Growing perfect graphene on a liquid metal: from self-organized flakes to the single layer

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Abstract

Two-dimensional materials (2DMs) are at the centre of attention due to their unique electronic, mechanical, thermal, and optical properties [1]. The CVD growth of 2DMs on liquid metals is an emerging and promising route towards the controlled fabrication of 2DMs of high quality, faster and more environmentally friendly than for the growth on solid substrates [2]. However, getting insight into fundamental processes occurring on liquid metals during growth was up to now challenging, even impossible, due to harsh prevailing conditions inside CVD reactors excluding most experimental methods. The aim of the LMCat (Liquid Metal Catalysis) EU Horizon 2020 FET-OPEN project is to overcome these limitations by delivering instrumentation and methodology, allowing to study *in situ* and *operando* the growth of 2DMs on liquid metal surfaces.

In this contribution, we will present the first experimental results of graphene growth on liquid copper in a newly developed CVD reactor [3], dedicated to the study of chemical reactions [4] on LMCats. By combining in situ synchrotron X-ray diffraction and optical microscopy, supported by ex situ Raman spectroscopy, we can resolve in real-time the growth dynamics and atomic structure of graphene during its growth on liquid copper. Contrary to solid surfaces, this later is an atomically smooth, isotropic and mobile medium, which allows to produce graphene crystals of high-quality and large sizes limited only by the size of the liquid bath surface. A multitude of growth scenarios was observed which allowed to fine-tune the fabrication procedures and to identify critical factors affecting the growth of individual flakes, their self-assembly and further association into a single layer with a coherent atomic structure. In-plane and out-of-plane atomic structure of graphene flakes on liquid copper is characterised by *in situ* synchrotron X-ray surface scattering techniques. These findings open new possibilities for the growth of 2D materials with unprecedented control over growth kinetics, hardly achievable by any method up to now.

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References

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