Quantum magnetometry and spectroscopy using laser-written vapor cells

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Abstract: We demonstrate atomic spectroscopy and optical magnetometry with picotesla sensitivity using laser-written Rb vapor cells. The technology can be integrated with photonic structures and microfluidic channels in a single platform for lab-on-chip atomic quantum sensing.

We introduce laser-written vapor cells (LWVCs), a technology based on femtosecond laser writing followed by chemical etching (FLICE), that allows arbitrarily shaped 3D hollow microstructures. In a first experiment [1] we demonstrated sub-Doppler saturated absorption spectroscopy and an optically-pumped magnetometer (OPM) with elliptically polarized light. In a second experiment [2] we report a sensitivity of 1pT/√Hz at 10 Hz using a zero-field-resonance (ZFR) OPM and 0.75 amg of N2 buffer gas in a sub-mm-width laser-written channel (Fig. 1). The device can be integrated with photonic structures and microfluidic channels with 3D versatility. LWVCs may find application in miniaturized atomic quantum sensors and chip-scale atomic frequency references.

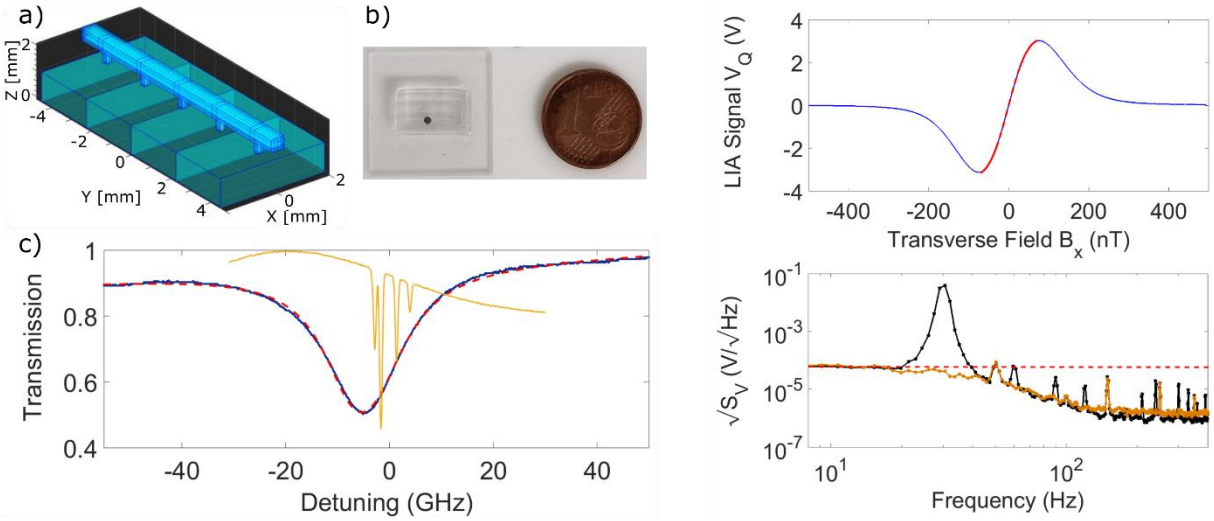

Fig. 1 Left a) Design of the LWVC with a top 9 mm-long sensing micro-channel. b) LWVC after fabrication by FLICE. c) Normalized transmission (blue) through the LWVC and a reference Rb vapor cell (yellow) evacuated to 10−8 Torr. **Right** LIA quadrature output signal (Top) and amplitude noise density (Bottom) in a ZFR-OPM using a LWVC. The LIA noise SV , converted to equivalent magnetic noise using the slope of the LIA signal, implies a magnetic sensitivity of 1pT/√Hz, shown by the red dashed line.

References

[1] V. G. Lucivero, A. Zanoni, G. Corrielli, R. Osellame, and M. W. Mitchell, "Laser-written vapor cells for chip-scale atomic sensing and spectroscopy," Opt. Express **30**, 27149-27163 (2022).

[2] A. Zanoni, K. Mouloudakis, M. C. D. Tayler, G. Corrielli, R. Osellame, M. W. Mitchell, V.G. Lucivero, "Picotesla optically pumped magnetometer using a laser-written vapor cell with sub-mm cross section," J. Appl. Phys **136**, 144401 (2024).