Ion Impacts on Graphene/Ir(111): From Vacancy Funnels to a Nanomesh

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Ion bombardment is a powerful tool to create nanostructured surfaces [1]. Often even regular patterns appear spontaneously due to a complex interplay of creation and thermally activated diffusion or annihilation of defects, thereby constituting an example of self-organization [2]. In case of graphene a periodic arrangement of vacancies, i.e. a nanomesh [3], may cause a bandgap opening making it suitable for a wide range of applications.

By combining ion beam experiments and atomistic simulations we study the production of a nanomesh in graphene on Ir(111) by low energy Xe ion bombardment. Based on our findings on single ion impacts causing arrays of defects under grazing incidence we explore the possibilities of tuning the defect pattern via thermal treatment.

While the graphene vacancies obtained by interface channeling persist up to 900K we find their edges bent down to the substrate, giving rise to a funnel-like shape. This shape is due to the formation of C-Ir-bonds saturating the dangling bonds of the vacancies. We further demonstrate that with the onset of vacancy cluster mobility around 800K, vacancies tend to move in certain areas within the moiré supercell formed by the graphene layer with the incommensurate Ir metal substrate. This observation corroborates our simulation findings of a strongly varying vacancy formation energy landscape, depending on the exact position of the defect with regard to underlying metal atoms. These tools at hand we are able to create a graphene nanomesh adopting the periodicity of the moiré pattern.

[1] W. L. Chan, E. J. Chason, *J. Appl. Phys.* **101**, 121301 (2007).
[2] S. Facsko, T. Dekorsy, C. Koerdt, C. Trappe, H. Kurz, A. Vogt, H. Hartnagel, *Science* **285**, 1551 (1999).
[3] J. Bai, X. Zhong, S. Jiang, Y. Huang, X. Duan, *Nat. Nanotechnology* **5**, 190 (2010).