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Materials Research Science and Engineering Center

MRSEC SEMINAR SERIES

STM studies of Controlled Metal Growth on Epitaxial Graphene

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Abstract:

Large single and bilayer graphene domains are now routinely grown on 6H-SiC(0001) [1] that are ideal for metal adsorption studies. After metal deposition on graphene, the metal morphology can be used to extract the strength of the metal-graphene interaction. This information can be used to determine growth conditions that lead to uniform films for optimal electrical contacts. The morphology is imaged in controlled STM experiments as a function of growth conditions (temperature, coverage, flux). From studies of several metals, common features and major differences about the metal-graphene interaction are deduced. Examples for both will be given. The experimental results are supported with DFT calculations.

Studies of free-electron like metals and non-free-electron-like metals (rare earth Gd, Dy, Eu and transition metal Fe) will be presented. For non-free-electron like metals the results show unusually strong metal-graphene bond [2] that are confirmed by DFT calculations. For practically all metals, the islands are 3-d due to the low ratio of the metal-graphene adsorption energy to the metal cohesive energy. Only Eu grows in large interconnected layers covering graphene. The growth of Fe on graphene is also unusual because it does not follow classical nucleation theory. The nucleated island density is unexpectedly high. It increases continuously with coverage and shows no temperature dependence [3]. These unusual results indicate the presence of long range repulsive interactions that are confirmed with kinetic Monte Carlo simulations and DFT calculations. The island density becomes tunable with coverage, which can be useful in magnetic storage applications. The growth of Dy islands shows ideal triangular instead of hexagonal shapes expected for hcp(0001) crystals. We analyze the island shape histogram and stacking sequence of grown layers to conclude that the Dy islands have fcc(111) and not hcp(0001) stacking. This can have important implications about the electronic and magnetic properties of these islands. Thermal annealing of the metal islands shows limited coarsening in almost all cases with the island density almost unchanged but the aspect ratio (height/lateral size) increases, which can be relevant for catalysis [4]. Finally preliminary controlled intercalation experiments after annealing to higher temperatures of Eu show how the layer can be sandwiched between the SiC $6\sqrt{3}$ and ideal graphene above.

References

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3. S. Binz, M.Hupalo, Xiaojie Liu, C. Z. Wang, Wen-Cai Lu, P. A. Thiel, K. M. Ho, E.H.Conrad and M. C. Tringides Phys. Rev. Let. 109, 026103 (2012).

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