Development of in-situ tools for characterization and manipulation of 2D materials during and after growth on liquid metal catalysts by CVD

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2D materials have emerged as a distinctive and promising alternative to conventional materials across various technological applications. Despite their potential, synthesizing large-scale, high-quality 2DMs remains a major hurdle for industrial use. Among the available methods, Chemical Vapor Deposition (CVD) is the most widely adopted technique for thin-film synthesis, offering scalability and compatibility with automation. Presently, most of the CVD processes rely on solid metal catalysts (SMCat) to grow graphene. However, this approach frequently leads to structural flaws such as wrinkles, cracks, and grain boundaries. In comparison, using Liquid Metal Catalysts (LMCat) for 2DM synthesis offers the potential to produce defect-free, single-domain graphene at faster growth rates, thanks to the superior atomic mobility, uniformity, and fluidity of LMCats. Real-time monitoring of this complex process is essential for precise control over graphene growth and a deeper understanding of its kinetics. However, the lack of in-situ observation techniques has limited our insight into the underlying growth mechanisms, resulting in largely trial-and-error-based approaches. In this talk we discuss the development of CVD reactors for 2D material growth on liquid metal catalysts compatible with in-situ characterization of the growth. The in-situ characterization includes X-ray and optical techniques. We will show examples of how such tools can greatly enhance understanding of the nucleation and growth modes and is a great tool for the optimization of the growth recipe, yielding fully covered samples with low-defect density graphene. We will also present the in-situ tools we developed allowing mechanical interaction with the as grown graphene on liquid Cu. Finally, we will discuss the ongoing developments on extending the work on other 2D materials.

References

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