Imaging solutions for a planar stacked MOT

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Summary

We present recent work on simplifying the imaging apparatus in a stacked chip-scale MOT to aid further miniaturization and reduce the complexity associated with this component. Our chip-scale MOT system builds upon recent work on the coupling of a grating magneto-optical trap (gMOT) and chip-scale UHV cell; with trapping, cooling and imaging of rubidium atoms performed by a single laser beam. The microfabricated nature of the MEMS cells offers a significant reduction in size, weight and power (SWaP), while the planar stack arrangement of cell, grating chip and imaging enables background-subtracted absorption imaging of the cold atom sample through an hole in the grating's surface. In this presentation we will discuss the simultaneous impact of grating hole size on laser cooling and absorption imaging, to facilitate a high dynamic range of data extraction for future applications in clocks and interferometers.

Motivation

Recent interest in the miniaturization of laser-cooling platforms has focused on the microfabrication of key components, such as replacing 6-beam MOTs with gMOTs and bulky actively-pumped vacuum chambers with UHV MEMS cells[1,2,3]. Although the benefits of these microfabricated MEMS cells in terms of size and power consumption are clear, imaging the trapped atoms has proven problematic due to the silicon sidewalls of the cell reducing optical access and prohibiting atom detection orthogonally to the trap beam. Additionally, the significant light scatter from the grating surface means detection looking directly down onto the grating chip is difficult without employing more complex two-photon spectroscopy schemes, adding additional size, weight and complexity to any device[2].

Results

We employ an absorption imaging set-up of two plano-convex lenses with the objective lens placed directly behind the grating as shown in Fig .1. The portion of the trap beam passing through the grating hole is used to obtain clear absorption images of the MOT, shown the inset of Fig .1, with no additional components required. By selecting the diameter of the grating hole the effect on maximum trapped atom number can be minimized while retaining clear images of the entire atom cloud. This imaging scheme allows atom detection in an extremely compact manner, consistent with the low-SWaP constraints of a truly miniaturized laser cooling platform. Also opening the possibility of further miniaturization using other microfabrication techniques to replace the bulk optics and CCD camera used here.

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Figures

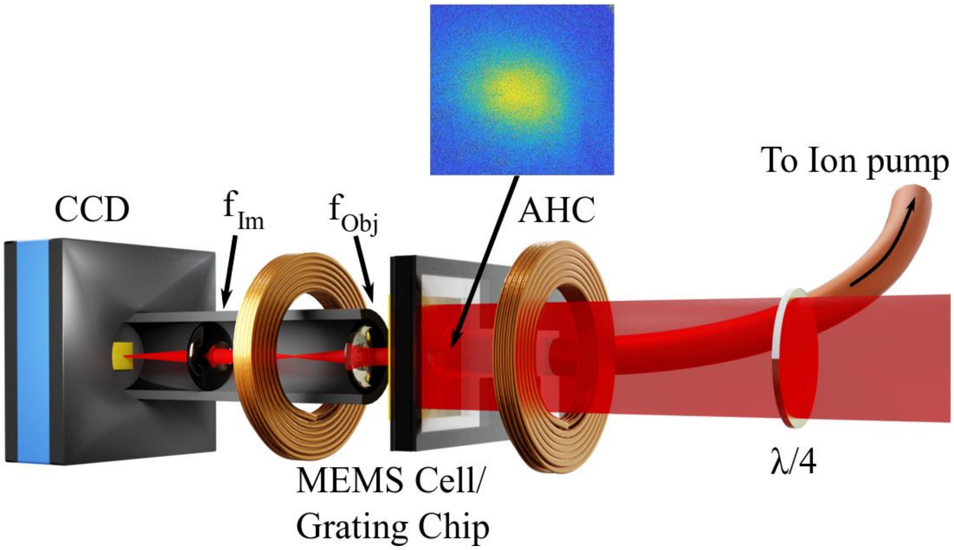

Fig. 1: Schematic of experimental set-up for planar stacked gMOT-MEMS cell absorption imaging. λ/4; quarter waveplate. AHC; anti-Helmholtz coils. f_{Obj}; objective lens. f_{Im}; imaging lens. CCD; charge coupled device. Also shown is the copper tube bonded to the cell for active pumping using an ion pump. The inset shows a typical through-hole absorption MOT image of $\approx 1\times 10^6$ atoms.