ELECTROCHEMICAL METAL DEPOSITION CONTROLLED BY SURFACE-BASED MOLECULAR SELF-ASSEMBLIES

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Metal structures in micrometre and sub-micrometre range are of interest to applications in electronics, sensing, electrochemical analysis and optics. The combination of electrometallisation and patterned self-assembled monolayers (SAMs) has shown the ability to produce metal structures with features down to 50 nm. The resolution is limited by the precision at which nucleation can be controlled. Experiments have identified a practical two-step procedure to deposit Pd on top of a pyridine-terminated SAM where metal clusters are generated via complexation and electrochemical reduction. Rather than relying on statistical defects in SAM, this two-step deposition scheme harnesses molecular properties, thus providing better control over metal nucleation and growth, from which new opportunities for producing metal structures with ultra-small dimensions arise.

Here we present an exploration of the two-step deposition scheme towards the generation of ultra-small metal structures. Density functional theory (DFT) calculations are employed to clarify the initial stage of metal cluster formation. They suggest that there is a substantial driving force towards the aggregation of Pd atoms on the SAM surface. Nucleation and growth of Cu-Pd nanoparticles via complexation and electrochemical reduction are investigated by cyclic voltammetry (CV), chronoamperometry, scanning tunnelling microscopy (STM) and atomic force microscopy (AFM). Metal patterns have been generated with dimensions ranging from micrometre to sub-20 nm.

References