TUNING THE Ag(111) SURFACE ELECTRONIC STRUCTURE WITH SELF-ASSEMBLED MOLECULAR NANOGRATINGS

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We report a low-temperature scanning tunneling microscopy (STM) and spectroscopy (STS) study aiming on the confinement of the 2-D electron gas of Ag(111) surface state electrons using molecular self-assembly. In particular, we employed the amino acid methionine to systematically fabricate regular 1-D nanogratings whose periodicity can be tuned by the molecular coverage in the ~2–10 nm range. The gratings comprise paired methionine rows separated by extended stripes of pristine Ag. The molecular rows locally quench the Shockley surface state of the substrate and represent highly regular 1-D reflectors for the 2-D electron gas in the adjacent Ag areas. The resulting 1-D confinement is recognized by the characteristic modification of the surface electronic structure in STS measurements.

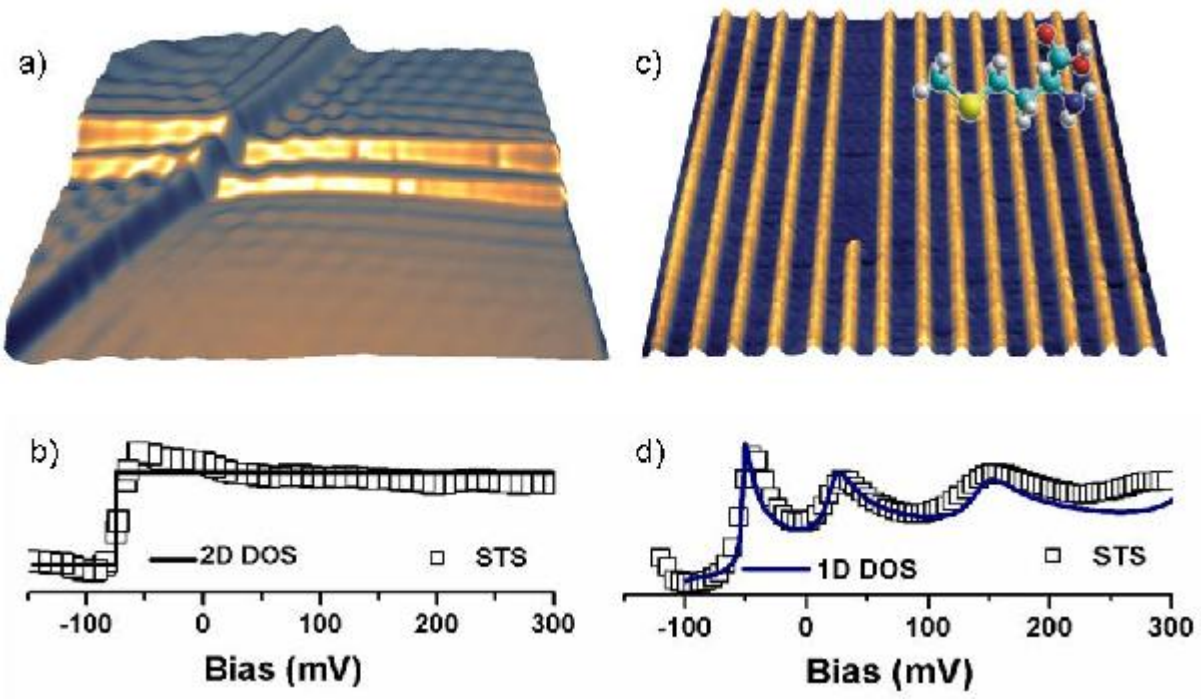

Fig 1: a) Topography of Ag(111) surface with atomic steps resolved overlaid with a dI/dV STS map in order to enhance the standing wave pattern of the surface state electrons reflected at the step edges. b) STS of the Ag surface state revealing the stepwise onset in the density of states typical for a 2-D electron gas. c) Regular methionine nanograting self-assembled on Ag(111); its periodicity can be easily controled by the molecular coverage. d) Tunneling spectra taken in between the molecular rows demonstrating the 1-D confinement of surface state electrons.

Moreover, it leads to a shift of the surface state band onset, which depends sensitively on the grating periodicity. As a consequence a systematic control of the surface electronic structure becomes possible, and the surface state band onset can be tuned in an energy range exceeding 100 meV (with the highest energies there is partial 2-D condensation of the methionine surface nanostructures). For the particular case of a grating corresponding to a confinement length of 7 nm a detailed analysis of the local density of states through spatially resolved STS shows that the molecular resonator can be described within the framework of the Fabry-Perot model, i.e., the self-assembled methionine rows act as excellent mirrors (r=0.7) for electrons at the Fermi level. Moreover, U-shaped arrangements where a resonator is closed at one side allow for an analysis of the standing wave pattern of the surface state electron gas subject to further confinement. Our results suggest that the engineering of molecular nanostructures on surfaces opens a new route to control electron confinement in low dimensions.

References:

[1] M. F. Crommie, C. P. Lutz, and D. M. Eigler, Science **262**,
[4] L. Burgi et al. PRL 81, 5370 (1998)
[5] J.V.Barth et al. *Nature* **437**, 671-679