Miniature Cs vapor cells and atomic clocks in FEMTO-ST

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The present paper aims to give an overview on MEMS Cs cell technology and CPT-based clocks activities performed in FEMTO-ST over the last ten years.

Our MEMS Cs vapor cell technology, using post-sealing laser activation of a Cs pill dispenser, will be briefly presented [1-2]. Different buffer gas or buffer gas mixtures, using generally Ne buffer gas, have been proposed to cancel the temperature dependence of the Cs clock frequency around a desired inversion temperature [3]. More recently, the use of a cesium dispensing paste has been proposed and studied in detail [4]. The latter avoids the delicate manipulation of numerous individual pills during the cell wafer development and is expected to be more suitable with the mass production of such MEMS cells. The cell technology developed in FEMTO-ST has been fully transferred to a MEMS foundry and manufacturer industrial partner, whose facilities allows the production of about 500 microcells on 6-inch wafers. Some first statistics on this production will be given.

Two automated dedicated setups, developed in FEMTO-ST for tests of MEMS Cs cells, will be presented. The first one is used to perform Cs activation and linear spectroscopy of multiple buffer-gas filled MEMS cells at the wafer-level. The second setup is a specific CPT clock setup dedicated to measure the contribution onto the clock long-term fractional frequency stability of the buffer gas permeation process through the cell windows [5-6]. Such tests, under progress with various MEMS Cs cells using borofloat glass or alumina-silicate glass (ASG), including industrial cells, will be reported.

Laboratory-prototype microcell-based Cs cell atomic clocks will be presented. These clocks use VCSELs tuned on the Cs D_1 line [7]. The typical clock fractional frequency stability is measured to be $2.5 \times 10^{-11}\ \tau^{-1/2}$ up to 500 s averaging time and better than 2×10^{-11} at 10^5 s (without drift removal). A detailed short-term and mid-term stability budget, at 1 s and 1 day averaging time respectively, will be reported. The implementation of advanced electronics stabilization loops has been tested to improve the clock long-term stability.

References

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