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SiGe MEMS Technology: a Platform Technology Enabling Different Demonstrators

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In imec's 200mm fab a dedicated SiGe above-IC MEMS platform has been set up to integrate MEMS and its readout and driving electronics on one chip. This monolithic approach results in more compact systems with a reduced assembly and packaging cost and a higher performance than current hybrid systems. The SiGe MEMS platform (Figure 1) consists of a number of standard modules (CMOS protection layer, MEMS via and poly-SiGe electrode, anchor and poly-SiGe structural layer and a thin-film poly-SiGe packaging module) which can be processed at ~450ºC above standard CMOS. Optional (optical, piezoresistive, probes,...) modules can be added depending on the functionality that is needed.

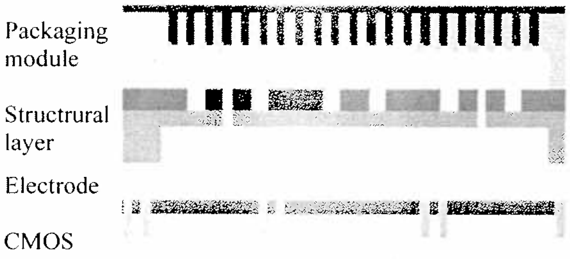

Figure 1: Above-IC SiGe MEMS platform

With this platform, several successful demonstrators have been built already. Examples are an integrated gyroscope for automotive applications [1], a reliable 11 megapixel micro-mirror array for high-end industrial applications (Figure 2, [2]) and a cantilever array for probe-based data storage [3].

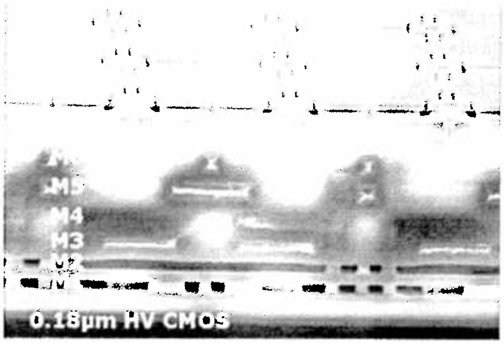

Figure 2: Cross-section of integrated mirror array, showing the mirrors (SG1, electrode and SG2, structural layer) on top of 6 layers of Al interconnect(M1-M6).

In the Flemish project Gemini [4] the possibilities of this platform have been further explored together with the project partners. In Gemini three different demonstrators are realized: mirrors for display applications, grating light valves (GLV) and accelerometers.

The novel Gemini mirror design relies on 6 electrodes and uses 2 possible electrode thicknesses of the SiGe platform (Figure 3). Two out of the six electrodes serve as landing electrodes. The other four attracting electrodes are driven by two anti-phase saw tooth signals and two fixed analog voltage signals. By applying this signal scheme, the duty cycle of the mirror is modulated in an analog way. Laser Doppler Vibrometer measurements have confirmed the feasibility of analog Pulse Width Modulation for 15 µm wide SiGe micro-mirrors

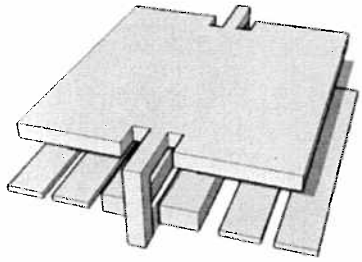

Figure 3 : Novel Gemini mirror

The Gemini GLV microbeams are clamped-clamped beams suspended over an electrode, which can modulate the intensity of the diffracted light when an actuation voltage is applied to half of the beams (Figure 4).

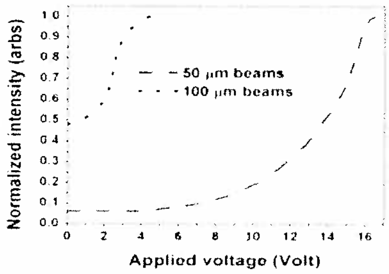

Figure 4: Change in 1st order diffraction intensity with actuation voltage

Whereas the mirrors and GLVs are realized with a 300 nm thick SiGe structural layer (+ optional 5nm SiC/30 nm Al coating for improved reflectivity), the SiGe structural layer thickness for the accelerometers is 4µm to improve the capacitive readout of in-plane devices. Both in-plane and out-of plane low-g accelerometers are made (Figure 5). Measurements of a fabricated out-of-plane accelero-meter show that this device can sense the gravitation projection to the main sensing axis with an average sensitivity of 0.5 mV/°.

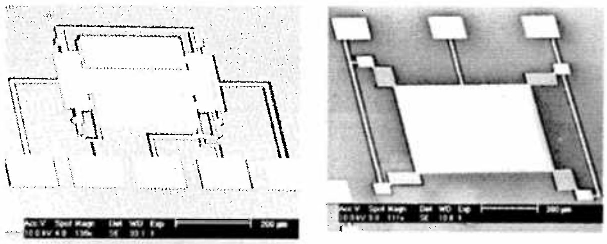

Figure 5: In-plane (left) and out-of-plane (right) SiGe accelerometer

In conclusion, the new demonstrators realized in the Gemini project reconfirm the generic nature of the SiGe MEMS platform.

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