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Low temperature scanning tunneling microscopy of metallic and organic nanostructures[1]

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Low temperature scanning tunneling microscopy (LT-STM) is capable of both characterizing and manipulating atomic-scale structures at surfaces. It thus provides a powerful experimental tool to gain fundamental insight into how electronic properties evolve when controlling size, geometry, and composition of nanometric model systems at the level of single atoms and molecules. The experiments discussed in this talk employ a Cu(111) surface onto which perfect nanostructures are assembled from native adatoms and organic molecules. Using single Cu adatoms as building blocks, we obtain zero-, one-, and two-dimensional quantum objects (corresponding to the discrete adatom, monatomic adatom chains, and compact adatom assemblies) with intriguing electronic properties. Depending on the structure shape and the number of incorporated atoms we observe the formation of characteristic quantum levels which merge into the sp-derived Shockley surface state in the limit of extended 2D islands; this state exists on many surfaces, such as Cu(111). Our results reveal the natural linkage between this traditional surface property, the quantum confinement in compact adatom structures, and the quasi-atomic state associated with the single adatom. In a second step, we study the interaction of pentacene ($C_{22}H_{14}$) with Cu adatom chains serving as model quantum wires. We find that STM-based manipulation is capable of connecting single molecules to the chain ends in a defined way, and that the molecule-chain interaction shifts the chain-localized quantum states to higher binding energies. The present system provides an instructive model case to study single organic molecules interacting with metallic nanostructures. The microscopic nature of such composite structures is of importance for any future molecular-based device realization since it determines the contact conductance between the molecular unit and its metal "contact pad".

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