MEMS atomic vapor cells fabrication and their performances in miniature atomic clocks

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MEMS atomic vapor cells have different applications in miniature atomic sensors such as chip-scale atomic clocks (CSACs) [1], atomic magnetometers [2] and atomic gyroscopes [3]. They consists of a microfabricated cavity sealed by transparent windows and containing an alkali metal and an optional buffer gas. Here, we review the recent developments realized at CSEM in term of design, fabrication, filling, sealing and functionalization of MEMS atomic vapor cells. Recent works on lifetime assessment of cells coated with Al_2O_3 and filled with CSEM patented method of RbN_3 UV decomposition will be presented [4]. It will be compared with filling done with dispensing micropills with Ar-Ne buffer gas mixture as alternative method. The development of Cu-Cu as alternative sealing method to anodic bonding [5] as well as work made on integrated functionalities (heating and temperature sensing) will then be described [6].

A particular focus will finally be given to the CSEM patent pending gold microdiscs. This technique allows to improve clock long-term frequency stability through preferential condensation of rubidium droplets inside the cell volume. Indeed, one of the main sources of long-term frequency instabilities in MEMS atomic vapor cell based clocks was identified to be the light power shift attributed to variation of light intensity inside the cell. These variations are attributed to alkali droplets migration within the lightpath of the interrogation laser. As a solution, gold microdiscs were proposed. These circular spots act as alkali preferential condensation zones which allows the alkali droplets to concentrated outside of the laser lightpath. Evidences of preferential condensation of Rb on Au microdiscs will be reported and the effect on the long-term frequency stability and short term dynamic frequency stability of a CPT clock setup will be discussed.

Figure 1: left: Cell filled by dispensing micropill and containing Au microdiscs - right: Cell filled by RbN_3 UV decomposition with integrated functionalities

[1] L. Liew et al., APL **84**(14) (2004)
[2] P. Schwindtet al., APL **85**(26) (2004)
[3] E. Donley, proceedings of SENSORS 2010 (2010)
[4] S. Karlen et al., Opt. Express **25**(3) (2017)
[5] S. Karlen, PhD Thesis (2018) http://doc.rero.ch/record/308907
[6] T. Overstolz et al., proceedings of MEMS'14 (2014)