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Silicon Carbide Transparent Chips for Compact Atomic Sensors

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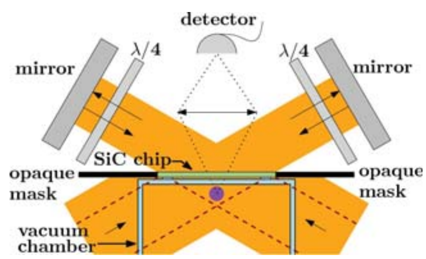
Atom chips [1] are an efficient tool for trapping, cooling and manipulating cold atoms, which could open the way to a new generation of compact atomic sensors addressing space applications. This is in particular due to the fact that they can achieve strong magnetic field gradients near the chip surface, hence strong atomic confinement at moderate electrical power. However, this advantage usually comes at the price of reducing the optical access to the atoms, which are confined very close to the chip surface. We will report at the conference experimental investigations showing how these limits could be pushed farther by using an atom chip made of a gold microcircuit deposited on a single-crystal Silicon Carbide (SiC) substrate [2]. With a band gap energy value of about 3.2 eV at room temperature, the latter material is transparent at 780nm, potentially restoring quasi full optical access to the atoms. Moreover, it combines a very high electrical resistivity with a very high thermal conductivity, making it a good candidate for supporting wires with large currents without the need of any additional electrical insulation layer [3].



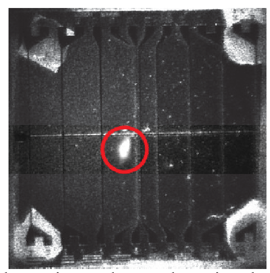


Figure 2 : Left: sketch of the experimental setup we used for demonstrating magneto-optical trapping and atom detection through the chip. Right: fluorescence from the magneto-optically trapped atoms (in the red circle) detected through the transparent chip.

One important issue is the birefringence of the substrate, which can affect the state of polarization of light going through it. In the case of magneto-optical trapping with beams propagating through the chip, the effect of birefringence can be compensated by using one single quarter wave plate per beam in a retro-reflected configuration, as illustrated on Figure 2. In particular, it can be shown that for one proper orientation of the wave plate, the state of polarization of light going through the chip and back depends on the chip orientation but not anymore on the associated phase shift. Using such a configuration, we have demonstrated robust magneto-optical trapping of about one million rubidium atoms through the SiC chip. The possibility of imaging the atoms through the transparent substrate is illustrated on the right picture of Figure 2.

Transparent SiC atom chips could open the way to new applications that would combine the flexibility and low power consumption of atom chips, with more complex optical architectures requiring full optical access, both for manipulation and detection of atoms. For example, Ramsey-Bordé interferometers or Bloch oscillators could be loaded from evaporatively cooled atoms trapped near a transparent chip surface while using beams passing through the chip. In a future experiment where the chip would be part of the vacuum chamber itself with atoms located very close to its surface, detecting the atoms through the chip could dramatically increase numerical aperture hence signal-to-noise ratio for atomic sensors. This is all the more true if one considers the possibility of etching lenses directly on the chip substrate [4], which would furthermore increase compactness and scalability of the device.

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[1] J. Reichel and V. Vuletić, *Atom Chips* (John Wiley & Sons, Weinheim, 2011).
[2] *Silicon Carbide Substrates and Epitaxy Product Specification*, datasheet from the CREE company.
[3] L. Huet *et al.*, Applied Physics Letters **100**, 121114 (2012).
[4] H. Lee, D. Kim, Y. Sung, and G. Yeom, Thin solid films **475**, 318 (2005).