuming some degree of backscattering from line-defects such as grain boundaries or cracks [1,3]. The same trend was observed on the microscale using micro four point probes, using the novel dual configuration approach to analyse the defect landscape [3]. Finally we discuss recent indications that carrier density and mobility can be mapped across large areas (4" films) with THz-TDS, even without a backgate.

References

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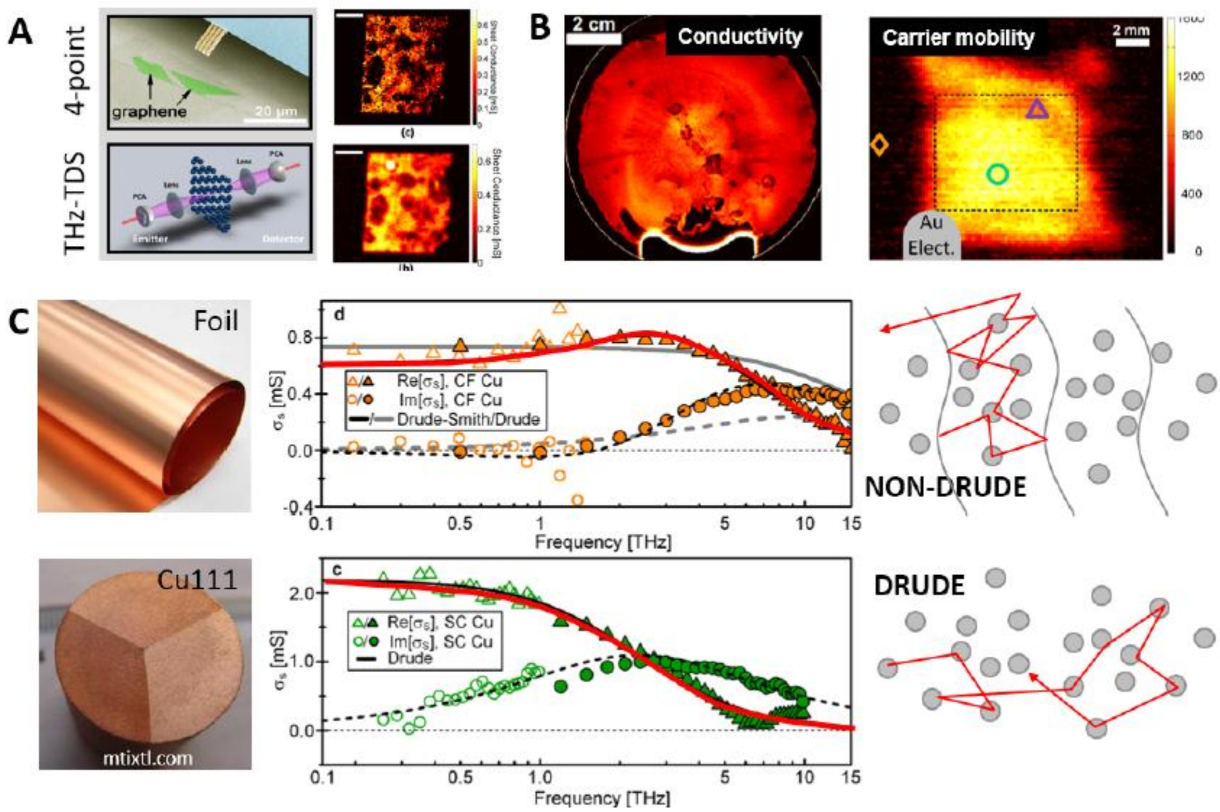

Figure 1. A. Direct comparison between THz-TDS and scanning 4-point conductivity maps. B. Large area conductivity and carre mobility maps. C. Analysis of frequency dependent conductivity to reveal Drude or non-Drude scattering in grapheme grown on different substrate types.