A magneto optical cesium trap for atom deposition

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Recently, atom deposition has attracted a great interest in the scientific community as a technique for fabrication of nanometer-scale ordered structures with a relatively simple apparatus [1, 2]. Generally, the source for deposition is an atomic beam, produced by heating the material at temperatures in the typical range of 400–1800 K. The atomic beam is first collimated by a bidimensional transverse laser cooling and then focused by a standing wave on a suitably prepared substrate. Depending on the details of the technique and on the element, atomic species can be directly deposited onto the substrate or can pattern a specific photoresist which, after deposition, undergoes chemical etching, to reveal the formed structures. Up to now, different atomic species have been used in atom deposition, helium [1], argon [1, 3], cesium [2] and chromium [4], and linear, square and also hexagonal lattices have been patterned, with spacing of hundreds of nanometers and structure definition of tens of nanometers.

The aim of the present work is the realization of an atomic source alternative to thermal sources for cesium atoms, to improve the quality of the produced structures, and to enable a deep study of the growth processes. Our atomic source is an intense source of cold cesium atoms, realized by a pyramidal magneto optical trap (MOT) with a funnel [5]. Expected advantages come from the lower translational velocity of the species leaving the funnel (a few m/s vs several hundreds of m/s typical for thermal beams). This leads to a greater interaction time in collimation and focusing phases, which gives rise to sharper deposited structures and to a decrease of the effects due to arrival of uncollimated/unfocused atoms onto the substrate. Moreover, the possibility to control the longitudinal velocity and the spread of the velocity distribution could be useful for the analysis of substrate-deposited species interaction, which will be carried out by exploiting in-situ scanning probe microscopy techniques.

However, the MOT would be a suitable alternative to thermal beams only if it permits to achieve deposition in a reasonable amount of time, and thus a sufficiently intense source is needed. This is why we have chosen the pyramidal MOT configuration, which produce intense beams of cesium atoms [5] and is characterized by a scalable structure (greater dimensions $\Rightarrow$ greater flux), expected to fulfill the reuqirements for an efficient atom deposition setup.

[1] J.H. Thywissen, K.S. Johnson, R. Younkin, N.H. Dekker, K.K. Berggren, A.P. Chu, M. Prentiss, and S.A. Lee, *J. Vac. Sci. Technol. B*, **15** 2093 (1997).

[2] F. Lison, H.-J. Adams, D. Aubrich, M. Kreis, S. Nowak, and D. Meschede, *Appl. Phys. B*, **65** 419 (1997).

[3] C. Keller, R. Abfalterer, S. Bernet, M.K. Oberthaler, J. Schmiedmayer, and A. Zeilinger, *J. Vac. Sci. Technol. B*, **16** 3850 (1998).

[4] W.R. Anderson, C.C. Bradley, J.J. McLelland, and R.J. Celotta, *Phys. Rev. A*, **59** 2476 (1999).

[5] J.J. Arlt, O. Maragò, S. Webster, S. Hopkins, and C.J. Foot, *Optics Comm.*, **157** 303 (1998).