Real-time Sub-Micrometer Resolution: Tracking Silver Intercalation with Photoemission Electron Microscopy

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Nanostructured materials can provide access to interesting phenomena such as catalysis and superconductivity. In particular, 2D materials such as bilayer graphene or atomically thin metal films have shown superconductivity under certain conditions.[1,2] The 2D metal films need to be protected from unwanted perturbations to ensure their performance in the real world. One way is to intercalate these metals between silicon carbide (SiC) and protective epitaxial graphene (EG) layer grown on top of it, through a process called confinement heteroepitaxy (CHet). While it has been demonstrated that many metals and metallic compounds can be intercalated with CHet, the exact mechanism is not known.[3]

Here, we use a full field, surface sensitive imaging technique called photoemission electron microscopy (PEEM) to track the intercalation process in real time with nanometer scale resolution. As a model system we first investigate an EG-silver (Ag)-SiC sample. The sample was prepared using the CHet procedure to intercalate Ag *ex-situ* at approximately 900°C. Still, to our surprise, we can still observe de- and re-intercalation of a small number of Ag atoms above and below the graphene surface even at moderate temperatures around 300°C, until the process eventually ceases. In addition, we performed atomic force and scanning electronic microscopy, as well as x-ray photoelectron spectroscopy to cross validate the PEEM results.

1. Y. Cao et al., Nature 556 (7699), 43-50 (2018).
2. N. Briggs et al., Nature Materials 19, 637-643 (2020).
3. N. Briggs et al., Nanoscale 11, 15440–15447 (2019).

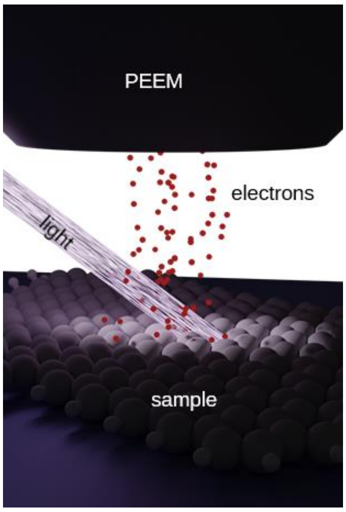

Fig. 1. Schematic of the full-field PEEM imaging which uses photons to eject photoelectrons (not to scale).

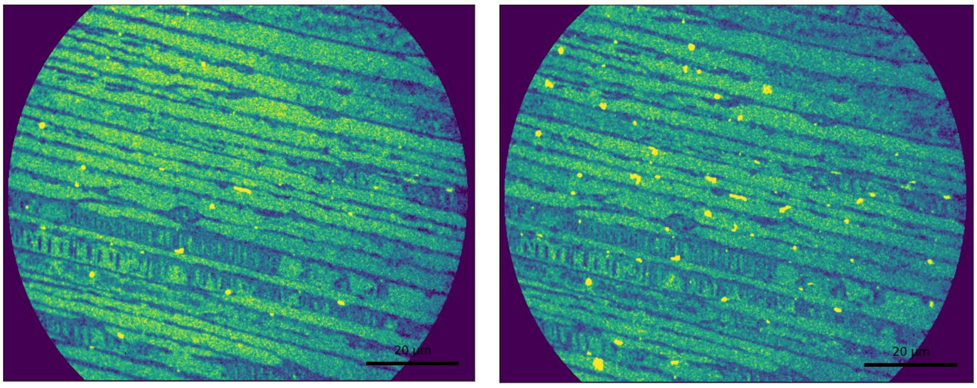

Fig. 2. Images of the intercalated 2D Ag epitaxial graphene surface where Ag (in yellow) before (left) and after (right) heating at 300°C for ~30 minutes. Scale bar in both images is 20 µm.