Characterization of Caesium Microcells with high buffer gas pressure

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Abstract: We present an ongoing activity for the characterization of cavity microcells filled with caesium (Cs) alkali-metal-vapor and high buffer gas pressure for magnetic microscopy via optically pumped magnetometers (OPMs).

Microfabricated vapor cells (MEMS cells) are widely used in miniaturized atomic quantum sensors of electromagnetic fields [1]. Recent studies have shown that cavity-based optical readout can preserve OPMs high sensitivity while improving spatial resolution, but current designs rely on bulky mirrors, limiting compactness and finesse[2]. In contrast, micro-cell technology enables wafer-scale fabrication, supporting compact and scalable devices[3].

Here we propose to directly coat the outer windows of MEMS Cs cell to realize an « optical cavity microcell » at the wafer level fabbrication, allowing cavity-enhanced measurements in a magnetic microscopy platform, as depicted in Fig.1 a). This approach is expected to enable highly compact sensors with sub-mm³ sensing volumes, stand-off distances below 1 mm, and projected sensitivities in the range of approximately 10–100 fT/√Hz.

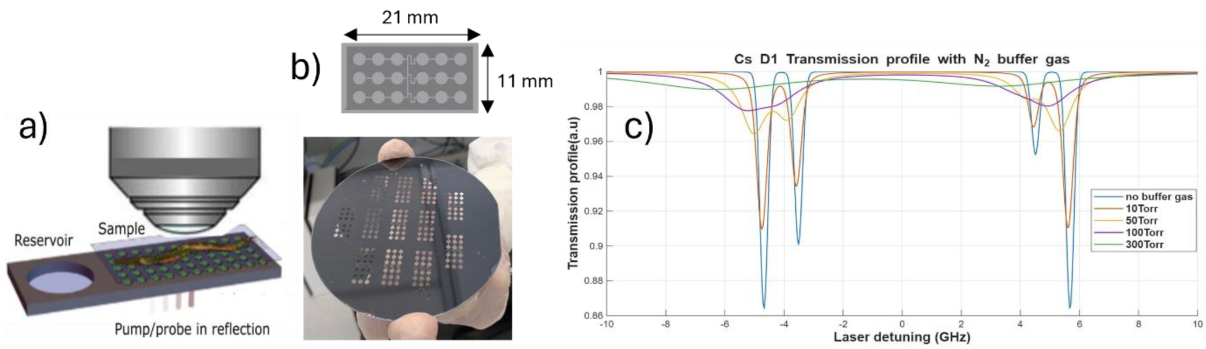

Figure 1 a) Cavity-microcell magnetic microscopy platform. b) MEMs cell wafer. The wafer consists of a glass–silicon–glass stack with a total thickness of 1 mm. The inner glass surfaces are coated with 25 nm of Al_2O_3 to reduce He permeation. Cells were filled with a CsN_3 solution to generate caesium vapor and additional buffer gas. d) Broadening and shift of the D1 hyperfine transitions due to the buffer gas.

The work we present here focuses on the characterization a first generation of caesium MEMS microcells shown in Fig. 1 b). The cells contain a mixture of Cs atoms and nitrogen, the latter serving as a buffer gas to mitigate spin decoherence caused by collisions between the atoms and the cell walls, which ultimately increases the magnetic sensitivity [4] .This scales as $\delta B \propto \sqrt{\Gamma}$ where Γ is the total collitions rate including atom–atom, atom-wall and atom-buffer gas collisions. Each of these exhibits distinct behavior depending on the buffer gas pressure. In microcells gas pressure higher than 1 bar is required to minimize the rate of the atomic collisions with the cell walls.

By fitting the pressure-broadened absorption spectra we aim at measuring the amount of buffer gas pressure inside the cells. These measurements provide a diagnostic tool to verify the quality and reproducibility of the filling and sealing processes, before implementation in the full magnetometry setup.

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