Metal-graphene interaction: weak vs strong bonding

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Understanding metal adsorption on graphene is important to determine the strength of the metal graphene interaction and the conditions to grow uniform films for optimal electrical contacts. Although clean graphene has been studied extensively with many probes to map its unique electronic structure, to tune the Fermi level and to open a gap, metal adsorption experiments are limited. Large single and bilayer graphene domains were recently grown on 6H-SiC(0001)[1]ideal for metal adsorption studies. STM experiments of metal deposition have been carried out as a function of growth conditions of temperature T, coverage θ and flux rate F to determine the grown morphology, diffusion and adsorption barriers, crystallization temperature and adatom-adatom interactions.

Non-free-electron-like metals (rare earth Gd, Dy, Eu and transition metal Fe) and free-electron like metal (Pb) were deposited. From the good agreement between measured and calculated barriers a classification of the strength of the metal graphene interaction. For Gd, Dy, Fe at RT high island densities ($\sim 10^{-2}$islands/nm^2) are observed , the island densities are stable and coarsening occurs only after heating to higher than ~800° K. These results show unusually strong metal-graphene bond[2] and DFT confirms the covalent nature of the bond[3,4]. Fe shows a steadily increasing island density with coverage which indicates long range repulsive adatom interaction. This high density of the Fe islands can be relevant for spintronics . For all metals the grown islands are 3-d as a result of the low ratio of the metal adsorption energy on graphene to the metal cohesive energy. On the other hand Pb has extremely weak interaction($\sim 10^{-4}$islands/nm^2 at 30° K) which implies very low diffusion and adsorption barriers[2]. Although graphene seems to be the ideal substrate for electron confinement and QSE-driven Pb uniform height islands, this is not the case[2,5]. Since height selection on Pb/Si(111) is due to very fast kinetics of the dense wetting layer, the absence of a wetting layer on graphene is the real limitation whether uniform heights form or not.

These results of metal deposition on epitaxial graphene will be compared with metal deposition on graphene grown on metals [6,7]where the graphene subsrate interaction is more important for the nucleation.

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