Channeling of graphene in environmental TEM: towards zero-disorder nanolithography

Tim J. Booth, Filippo Pizzocchero, Marco Vanin, Henrik Andersen, Thomas W. Hansen, Jakob B. Wagner, Joerg R. Jinschek, Rafal E. Dunin-Borkowski, Ole Hansen and Peter Bøggild

DTU Nanotech, Technical University of Denmark, Kgs. Lyngby, Denmark

tim.booth@nanotech.dtu.dk

Catalytic channeling of graphene by metallic nanoparticles is unique due to the tendency of the trenches to follow the graphene lattice orientations, and the possibility of forming long trenches in graphene with a width of a few nanometers, sub-nanometer edge roughness and consistent lattice orientation. We have studied the rich and complex microscopic behaviour of silver nanoparticle gasification in in-situ environmental transmission electron microscopy and account for some of the observed trends and phenomena, including the "shot-noise"-like discrete removal of carbon atoms from the graphene lattice resulting in Poisson distributed temperature dependent instantaneous measured particle velocities [1], and the fact that nearly all edges have zig-zag orientation.

With the support of DFT calculations, we identify the rate limiting step to be the removal of carbon atoms from zig-zag edges. Other phenomena remain to be explained, such as the curious fact that the characteristic shape of even large silver particles appear to be determined by the 1D graphene-silver interface involving just a few hundred atoms. In the light of these findings, the scientific challenges and technological opportunities involved in turning this process into a zero-disorder nanolithographic technique are discussed.

References

[1] Tim J. Booth, Filippo Pizzocchero, Henrik Andersen, Thomas W. Hansen, Jakob B. Wagner, Joerg R. Jinschek, Rafal E. Dunin-Borkowski, Ole Hansen and Peter Bøggild, Nano Letters 11 (2011) 2689

[2] Filippo Pizzocchero, manuscript in preparation.