Copper growth on graphene - in situ X-ray scattering study

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Abstract

We present an in situ study of Cu growth on graphene by means of the grazing-incidence small-angle X-ray scattering (GISAXS) technique[1]. We adapted this conventionally synchrotron-based scattering X-ray technique to laboratory conditions. The large surface energy mismatch between Cu and graphene indicates the Volmer-Weber (island-like) growth of Cu film. Using GISAXS we can elucidate all the initial stages of the thin film growth including nucleation of the Cu clusters, their growth and coalescence. Among the other in situ scanning probe and/or scattering techniques the GISAXS offers the real-time tracking of thin film morphology evolution irrespective of the film crystallinity and ambient deposition conditions.

Experimentally, the CVD grown graphene transferred onto silicon substrate was used as template for growth of Cu film. The Cu was thermally evaporated onto annealed graphene in a dedicated vacuum chamber equipped with collimated microfocus X-ray source and two-dimensional X-ray detector assembled in GISAXS configuration[2]. The temporal evolution of Kratky plot based on the X-ray scattering profiles extracted at the critical exit angle is shown in Fig. 1. Here the time axis is interpreted as the effective Cu layer thickness. The thin film nucleation phase is observed as increased scattering in the region corresponding to Cu thicknesses below 2 nm. Here we provide the Guinier analysis of the mean Cu cluster size. At approximately 2 nm of the effective Cu thickness, a noticeable interference function appears. The interference function stems from the pronounced position correlations of the growing Cu clusters on graphene surface. We track the maximum position of the interference function and interpret the results with the 2D paracrystal growth model. To support the experimental findings, we performed an ex situ AFM measurements of Cu cluster morphology at different growth stages. We complement the study with stress measurements of the underlying graphene film by Raman spectroscopy.

References

[1] G. Renaud, R. Lazzari, F. Leroy, Surface Science Reports **64**, (2009) 255.
[2] M. Hodas *et al.*, Proc. SPIE - Advances in X-Ray/EUV Optics and Components X **9588**, (2015) 958804.

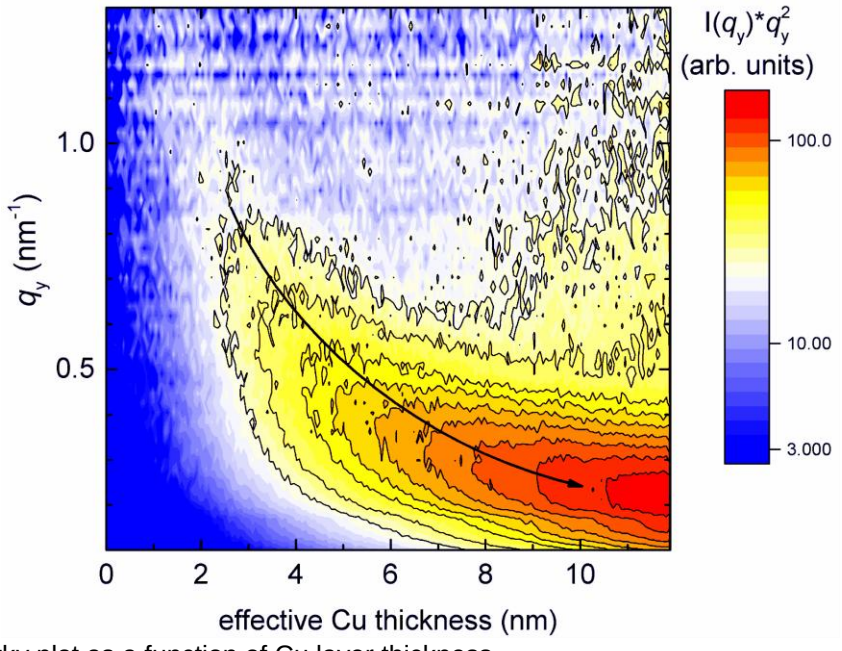

Fig. 1 - The Kratky plot as a function of Cu layer thickness.