Microscopic Atom Trap Arrays

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Microscopic atom trap arrays permit the miniaturisation of cold atom experiments and provide large numbers of individually addressable atom traps in a regular formation. They are therefore a promising environment for quantum simulation and the experimental realisation of quantum information processing[1]. We are developing a versatile and cost effective method for producing such arrays, in which the trap spacing can be set anywhere between 100μm and 20nm. This enables a movement away from the wavelength scale spacing required for optical lattice based systems.

Regular arrays of concave micro-mirrors are fabricated via a templated electrodeposition process[2]. The use of a novel geometry[3] has allowed a magneto-optical trap (MOT) for ^{85}Rb atoms to be formed a few mm below one such structure. The array contains $\sim$230 concave gold mirrors; each has a focal length of 25μm and brings the light from its projected area of 3,300μm^2 to a focus with a waist of 6μm.

It is intended to illuminate these mirrors at normal incidence with an 808nm laser, thus forming an array of dipole traps at their foci. This will be followed by magnetic transfer of the MOT cloud to the region of the dipole traps. To allow loading from the atom cloud, a 2D-MOT will be created in the plane of the dipole trap array. This should result in the capture of $\sim$100 atoms per trap site. We expect trap depths in the mK range and lifetimes of several seconds. A multi-level, low-background imaging system (based on the 420nm transition of ^{85}Rb atoms) will be used, eliminating scattering from the gold surface as a source of noise[3]. It should be possible to detect single trapped atoms on timescales of $\sim$5μs with a PMT, or $\sim$2ms with an EMCCD camera.

In the longer term, fabrication techniques that may allow the production of microscopic MOT arrays are being considered. The structures required for these would permit simultaneous formation of dipole traps and MOTs, with coincident trap centres. As such, the MOT array could be used to facilitate the loading of the dipole traps, and the whole system may provide a convenient framework for the sympathetic cooling of molecules.

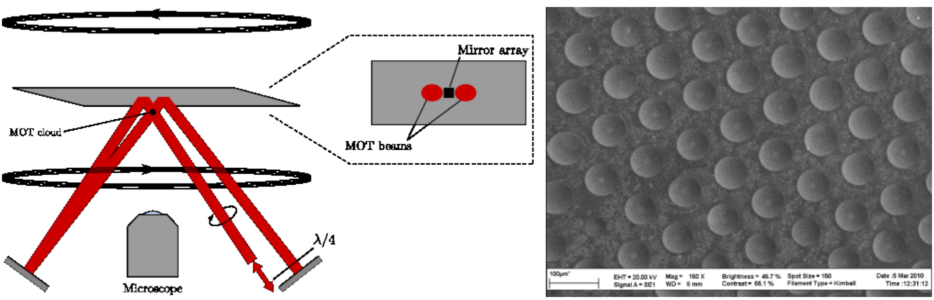

Figure 1: *[left] arrangement used to form a MOT close to the micro-mirror array (another trapping beam is applied perpendicular to the plane of the diagram); [right] SEM image of part of the array.*

[1] I. Buluta and F. Nori, Science **326**, 5949 (2009)
[2] P. Bartlett *et al.*, Chem. Comm. 1671 (2000)
[3] H. Ohadi, M. Himsworth, A. Xuereb and T. Freegarde, Opt. Exp. **17**, 23003 (2009)