Micro-machining for vapour cell atomic sensors

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The separation of atomic energy levels provides previously unobtainable accuracy and precision in metrology, with a système international traceable reference to frequency, length, and temperature. Instrumentation that utilise atomic spectroscopy for metrology remain at the state-of-the-art for atomic clocks, magnetometers and wavelength references. On-chip atomic systems offer a simplicity and design versatility that has found application in the measurement of physical quantities such as time, length, magnetic field, and rotation, finding commercial deployment in navigation, medicine, surveyance and communication. However, the trade-offs made to scale down these early proof-of-principle apparatus have restricted the performance capabilities of field deployable atomic sensors compared to their lab-based counter-parts.

In this presentation, we will discuss our recent work on micro-machined atomic vapour cells [1,2], highlighted in Figure 1. Our simple fabrication routines not only enable rapid-prototyping outside of the clean-room environment, but also provide 6 mm optical path-lengths for an improved atom-light interaction length. Furthermore, we will discuss our implementation of the micro-machined vapour cells into sensor heads for wavelength referencing [3], magnetometry [4] and optical frequency referencing. Finally, we will discuss our recent work on integrated micro-optical components for light routing through the vapour cell.

Figure 1. The figure caption begins with "Figure 1." in bold face. The font is also Times New Roman 11pt with a line spacing of 110%.

[1] S. Dyer, P. F. Griffin, A. S. Arnold, F. Mirando, D. P. Burt, E. Riis, and J. P. McGilligan, Micro-machined deep silicon atomic vapor cells, Journal of Applied Physics, **132**, 13 (2022).
[2] S. Dyer, A. McWilliam, D. Hunter, S. Ingleby, D. P. Burt, O. Sharp, F. Mirando, P. F. Griffin, E. Riis, and J. P. McGilligan, Nitrogen buffer gas pressure tuning in a micro-machined vapor cell, Applied Physics Letters, **123**, 7 (2023).

[3] S. Dyer, K. Gallacher, U. Hawley, P. F. Griffin, A. S. Arnold, D. J. Paul, E. Riis, and J. P. McGilligan, Chip-scale packages for a tunable wavelength reference and laser cooling platform, Physical Review Applied, **19**, 4 (2023).
[4] D. Hunter, C. Perrella, A. McWilliam, J. P. McGilligan, M. Mrozowski, S. J. Ingleby, P. F. Griffin, D. P. Burt, A. N. Luiten, and E. Riis, Free-induction-decay magnetic field imaging with a microfabricated Cs vapor cell, Optics Letters, **31**, 20 (2023).