Growth, transfer and quality control of 2D materials

Peter Bøggild, Abhay Shivayogimath, Jose Caridad, Lene Gammelgaard, Tim Booth, Peter Uhd-Jepsen, Patrick Whelan
Center for Nanostructured Graphene, DTU Physics & DTU Photonics, Technical University of Denmark, Kgs. Lyngby

pbog@dtu.dk

While graphene's intrinsic qualities and potential for e.g. electronics, optoelectronics, barriers and thermal management are undisputed, the practical realisation of applications where those intrinsic properties are truly expressed, has turned out to be highly challenging. Significant progress of the CVD method of synthesis of graphene on a copper catalyst has made it an industry standard, and I will like to discuss how this highly succesful self-limiting growth scheme of Graphene/Cu may be generalised to grow other 2D materials, such as TMDs[1] and hBN. Another issue is *transfer*, where the wide-spread Cu etching transfer process is now being surpassed by greener, faster and higher-quality "peeling" techniques that have the potential to be applied to roll-2-roll systems. The PVA-based peeling transfer method with excellent speed and quality, involving no other chemicals than water [2], is such an example. As these difficulties are tackled, the next serious bottleneck becomes *quality control*. Conventional field effect or Hall measurements are becoming increasingly irrelevant as graphene production throughput is ramped up. We have developed Terahertz time-domain spectroscopy (THz-TDS) into a powerful, non-destructive high-throughput alternative for characterisation of the electronic properties of large-scale graphene, including key performance characteristics such as sheet resistance, carrier density, mobility and grain structure[3]. For roll-2-roll production and many applications including flexible electronics, it is essential to be able to characterise graphene on polymer substrates – maybe even in-line - and this turns out to be difficult due to relatively thin substrates with low refractive indices compared to silicon, silicon carbide and sapphire wafers [4,5]. Based on our learnings and progress achieved through numerous scientific collaborations[6], we now propose THz-TDS gold standard of graphene electrical characterisation for wafer- and roll-to-roll production, with the first THz-TDS metrology standard for graphene being published ultimo 2020.

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