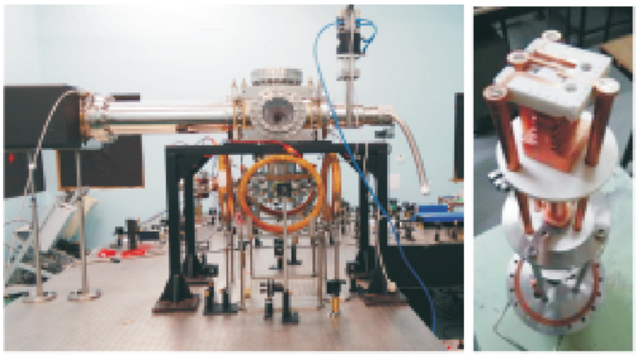
L.11: Atom chip magneto-optical trap for Rb atoms

The enormous progress in the techniques of laser cooling are mainly responsible for the rapid evolution of the field of Atom Optics with applications in the development of novel sensors, precision measurements, ultra cold chemistry, etc. One important requirement for the development of atom-optical devices for various applications is their miniaturization and integration. In this direction, the trapping atoms on an atom-chip is an important step. An atom-chip can be developed for various functions such as trapping, guiding and splitting of the cold atom cloud on the miniaturized scale. Therefore, the atom-chip is expected to be a basic building block of atom optical devices for various applications in quantum information processing, communication, precision sensors, etc, similar to role of the integrated circuits in electronics. The atom-chip consists of a reflecting surface and current carrying wires for magneto-optical trap (MOT) formation and magnetic trapping of cold atoms on this surface.

A magneto-optical trap (MOT) on atom-chip for alkali ^{85}Rb atoms is successfully developed and operated recently at Laser Physics Applications Section, RRCAT. A photograph of this in-house developed setup for atom chip-MOT is shown in Fig.L.11.1 (A).



(A) (B)

Fig. L.11.1: (A) Photograph of the experimental setup for atom-chip MOT of Rb atoms. (B) The chip-mount assembly for attaching the atom-chip.

An atom-chip magneto-optical trap (MOT) is the first step towards trapping cold atoms on chip on a miniaturized scale. This MOT provides cold atoms on a surface in the temperature range of few hundreds of micro-Kelvin. The atom-chip MOT is formed by applying three pairs of counter propagating laser beams in a reflection geometry in the presence of an inhomogeneous magnetic field. The atom chip is prepared by gold coating of a Si substrate which is attached to a chip-mount assembly (length~ 472 mm) and placed in an octagonal MOT-chamber with pressure ~ 1 x 10^{-8} torr. The chip-mount assembly provides electrical connections from the outside of the vacuum chamber to the U-shaped copper wire structure underneath the atom chip (Fig.L.11.1 (B)). The quadruple magnetic field required for the operation of the atom-chip MOT is produced by passing a DC current in this U-shaped wire structure along with a bias field produced by two pairs of coils in Helmholtz configuration placed outside the MOT-chamber. The values of current used in U-shaped wire and in the bias coils are ~30 A and ~2 A, respectively. The optical alignment for the atom chip MOT is different from a conventional MOT. It involves two counter propagating circularly polarized cooling laser beams incident on the reflecting surface of the atom-chip at an angle of 45º. Another circularly polarized cooling laser beam is passed and retro-reflected parallel to the atom-chip surface and perpendicular to the plane containing the other pair of beams. In our setup, the beam waist and power of each cooling laser beam was ~ 7 mm and 10 mW respectively.

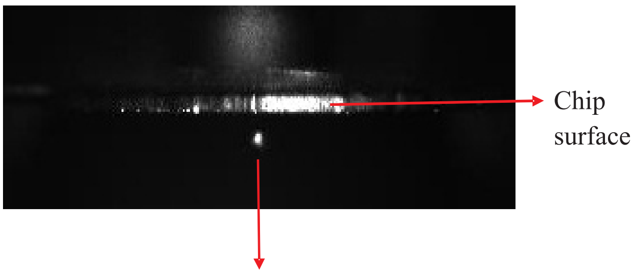


Fig. L.11.2: The CCD camera image of cold atom cloud on the chip surface.

The CCD camera image of the cold atom cloud in the atom-chip MOT near the surface of atom-chip is shown in Fig.L.11.2. The cold cloud of ^{85}Rb atoms was formed at a distance of ~ 3 mm vertically below the surface of the atom-chip. The number and temperature of cold atoms were estimated to be ~ 2 x 10^5 and ~ 350 μK respectively. The number density in the cold atom cloud was ~ 2 x 10^9 /cm^3. Further work to characterize the cold atom cloud on atom-chip is under progress.

We acknowledge the contributions of Mechanical & Optical Support Section, Optical Coatings Lab, Solid State Laser Electronics Section, Laser Electronics Support Division and Semiconductor Physics and Devices Lab to the development of atom-chip setup.

We also thank Dr H S Rawat, Ex-Head, LPAS for his contribution and Director, RRCAT for continuous support and encouragement to this work.

Reported by:
Vivek Singh, V. B. Tiwari
and S. R. Mishra (srm@rrcat.gov.in)