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MEMS atomic standards

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Atomic standards enables very precise control of time and frequency (atomic clocks), as well as high precision of magnetic field measurements. Research on miniature atomic references utilized MEMS alkali atom cell, are conducted in several research groups. The common motivation to work on this topic is growing demand on high precision and equate time and frequency references, mostly for telecommunication (terrestrial base stations for GSM), global navigation satellite systems (GNSS), but also to develop highly sensitive magnetometers. To achieve market success, atomic standards must comply with the good parameters and be mass produced to give a low price. It is possible in way of miniaturization and integration utilized microengineering technology.

Miniaturized atomic standards are based on optically pumped miniature cell filled with alkali atoms vapor (Rb, Cs) and utilized the CPT effect (***C****oherent* ***P****opulation* ***T****rapping*) [1]. Optical cells of about few cubic millimeters are made of silicon and glass wafers hermetically sealed usually by the use of the anodic bonding process. Optical devices like VSCEL laser, photodiode, quarter-wave plate and the alkali atoms vapor cell are integrated toward ~1 cm^3 MOEMS device (***M****icro*-***O****pto*-***E****lectro*-***M****echanical* ***S****ystem*) Based on this technology several CSAC's (***C****hip* ***S****cale* ***A****tomic* ***C****locks*) has been developed. Some of them are available on market.

Lately, a new version of optical clocks has been presented and possibility of their miniaturization has been discussed [2]. In this clocks – called as cool-atom clocks – light is absorbed inside an optical cell fulfilled with the cooled to micro-Kelvin range vapors of alkali atoms (Rb / Cs). The critical issue of miniaturization of cold-atoms clocks is strong demand on a quality of a vacuum kept inside cell, usually in range of $10^{-6} \div 10^{-7}$ hPa.

In our presentation, a miniaturized MEMS optical Rb/Cs cell with the on-chip integrated source of alkali atoms, as well as micropumping unit able to ensure at least 10^{-7} hPa vacuum level inside the cell, will be shown for the first time ever. First tests have indicated promising features of this solution dedicated toward micro-cold-atom atomic clocks.

References

[1] B. J. Dalton, R. McDuff, P. L. Knight, „Coherent Population Trapping'', Jurnal of Modern Optics, 32: 1, pp. 61-70

[2] F.-X. Esnault, E. Blanshan, E. N. Ivanov, R. E. Scholten, J. Kitching, E. A. Donley, "Cold-atom double-Λ coherent population trapping clock, Physical Review A 88, 042120, 2013