Controlling the electric charge of gold nanoplatelets on an insulator by field emission nc-AFM

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Flat metallic islands on an insulating substrate can be used as electron reservoirs to contact a molecule or a graphene nanoribbon in a planar geometry for molecular electronics applications. The challenge is then to stabilize the charge on a metallic nanocrystal for a time long enough to perform in-plane operations. Here, we report on the controlled charging of 2D Au nanocrystals deposited on a SiO₂ insulating substrate by electron field emission from the tip of an AFM in UHV environment. We image the platelets in the nc-AFM mode [1] and characterize their charge state by Kelvin Probe Force Microscopy (KPFM) (see figure 1) [2,3]. Our results demonstrate that the charge of these metallic islands can be precisely controlled by monitoring ∆f(V) spectroscopy curves. The procedure works for both polarities, electrons being emitted by the tip or the substrate. As shown by an analytical model and complementary numerical simulations, the rise of the island's potential upon charging leads to a constant charging current and tip-island electric field [4]. Our measurements suggest that this method can be used to set the island’s potential with a single-electron precision. This degree of control is achieved thanks to the increased stability and sensitivity provided by the UHV environment. The procedure is robust and opens the way to original experiments, such as establishing a bias at the extremities of a molecule connected between two islands or exploring locally the charge leaking mechanisms across an insulating layer.

Figure 1. Topography and Kelvin potential image of an Au island on SiO₂ before (a, b) and after (d, e) charging. Profiles before (c) and after (f) charging. (g) ∆f (V ) curves measured on the Island showing the negative charging (∆f = −7Hz, ∆z = 2nm). The black curves are recorded before the red ones. The green curves are simulated with a virtual AFM [4]

References

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