Wafer-scale fabrication of MEMS atomic vapor cells

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CSEM started the development of MEMS atomic vapor cell fabrication for miniature atomic clock applications about 12 years ago. Right from the beginning, the selection of the fabrication process has been made such that it remains compatible with low-cost wafer level production, while still meeting the atomic clock performance requirements.

CSEM's baseline approach for the fabrication of MEMS atomic vapor cells relies mainly on anodic bonding and alkali azide filling, as patented in [1]. The fabrication process was continuously improved, both in terms of reliability and long-term frequency stability performances [2]. The cells, with integrated heating and temperature sensing, meet commercial atomic clock requirements in terms of size, costs and long-term performances, with measured relative frequency drift lower than $1 \cdot 10^{-11}$/day.

CSEM's MEMS atomic vapor cells were successfully integrated in a novel flat form factor ceramic based miniature atomic clock physics packages having a height of less than 5 mm [3], and they are currently being integrated in a commercial type CPT clock within the Quantum Flagship project macQsimal [4].

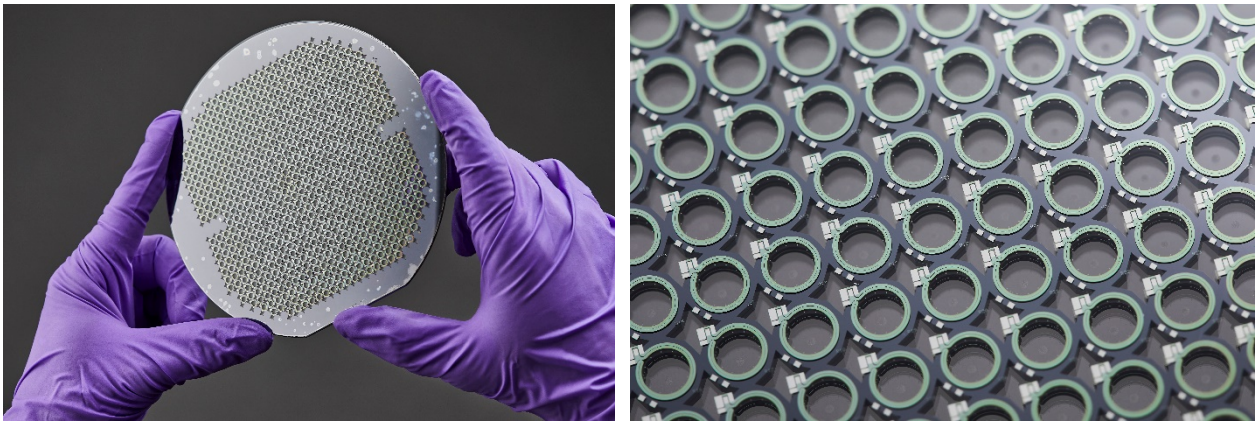

Figure 1. 6-inch wafer with more than 700 cells per wafer. Typical single atomic clock vapor cells are 4 x 4 x 1.9 mm^3 in size, with integrated Pt heaters.

Customized MEMS atomic vapor cells have also been fabricated at the wafer-scale within the macQsimal projects for different types of Quantum sensors like magnetometers, gyroscopes, GHz/THz sensors and imagers, as well as gas sensors.

[1] US patent US 8,906,470 B2 (2011)
[2] S. Karlen, PhD Thesis (2018) – http://doc.rero.ch/record/308907
[3] J. Haesler et al., Proceedings GNSS / Galileo, Valencia (2017)
[4] https://www.macqsimal.eu/