A cold and highly collimated Cesium beam: realization and characterization

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Atom deposition [1] has attracted a great interest in the scientific community as a technique for fabrication of nanometer-scale ordered structures with a relatively simple apparatus.

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. The atomic source developed in this work is an intense source of cold cesium atoms, based on a pyramidal magneto-optical trap (MOT) with a funnel [2]. Main advantage of this choice are the lower translational velocity of the species leaving the funnel (10 m/s vs hundreds of m/s typical for thermal beams). This leads to a greater interaction time in collimating and focusing stages, which is expected to give rise to sharper deposited structures and to decrease 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 the specific growth process, which will be carried out by in-situ scanning probe microscopy techniques.

The atomic funnel is built with a set of two prisms and two mirrors in the configuration of an inverted pyramid with a small hole at its vertex [2]. This configuration enables an arrangement similar to a standard six-beam MOT in a σ^+/σ^- cooling configuration. Anti-Helmoltz coils are used to produce a magnetic field gradient which can be tuned in the range 5–15 G/cm. Three pairs of coils in the Helmoltz configuration allow us to shift the zero point of the quadrupole magnetic field and, consequently, of the trap region. As trapping, collimating and repumping laser sources, we use two diode lasers (DLs) in master-slave configuration, and a Distributed Bragg Reflector (DBR). Another diode laser is used to probe the cesium beam. Master, collimating and probing lasers are stabilized by an external cavity (coupled with a grating) tuned on the trapping $|F=4\rangle \rightarrow |F'=5\rangle$ transition by saturation absorption spectroscopy on cesium vapour. The DBR laser is tuned on the $|F=3\rangle \rightarrow |F'=4\rangle$ transition and is used as a repumper.

In the early stages of the experiment the MOT has been characterized and the fluorescence measurements showed up to 10^8 trapped atoms in a ~ 1 mm^3 region. We have also carried out a characterization of the atomic beam leaving the funnel, i.e. the density, the divergence and the longitudinal velocity and temperature. Induced fluorescence images, acquired using a CCD camera, show a beam divergence of 25 mrad and a density up to 10^8 atoms/cm^3 . The longitudinal velocity distribution of the beam has been measured using a time of flight technique. Briefly, the transient absorption of the atomic beam, switched on and off by a pushing laser (pulse duration < 0.5 ms), is acquired providing us with information of the beam dynamics. We find a translational velocity in the range 6–12 m/s, depending on the trapping parameters (i. e., laser trapping intensity and detuning).

The divergence of the atomic beam is reduced by a two dimensional molasses, by two retro-reflected laser beam in the lin $\perp$ lin configuration. The divergence is reduced to a value of 8 mrad. Characterization of the collimated beam is still in progress.

The next steps of the experiment will involve the focusing of the atomic beam by a one dimensional standing wave. The realization of an in-situ diagnostics for the deposited structure, based on STM, is also planned.

[1] Special issue: "Nanomanipulation of atoms", *Appl. Phys. B* **70**, 649-739 (2000).

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