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Nanotemplate Surfaces

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The availability of stable patterned surfaces with regular feature sizes of a few nanometers represents a prerequisite for the build-up of new devices and also for the creation of new concepts in nanotechnology. Our group has taken two different approaches to the preparation of such nanotemplates.

Vicinal crystal surfaces offer a convenient way to produce surfaces with regular superlattices of steps and kinks. The periodicities can be controlled with subnanometer precision simply by adjusting the miscut angle. On vicinal Cu(111) surfaces the step lattices are not entirely perfect but they are regular enough to induce clear signatures of coherent quantum behaviour in the two-dimensional electron gas represented by the Shockley surface state [1,2]. In a first attempt at organizing a molecular layer by means of a stepped surface, it was discovered that such templates are by no means rigid but take part in a complex self-assembly process involving both substrate and molecules. A monolayer of C_{60} molecules on a Cu(221) surface leads to the formation of very regular molecular chains along the step direction, with alternating brighter and dimmer chains as imaged by scanning tunnelling microscopy. In the process, the underlying substrate is reconstructed locally from a Cu(221) surface with a terrace width of 7.7 Å to a Cu(553) surface with 9.8 Å terraces [3], accompanied by the formation of step bunches.

The second approach relies on the propensity of hexagonal boron nitride (h-BN) monolayers to form highly regular nanostructures on poorly lattice-matched transition metal surfaces. Borazine (HBNH)3 molecules decompose readily on a Ni(111) surface at a temperature of 1050 K and form an ideal and abrupt h-BN layer that self-saturates at one monolayer [4]. On Rh(111) with a lattice mismatch of 6.7% the internal stiffness within the h-BN layer leads to a surprising hexagonal double-mesh structure with a periodicity of 3.2 nm and mesh pores of 2.4 nm diameter [5]. The two mesh layers are shifted with respect to each other in such a way as to expose a minimum metal surface area. This nanomesh is chemically and thermally very stable. A monolayer of C60 deposited on top reflects its periodicity and topography [5]. On Pd(110) domains of one monolayer thickness are observed with various Moiré patterns resulting from different relative orientations of substrate and h-BN layer, each preserving its own symmetry and lattice constant [6].

References:

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