Laser-written vapor cells for chip-scale atomic sensing and spectroscopy

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We introduce laser-written vapor cells (LWVCs), a technology based on femtosecond laser writing followed by chemical ething (FLICE), that allows arbitrarily-shaped 3D hollow microstructures. In a first experiment [1] we demonstrate 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 $1\mathrm{pT}/\sqrt{\mathrm{Hz}}$ at 10 Hz using a zero-field-resonance (ZFR) OPM and 0.75 amg of N_2 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 frequency references.

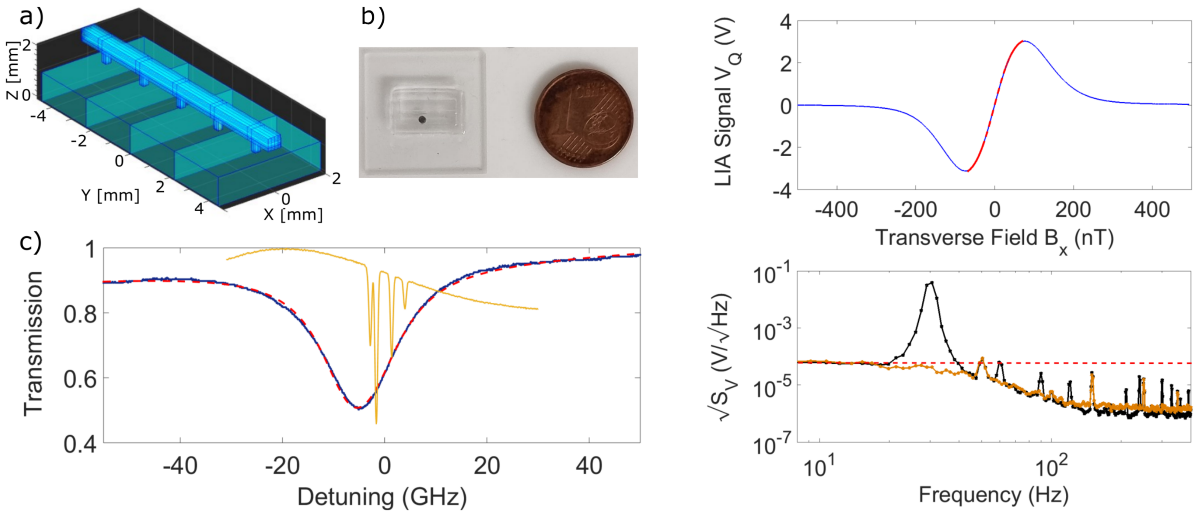

Figure 1: **Left** a) Design of the LWVC with a top 9 mm-long sensing micro-channel. b) LWVC after fabrication by FLICE. c) Normalized transmission (blue) through the LWVC and a Rb reference vapor cell (yellow) evacuated to 10^{-8} Torr. **Right** LIA quadrature output signal (Top) and amplitude noise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

[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 and V. G. Lucivero, Laser-written micro-channel atomic magnetometer, arXiv:2404.14345 (2024).