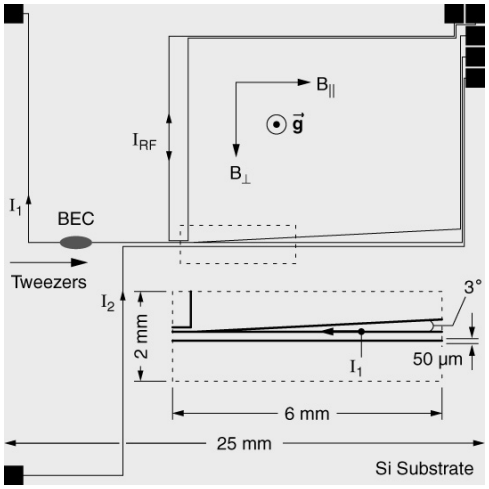
Propagation of Bose-Einstein condensates in a magnetic waveguide

Progress in the field of atom optics depends on developing improved sources of matter waves and advances in their coherent manipulation. Miniaturizing the current carrying structures used to confine Bose-Einstein condensates offer prospects for finer control over the clouds. We have demonstrated that a gaseous Bose-Einstein condensate transported with optical tweezers [1] can be transferred into a magnetic trap microfabricated on a silicon substrate (see figure) [2]. This has opened up a front on which further techniques for coherent condensate transport and manipulation can be explored.

We released the condensate from the magnetic microtrap into a single-wire magnetic waveguide and studied its propagation. Condensates were observed to propagate 12 mm before exiting the field-of-view of our imaging system. We observed single-mode (excitation-less) condensate propagation along homogeneous segments of the waveguide. Transverse excitations were created in condensates propagating through perturbations in the guiding potential. These perturbations resulted from geometric deformations of the current carrying wires on the substrate. Finer imperfections were observed when trapped condensates were brought closer to the microchip as evidenced by the longitudinal fragmentation of the cloud. Such imperfections have to be controlled in order to use atom chips for precision atom interferometry.



Microfabricated magnetic trap and waveguide. Optical tweezers loaded a Bose-Einstein condensate into the microtrap formed by currents I_1 and I_2 in conjunction with the magnetic bias field $B_{\perp}$. Lowering I_2 to zero released the condensate into a single-wire magnetic waveguide. Atom flow was from left to right. The condensate was trapped above the plane of the page and the gravitational acceleration, **g**, points out of the page. All microfabricated features are drawn to scale.

1. T.L. Gustavson, A.P. Chikkatur, A.E. Leanhardt, A. Görlitz, S. Gupta, D.E. Pritchard, and W. Ketterle, *Transport of Bose-Einstein Condensates with Optical Tweezers*, Phys. Rev. Lett. **88**, 020401 (2002).
2. A.E. Leanhardt, A.P. Chikkatur, D. Kielpinski, Y. Shin, T.L. Gustavson, W. Ketterle, and D.E. Pritchard, *Propagation of Bose-Einstein condensates in a magnetic waveguide*, Phys. Rev. Lett. **89**, 040401 (2002).