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Review

Tunnelling junctions with additional degrees of freedom: An extended toolbox of scanning probe microscopy



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ABSTRACT

Considering studies of molecular adsorption we review recent developments in the field of scanning probe microscopy and in particular in scanning tunnelling microscopy, concentrating on the progress that has been achieved by controlled decoration of the microscope tip. A view is presented according to which the tip decoration generally introduces additional degrees of freedom into the scanning junction and thus extends its functionality. In particular tips decorated with atomic point-like particles may attain the additional function of a force sensor which is realized through the degrees of freedom associated with the relative position of the decorating probe-particle with respect to the tip. It is shown how the force sensor function of such tips helps when studying large molecular adsorbates. Further prospects of more complex junctions equipped with numerous internal degrees of freedom are discussed. It is argued that the main problem impeding the utilization of such junctions is related to their control. An approach towards a higher degree of control is presented that is based on the analysis of single molecule manipulation experiments.

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Nomenclature

AFM	atomic force microscope(y)
CO	carbon monoxide
DFT	density functional theory
DOF	degree(s) of freedom
DOS	density of states
HBS	high-bias state
HOMO	highest occupied molecular orbital
IETS	inelastic electron tunnelling spectroscopy
LBS	low-bias state
LDOS	local density of states
L–J	Lennard–Jones
LT STM	low-temperature scanning tunnelling microscope(y)
LUMO	lowest unoccupied molecular orbital
NC AFM	non-contact atomic force microscope(y)
NTCDA	naphthalene tetracarboxylic dianhydride
PP	probe-particle
PTCDA	perylene tetracarboxylic dianhydride
SPM	scanning probe microscope(y)
SP STM	spin-polarized scanning tunnelling microscopy
STHM	scanning tunnelling hydrogen microscopy
STM	scanning tunnelling microscope(y)
TED	total electron density
TTCDA	terrylene tetracarboxylic dianhydride
UHV	ultra-high vacuum
vdW	van der Waals

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