Studies on He and Ne gas permeation in microfabricated cells using Al_2O_3 coatings

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The stability of cell-based atomic devices can be affected by the evolution of the cell inner atmosphere. The use of efficient gas permeation barriers is then of significant importance to enhance the performances of these instruments.
In a recent study[1], we have demonstrated the reduction of helium permeation through the borosilicate glass (BSG) and aluminosilicate glass (ASG) of MEMS vapor cells using Al_2O_3 thin-film coatings. Similarly to previous studies targeting a lower alkali consumption[2,3], 20 nm-thick Al_2O_3 layers were used.
Here, we report how helium permeation is influenced by the thickness of the Al_2O_3 coating[4] deposited on BSG windows of the microfabricated cells. Coatings with thickness of 5, 10, 20 or 40 nm were tested. Permeation rates are derived from long-term measurements of the pressure-shifted transition frequency of a coherent population trapping (CPT) atomic clock. A strong reduction of He permeation, by about two orders of magnitude, is observed between 10 nm and 20 nm thicknesses whereas only a moderate reduction is obtained between 20 nm and 40 nm. For the best cell, with a 40 nm-thick coating, the He permeation rate is about 220 times lower than with uncoated BSG and only 1.8 times higher than for cells built with uncoated ASG windows.
Al_2O_3-coated cells with neon buffer gas have also been tested and showed a significant reduction of the permeation rate. A CPT clock, running the pulsed Symmetric Auto Balanced Ramsey (SABR) sequence[5] in such Al_2O_3-coated Cs-Ne cell is demonstrated with a fractional frequency stability of 4×10^{-12} at 1 day. Despite a long-term still limited by light-shift effects, these results are comparable with those obtained from a Cs-Ne cell made with ASG windows[5].
These results of more hermetic cells have motivated the development of Cs microcells filled with buffer gas mixtures for higher operation temperature. These cells rely on the break-seal approach described in Ref. [6]. Successive openings of reservoir cavities yield tunability of the gas mixture turnover temperature to values higher than 80 °C. Studies are still in progress. Latest results will be presented at the conference.

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