2D - nanostructuring with atomic beams

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Creating nanostructures by controlled deposition of atoms is a promising field of research. In contrast to the commonly used nanofabrication methods, desired atomic elements can in principle directly be deposited on surfaces in a one-step procedure. On our poster we present two different techniques for generation of nanostructures with atomic beams: (a) parallel writing process utilizing optical masks generated by a hologram. (b) Concept of a serial writing process with an atomic pencil.

We investigate both systems with a cesium atomic beam and a resist technique. Our lithography system consists of a self assembled monolayer of nonanthiol on top of a thin gold layer (30 nm). The wetting properties of this monolayer are locally altered by cesium atoms impinging on the surface, such that an aqueous etching solution can remove the underlying gold only in the regions illuminated by cesium atoms [1].

(a) In atom lithography with optical masks, optical dipole forces are utilized to concentrate atoms near the nodes of a blue detuned standing light-wave field. Light forces of a plane standing wave have been applied in several laboratories to create arrays of straight parallel lines at sub-nanometer scales and to investigate basic properties of atom nanofabrication processes. Here we present a method that induces a tailored complex 2D-pattern into the density distribution of atomic beams at nanometer scale. This modulation is caused by a light mask that is reconstructed from a hologram that is stored in a photorefractive crystal. We use a three-beam geometry, i.e. one read-out laser beam diffracts two additional laser beams. All contributing laser beams assemble the light mask by interference. This three beam interference mask causes an atomic pattern as shown in fig. 1[2]. This method can be expanded to light masks that are generated by interference of more than 1000 laser beams.

(b) With the atomic pencil arbitrary structures can be written in a serial process. The idea of the atomic pencil is to limit the diameter of an atomic beam with an aperture to some microns or less and to deposit atoms on a substrate behind the aperture. Thus arbitrary structures can be written by moving the substrate relatively to the aperture. The minimum structure size thus is only limited by the diameter of the aperture. To obtain short writing times with this serial process, it is necessary to increase the atomic flux through the aperture. Therefor the thermal cesium atomic beam is routed through a magnetic 2D-quadrupole, that accelerates the atoms towards the quadrupole-axis. Consequently the atomic flux density is increased behind the quadrupole with a factor of (20-200).

[1] M. Kreis *et al.*, Appl. Phys. B **63**, 649 (1996)

[2] M. Mützel *et al.*, Phys. Rev. Lett. **88**, 083601 (2002)

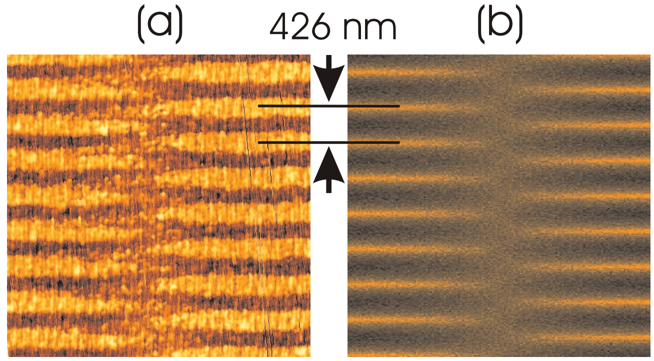

Figure 1: (a) Atomic force microscope picture of generated gold structures (bright regions). (b) Numerical simulation of atomic flux density in the substrate plane. Bright regions indicate high atomic flux density.