0D SEMICONDUCTOR NANOSTRUCTURES PROBED BY STM: FROM QUANTUM DOTS TO SINGLE ATOMES

G. Rodary$^1$, K. Badiane$^1$, C. David$^1$, J.-C. Girard$^1$
$^1$Laboratoire de Photonique et de Nanostructures (LPN), CNRS, Université Paris-Saclay, route de Nozay, F-91460 Marcoussis, France

In this presentation, we address the question of the electronic structure of zero-dimensional nanostructures inserted into semiconductor matrix. In this purpose, we use cross-sectional Scanning Tunneling Microscopy and Spectroscopy (STM/STS) in order to investigate the band structure and the wave function shape of the confined carriers in the nanostructures at the atomic scale.

Semiconductor self-assembled quantum dots, such as InAs/GaAs, are systems where electrons are confined in the three space dimensions. As a consequence, their electronic structure presents discrete states often described by analogy as "artificial atoms". We show that STS allows to reveal the discrete states of quantum dots and to map their eigen wave function. When two quantum dots are intentionally grown very close, we also measure that electronic coupling happen and gives rise to "artificial molecule" behavior, meaning bonding and antibonding states.

The "artificial atoms" description is nevertheless much too schematic. Indeed, real single atoms in a semiconductor like GaAs do not behave as isolated atoms but interact strongly with the semiconductor host. In order to address this point, we investigate the coupling between a single magnetic transition metal, namely Cr, and the GaAs matrix by STM. In order to study different electronic bonding and hybridization between magnetic atoms and the semiconductor, we manipulate single Cr atoms deposited on the GaAs(110) surface with the STM tip in order to substitute Ga atoms by Cr. We manage to obtain Cr in three different environments depending of their position relative to the surface: Cr surface adatom, Cr bond to 3 As neighbor and Cr bond to 4 As. Study of the electronic states energy and shape of Cr in such positions reveals large difference. Wave functions are surprisingly extended and anisotropic and are discussed in terms of p-d hybridization between the transition metal and the GaAs.

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Presenting author's email: guillemin.rodary@lpn.cnrs.fr