

## SILOSCAPE—a Novel Silicon-based FlexTech Watch Escapement

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*Using micro-manufacturing techniques inherited from the microelectronics industry, it is possible to batch process with a micrometric precision, centimeter scale silicon parts featuring extremely fine mechanical functions. High precision mechanical watch can particularly benefit from this approach which fosters the emergence of novel ideas and allows their concretization at the watch scale. CSEM has always played a pioneering role in this field and aims at becoming the Swiss Competence Center for the design, manufacturing, assembly, and characterization of hybrid silicon based innovative watch micro-mechanisms. In the Frame of the SILOSCAPE MIP, a novel escapement has been invented, designed, produced and integrated in a watch caliber; its functionality has been validated through a first characterization campaign.*

Silicon is amagnetic, corrosion free and characterized by an ideal elastic behavior, a high fracture strength and a low density. Using microfabrication techniques inherited from the microelectronic industry (DRIE), it can be batch processed in 2.5D with a micrometric precision for the production of large quantities of centimeter scale mechanical parts that can comprise several levels and fine mechanical functions such as flexure blades. It is because of to the combination of all these interesting features that silicon has progressively opened up new opportunities for the design and production of novel and innovative watch mechanisms.



Figure 1: Assembly of the SILOSCAPE escapement in a watch caliber.

In the late 90's CSEM was a precursor in this field<sup>[1]</sup>, paving the way for a new trend that is now followed by several key players in the Swiss watch industry. Since then CSEM has kept carrying on its pioneering work by pushing back the frontiers of the micromechanical structuration of silicon and by improving its mastery of the production of such delicate parts<sup>[2,3,4]</sup>.

The oscillator and the escapement are the most delicate and high added-value technical parts of a mechanical watch. For the past ten years, CSEM has proposed several original designs of mechanical watch oscillators and, in a close partnership with Vaucher Manufacture Fleurier, integrated at the watch level, the very original FlexTech and silicon-based Genequand<sup>[5]</sup> escapement, the very first in its kind. The SILOSCAPE escapement is the last FlexTech based escapement designed and produced by CSEM (Figures 1 and 2).



Figure 2: SILOSCAPE escapement (right) integrated in a watch caliber (left).

Like the Genequand escapement, the SILOSCAPE escapement is based on the use of flexure blade pivots, replacing conventional ruby pivots and allowing very precise and frictionless oscillations of the guided components. Paired with a Wittrick oscillator and comprising a total of four monolithic silicon parts, from the escapement wheel to the oscillator, this original escapement is assembled by a mixed of wafer level and manual assembly technics. The SILOSCAPE escapement features a high-power reserve (typically three times higher than conventional Swiss anchor escapements) and, when subject to external perturbations causing it to halt, it can instantly restart by itself using the torque provided by the escapement wheel, behaving therefore similarly to the classical Swiss anchor escapement. As far as its isochronism is concerned, it is expected to be comparable to a Swiss anchor escapement but a fine tuning mechanism is required to set it properly; this mechanism is directly integrated in the escapement itself so that, in the end, no additional part is required.

The experimental tests carried out on the first prototypes allowed the validation of the intrinsic auto-starting specificity of the SILOSCAPE escapement. A design update is still required to better tune/compensate the isochronism; a solution has been found and is ready to be implemented on the next run of parts. The next steps required to fully validate the last main design iteration are: a shock analysis leading to a specific anti-shock design, the integration of all these updated parts in a watch caliber and a full characterization campaign similar to the procedure followed by watch makers when they want to validate a new design prior to its industrialization.

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