HybSi—Silicon Hybridization Process for Watch Industry and Precision Mechanisms

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Centimeter scale high precision mechanisms and systems can greatly benefit from the high precision micro-structuration of silicon and its good mechanical properties. Important Swiss industrial sectors such as the watch industry and scientific instrumentation are particularly concerned by this approach which is opening up new opportunities. However, silicon being a brittle material, its handling and its assembly with other materials is a true hybridization challenge. Combining its expertise in the domains of precision mechanisms and micro-manufacturing techniques, CSEM is taking up the challenge to become the Swiss competence center for the design, manufacturing, assembly and characterization processes of hybrid silicon based micro-mechanisms.

Using microfabrication techniques inherited from the microelectronic sector, it is possible to produce, with a micrometric precision, large quantities of centimeter scale mechanical parts made out of silicon, also referred to as MacroMEMS. Sectors such as the watch industry can benefit from this approach [1] which does not only offer an alternative option for the production of precise parts, but also opens up new opportunities for innovations [2]. However, due to the brittleness of silicon, its handling and assembly with other materials is a delicate task.

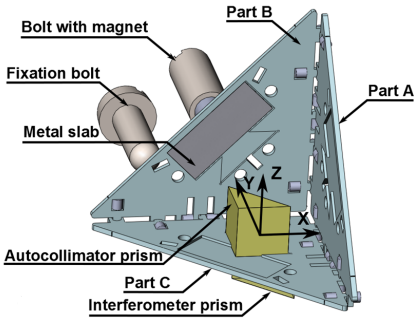

Figure 1: 6 DOF repeatability measurement of 3D puzzle like assembly of centimeter scale silicon parts.

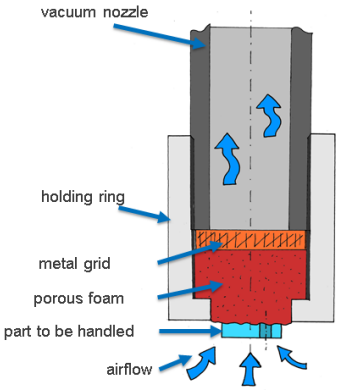

Figure 2: Proposed gripper for the handling of fragile silicon parts.

CSEM has been working on this hybridization challenge over the past few years. As far as the assembly is concerned, a 3D assembly methodology (Figure 1) based on a puzzle like assembly approach with interconnection features directly integrated in the design of silicon parts has been implemented and experimentally validated. With this approach it has been shown that a challenging 3D assembly of silicon parts can be achieved with submicron repeatability [3].

As far as the handling his concerned, a gripper design has been proposed (Figure 2) for the handling of delicate MacroMEMS silicon parts, such as those comprising flexure hinges. The concept is based on a vacuum gripper featuring a foam interface to avoid damaging the part during manipulation. Coupled with a vision system to detect the orientation of the handled part, this micromanipulation strategy paves the way towards a semi-automated assembly of MacroMEMS.

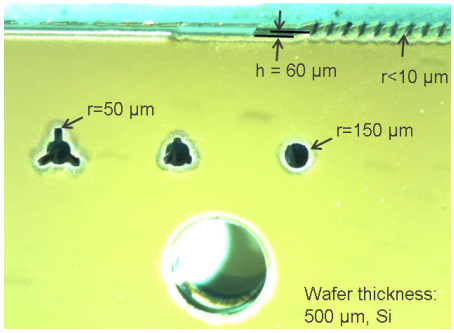

Figure 3: MacroMEMS laser micromachining.

Besides assembly and handling of MacroMEMS parts, CSEM has also investigated the potential of laser micromachining for fast prototyping of silicon based MacroMEMS parts. This serial production approach is not a substitute to the classical DRIE (Deep Reactive Ion Etching) approach; the idea is to offer an alternative to DRIE for the fast production of small quantities of MacroMEMS parts made out of silicon. The first machining tests show the potential of the approach (Figure 3): small size mechanical features that could be found in a watch mechanism have been successfully machined with a surface roughness Ra of 170 nm.

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[1] S. Jeanneret, A. Dommann, N. F. de Rooij, “Procédés de micro-fabrication avec application horlogère, développements récents”, SSC, 2008

[2] F. Barrot, P. Genequand, I. Kjelberg, T. Hamaguchi, “Un nouveau régulateur mécanique pour une réserve de marche exceptionnelle”, SSC, 2014

[3] J. Kruis, P. Gentsch, P. Theiler, F. Barrot, F. Cosandier, S. Henein, “6 DOF repeatability measurement setup for measuring position of assembled silicon parts with nanometric resolution”, EUSPEN, 2015