Subproject C2: A Novel High Aspect Ratio Technology for MEMS Fabrication Using Standard Silicon Wafers

Gessner, Thomas[1,2]; Ebest, Gunter[3]
[1] Fraunhofer-IZM Chemnitz, Department MD & E
[2] TU Chemnitz, Fakultät für Elektrotechnik und Informationstechnik, Professur Mikrotechnologie
[3] TU Chemnitz, Fakultät für Elektrotechnik und Informationstechnik, Professur Elektronische Bauelemente

1 Introduction

The development of a novel CMOS compatible technology for the fabrication of high aspect ratio microstructures (HARMs) is part of the Collaborative Research Center 379. First prototypes of *"Air gap insulated Microstructures (AIM)"* were manufactured and characterized in the third period of the project, presented elsewhere [1, 2].
According to the objectives of subproject C2 within the first year of the last funding period there are technology as well as application issues to be considered. Exemplary a description of the progress achieved will be given in the following.

2 Technology developments

The continuing development in the field of anisotropic silicon etching is resulting in increasing aspect ratios of etched trenches. Especially HARMs technology may profit form these results of research. To transfer the advantages of the increased aspect ratio to the AIM technology, the deposition process of the CF-polymer, the release etch and the final highly parallel isotropic silicon etch process for the removal of silicon underneath the interconnection beams has to be adapted.

2.1 CF plasma polymer for release etching

The deposition characteristic of CF-polymers on the sidewalls of deep silicon trenches depends on the process parameter and is strongly affected by transport mechanism inside the trenches. For high aspect ratio trenches, a breakdown of the passivation layer could be observed while the sidewalls of lower aspect ratio trenches are free of any defects (Fig. 1).

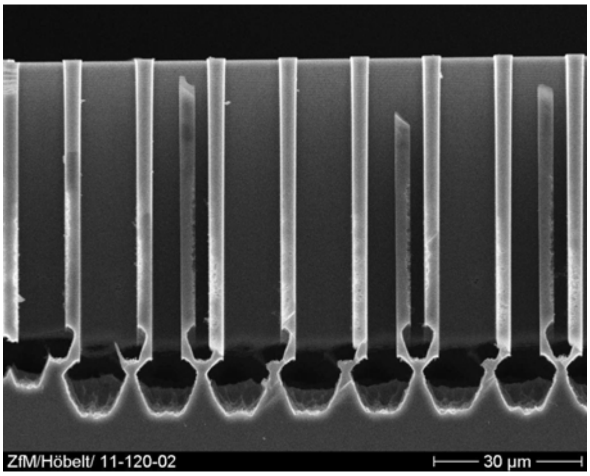

Fig. 1: Aspect ratio depending quality of the passivation layer consisting of a CF-polymer

2.2 Process optimization

For the fabrication of 50 µm high silicon structures, using trenches with an aspect ratio up to 16:1, an optimization of the existing deposition process, release etch and the highly parallel isotropic silicon etch were necessary. The results can be seen in Fig. 2, which is a SEM-picture of a part of an inclination sensor with a structure height of about 55µm.

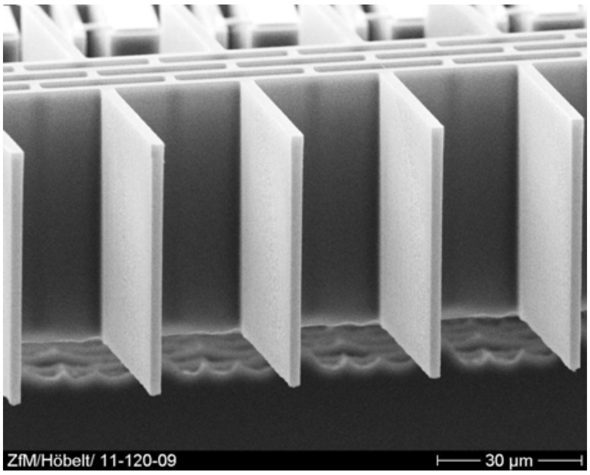

Fig. 2: SEM-picture: cross section of a silicon structure

3 Devices fabricated

Exemplarily, a sensor and a sensor-actuator system fabricated by the AIM technology are presented:

3.1 Large area sensor-actuator

In order to get an impression of the capability of the AIM principle, an electrostatically driven system for AFM-applications has been designed and fabricated. It includes a one-axis actuator enabling a large positioning range, a separate actuator for generating oscillation and a capacitive sensor (Fig. 3). It is comparable to former developments based on the SCREAM technology.

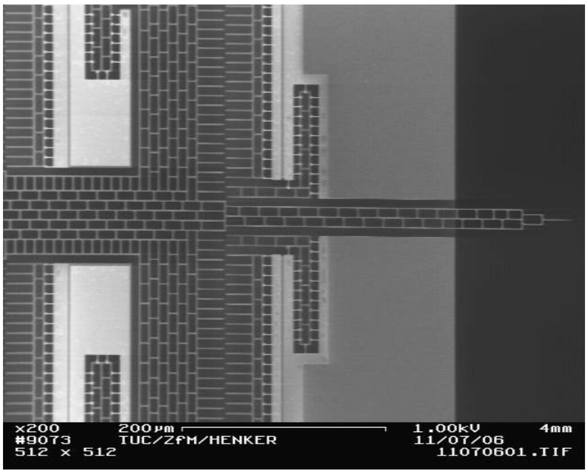

Fig. 3: SEM-picture of a large area sensor-actuator

As expected, when using the AIM technology there was no out-of-plane deformation detected like before. The system has been tested for actuation voltages up to 40 V. The long-term behaviour of the system has been controlled by measuring the mechanical resonance too. No significant shift of the resonance frequency is detected indicating that there is no creep fatigue.

3.2 *Low-g* inertial sensor

A *low-g* inertial sensor has been chosen as a second device for AIM technology evaluation because it is a very sensitive and fragile system during fabrication as well as application. Due to the low spring constant "sticking" during fabrication as well as in operation is a serious issue (Fig.4).

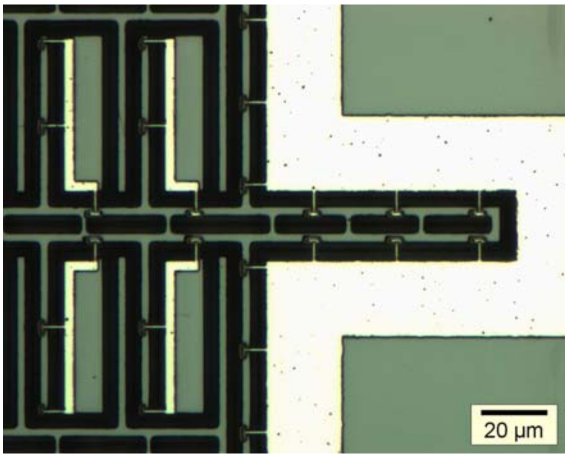

Fig. 4: Top view (detail) on fixed electrode and seismic mass of a low-g sensor fabricated by AIM technology

Throughout dry processing and respecting the existing design rules is a guarantee to avoid sticking. Meanwhile a proven technology is available offering a high yield and device applications for inclination measurements as shown in Fig. 5.

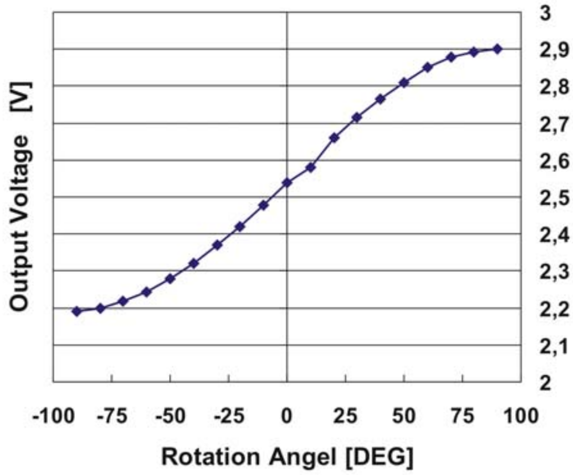

Fig. 5: Output vs. rotation of low-g sensor (GEMAC: CV2 ASIC and measurements)

References

[1] Bertz, A.; Küchler, M.; Knöfler, R.; Gessner, T.: *A novel high aspect ratio technology for MEMS fabrication using standard silicon wafers*, Sensors and Actuators A 97-98 (2002) pp. 691-701.

[2] Lohmann, C.; Bertz, A.; Kuechler, M.; Gessner, T.: *Mechanical reliability of MEMS fabricated by a special technology using standard silicon wafers*, Presentation at the Photonics West (SPIE Conference 4980), San Jose, USA, Jan. 2003