TF-01-4-I-M

# Metal growth on graphene: morphology, intercalation and magnetization

Michael TRINGIDES[1], Patricia THIEL[2], Myon HUPALO[1], Matt HERSHBERGER[1] and Dan MCDOUGAL[1]

[1] *Department of Physics, Iowa State University and Ames Laboratory, USA*
[2] *Department of Chemistry, Iowa State University and Ames Laboratory, USA*

---

Graphene based electronic and spintronic devices require understanding the growth of metals on graphene. Several metals (Gd, Dy, Eu, Fe,Pb ) deposited on epitaxial graphene were studied with STM, SPA-LEED and DFT. The grown morphology (island density and domain size distributions) was used to extract the metal diffusion and adsorption barriers. For practically all metals the grown mode is 3-d as a result of (i) the low ratio of the metal adsorption to metal cohesive energy and (ii) the repulsive energy due to charge transfer at the metal-graphene interface that favors islands of reduced island "footprint". These experimental results are fully supported with DFT calculations [1]. It is essential to find ways to modify the growth to layer?by?layer for high quality metal contacts in graphene devices and for using graphene as spin filter. By growing Dy at low temperatures or high flux rates it is found that upward adatom transfer is suppressed kinetically and layer-by-layer becomes possible, although the grown film is amorphous.

The growth of Fe on graphene is unusual because the nucleated island increases continuously with deposited amount which indicates the presence of long range repulsive interactions [2]. An advantage is the tunability of the island density with the deposited amount which can be useful for magnetic storage applications. Dy was found to grow fcc(111) instead of hcp(0001) islands expected from its bulk structure. This is seen from the triangular island shape and the ABCABC (instead of ABABAB) stacking sequence of islands nucleating on successive layers[3].

Ex situ SMOKE nagnetization measurements on the Fe islands show a transition from superparamagnetic to ferromagnetic islands with coverage. XMCD measurements on the Dy islands show that the islands are paramagnetic .

Initial experiments on graphene partially intercalated with Dy show that nucleation is preferred on the intercalated than pristine areas, which can be a general method to control metal nucleation and patterning of metallic films on graphene.

Figure caption: 200x200nm2 Fe nucleation on graphene shows increasing island density with Fe deposited amount.

References

1. M. Hupalo et al Advanced Materials 23 2082 (2011)
2. S. Binz, et al Phys. Rev. Let. 109, 026103 (2012)
3. M T Hershberger, et al JCMP 25 225005 (2013)
4 X. Liu, et al. Progr. Surf. Sci. 90 397 (2015)