Terahertz Spectroscopy for Electrical Characterization of 2D Materials

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Over the past decade, we demonstrated terahertz spectroscopy to be an efficient tool for fast, nondestructive electrical characterization of graphene on various substrates [1-2], including silicon, sapphire, and polymers. Key parameters such as conductivity, carrier density, carrier mobility, and uniformity can be extracted across wafer-scale graphene, and a metrology standard for THz-TDS graphene was recently published through the International Electrotechnical Commission [3]. Several important questions arise: can THz quality control (QC) be applied to roll-2-roll production systems? How reliable and robust is THz-QC and does it work equally well on all substrates? Will THz-QC be useful for process development? What can we learn about the uniformity and grain structure of 2D films [4]? With the increasing interest and progress in large-scale manufacturing of other 2D materials, such as transition metal dichalcogenides, how will THz-TDS contribute to scientific research and quality control of these materials? In this talk I will discuss the state-of-the-art and recent progress in THz-based quality control (THz-QC) and address possibilities, problems, and open questions related to this emerging technology, and show results on R2R inline THz-QC, large-scale mapping of TMD films [5], graphene micro and nanoribbon gratings, and nanoscale conductivity measurements on graphene with THz scattering SNOM [6].

References

[1] P. Bøggild et al, 2D Materials 4 (2017) 042003
[2] P. W. Whelan et al., 2D Materials 8 (2021) 022003
[3] P. U. Jepsen et al., Graphene-based material – sheet resistance : terahertz time domain spectroscopy, IEC TS 62607-6-10:2021 (2021)
[4] W. W. Whelan et al., Scientific Reports 14 (1) 3163 (2024)
[5] Jie Ji et al, ACS Appl. Mat Int, 15 44 51319 (2023)
[6] H. B. Lassen et al., https://arxiv.org/abs/2310.07479

Figures

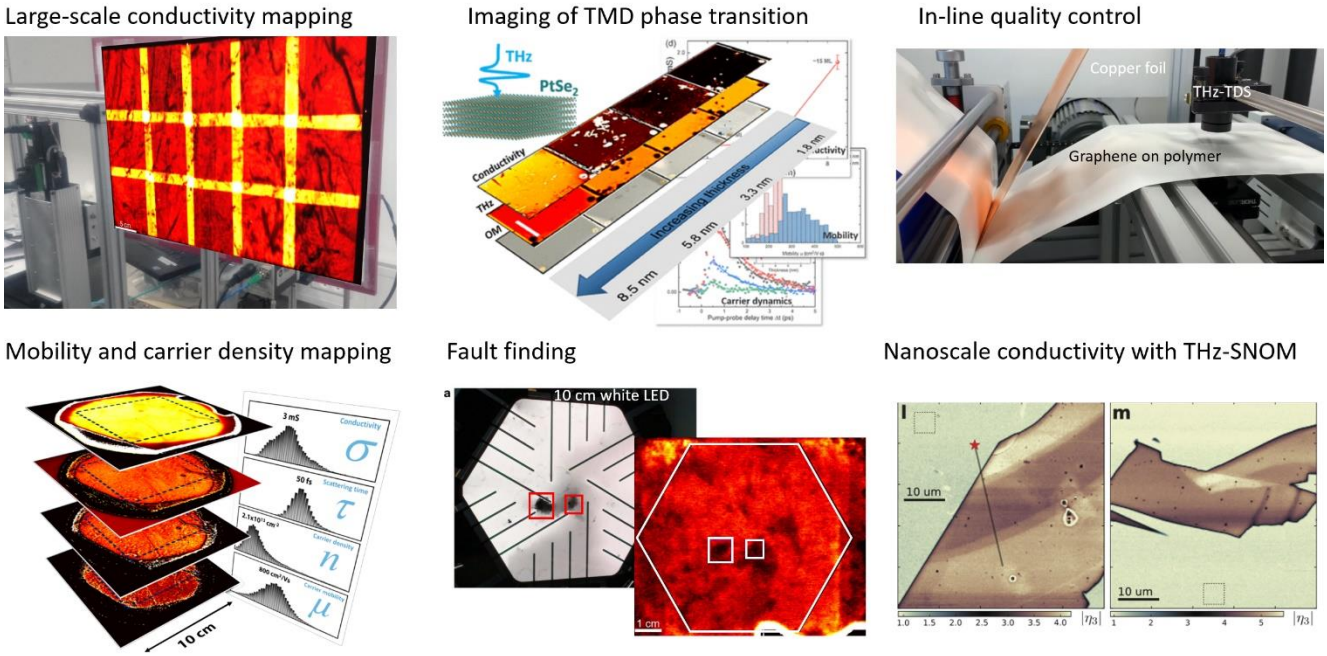

Figure 1: The talk will cover different examples of THz-TDS used for quality control, R&D and research.