# Non-contact conductivity mapping of graphene: setting new standards

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The significant progress in fabricating large-area graphene films for transparent electrodes, barriers, electronics, telecommunication and other applications dictates the development of large-area characterisation and quality control. Conventional methods for electrical mapping are often slow, destructive, unreliable or combinations of these.

I will briefly review and compare three different, but complementary approaches that all have been optimized for throughput, accuracy and minimal damage to the graphene. These include (1) fixed contacts using dry laser lithography, (2) movable contacts using micro four point probe, and (3) THz time domain spectroscopy (THz-TDS), which analyses the electrical properties from the absorption of terahertz pulses.

The main emphasis will be on THz-TDS, which is non-destructive, highly accurate and allows both conductivity, carrier density and carrier mobility to be mapped across arbitrarily large areas at rates that by far exceed any other known method. Moreover, I will show how the THz conductivity spectra reveals hidden information on the carrier scattering dynamics which are subject to growth, transfer and processing conditions. This is highlighted through insights from recent collaborative projects. The ongoing efforts to turn THz-TDS into a metrology standard, and to upscale the method will be discussed.

## References

[1] P. Boggild, D. M. A. Mackenzie, P. R. Whelan, D. H. Petersen, J. D. Buron, A. Zurutuza, J. Gallop, L. Hao, P. U. Jepsen, 2D Materials, 4, 042003 (2017)

## Figures

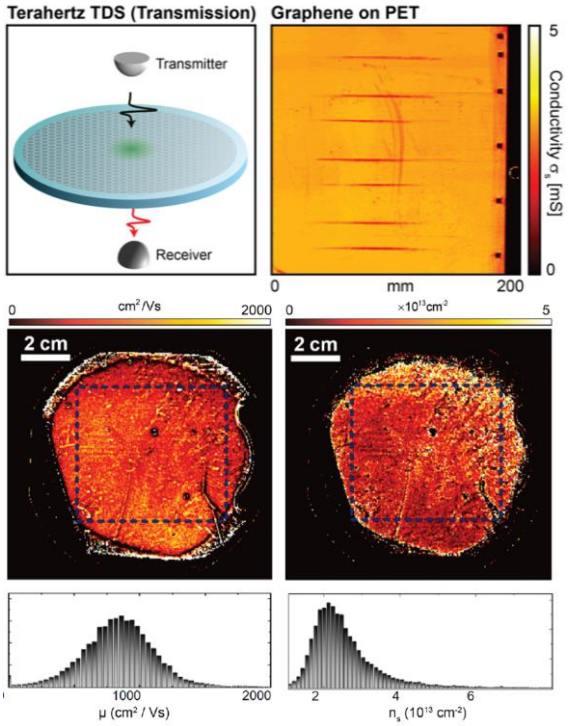


**Figure 1:** Top: illustration of THz-TDS setup, with a conductivity map of a 200x200 mm graphene sheet on PET polymer. Bottom: carrier mobility (left) and density (right) of 4'' graphene sheet.

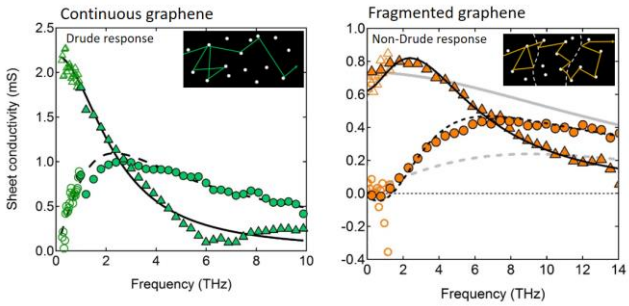


**Figure 2:** Comparison of THz-TDS conductivity spectra from continuous high quality graphene (left) and discontinuous graphene with line-defects.