Poster

NANOSCALE STRUCTURING OF GOLD SURFACES WITH LASER MANIPULATED NEUTRAL CESIUM ATOMS

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Atom lithography was invented in the last decade at Bell Labs, where the possibility of producing nanostructures with laser manipulated neutral Na atoms was demonstrated for the first time [1]. Atom lithography [2] is in principle similar to optical lithography, the main difference being that the roles of light and matter are reversed each other. While in optical lithography matter (material masks) is used to pattern a light beam (which is then used to impress the photoresist), in atom lithography nanopatterns are produced through interaction of a neutral atom beam with a "light mask", a suitable configuration of stationary e.m. fields quasi-resonant with an atom transition. Such interaction leads to space segregation of the beam into regular arrays of atoms, which can be used either for direct deposition or to impress a particle sensitive resist. The process keeps the advantageous possibility of large-area patterning typical of conventional lithography, while using a virtually defect-free mask able to produce regular nanopatterns with interferometric precision. Furthermore, the process is not limited by diffraction effects, as the de Broglie wavelenght of an atomic beam is well below the nanometer range.

The atom lithography apparatus developed in this work exploits a beam of cold cesium atoms, offering advantages in terms of atom/field interaction time, with expected increase in the laser manipulation efficiency. The source of cold Cs atoms is a pyramidal magneto-optical trap (MOT), a special configuration of mirrors with the shape of an inverted hollow pyramid operating like an "atom funnel", able to produce a continuous flux of cold Cs when a suitably tuned and arranged laser beam is sent into the pyramid [3]. The divergence of the atomic beam is reduced by a futher collimation stage based on standard laser cooling techniques. We obtain an atom flux of 4*10^{9} atoms/s, a divergence below 2 mrad and a longitudinal velocity of 10 m/s [4]. As the light mask we use a 1-D standing wave, with wavelength of 852 nm, that produces parallel lines spaced 426 nm. A self assembled monolayer (SAM) of thiols (Nonanethiols: $CH_3(CH_2)_8SH$), grown on gold substrates, is employed as the resist, and the pattern impressed by the arrival of the Cs atoms is transferred to the underlying substrate by standard wet etching. An array of parallel trenches into the substrate is produced, spaced exactly 426 nm, and wide in the 50-100 nm range, depending on the process parameters [5].

The interaction by the Cs atoms and the SAM molecules is up to now not well understood; as the energy involved in the atom arrival process is well below the typical binding energy of the SAM molecule, processes more complex than the simple collisional bond breaking are expected to play some role. Therefore we are performing a detailed analysis of cesium-thiol interaction effects, based on surface characterization (either by AFM and lateral force microscopy or by macroscopic contact angle measurements). Results are expected by the conference time.

One major effect limiting the minimum attainable feature size in our fabrication technique is the interaction between the deposited atoms and the substrate surface in the specific regime where arrival of subthermal particles is involved. In order to investigate such

surface phenomena, involving, e.g., particle diffusion, self-aggregation and coalescence, and to contribute in the assessment of the ultimate space resolution of atom lithography, the development of an apparatus with a scanning tunneling microscope (STM) for in-situ diagnostics of Cs nanostructures directly deposited onto different substrates is in progress .

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