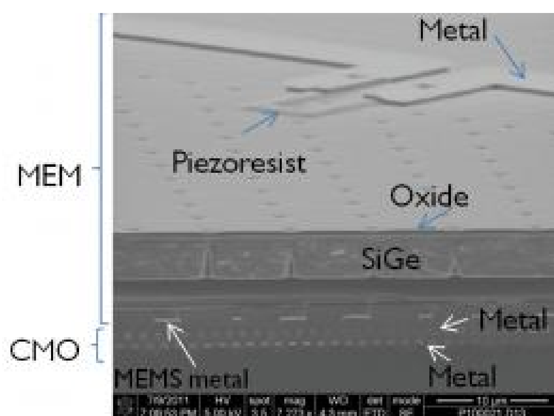
Imec demonstrates CMOS integrated poly-SiGe piezoresistive pressure sensor

October 11 2011



Cross-section SEM picture of the integrated sensor. At the bottom, the two Cu metal lines of the CMOS circuit can be observed. Above, the MEMS layers (the poly-SiGe membrane and piezoresistors, the oxide sealing layer and the metal interconnects) are visible.

Imec realized an integrated poly-SiGe-based piezoresistive pressure sensor directly fabricated above 0.13 µm copper (Cu) -backend CMOS technology. This represents not only the first integrated poly-SiGe pressure sensor directly fabricated above its readout circuit, but also the first time that a poly-SiGe MEMS device is processed on top of Cu-backend CMOS.

Polycrystalline SiGe has emerged as a promising MEMS structural material since it provides the desired mechanical properties at lower

temperatures compared to poly-Si, allowing the post-processing on top of CMOS. The MEMS-last approach is the most interesting approach for CMOS-MEMS monolithic integration as it leads to smaller die areas and enables integrating the MEMS without introducing any changes in standard foundry CMOS processes. Comparing to alternative technologies, for example using the CMOS top interconnect layers to fabricate the MEMS device, poly-SiGe offers a more generic and flexible technology for above CMOS integration, thanks to the fact that the MEMS fabrication can be completely decoupled from the CMOS fabrication.

In the past, imec already proved the potential of poly-SiGe for MEMS above-aluminum-backend CMOS integration. However, aggressive interconnect scaling has led to the replacement of the traditional aluminum metallization by copper metallization, due to its lower resistivity and improved reliability. Our results now broaden the applications of poly-SiGe to the integration of MEMS with the advanced CMOS technology nodes.

Our integrated sensor (fully fabricated in imec) includes a surface-micromachined piezoresistive pressure sensor, with a poly-SiGe membrane and four poly-SiGe piezoresistors, and an instrumentation amplifier fabricated using imec's 0.13 µm standard CMOS technology, with Cu- interconnects (two metal layers), oxide dielectric and tungsten-filled vias. To enable above-CMOS integration the maximum processing temperature of the complete sensor, including the poly-SiGe piezoresistors, is kept below 455°C. Moreover, an appropriate passivation layer was included to protect the electronic circuit from the aggressive etch and deposition steps needed to fabricate the MEMS devices. The CMOS circuit showed no significant deterioration after the MEMS processing. Despite the low processing temperature, the poly-SiGe piezoresistive sensor alone (250x250µm2 membrane) showed a sensitivity of around 2.5 mV/V/bar. The integrated sensor (same sensor

+ Cu-based CMOS amplifier underneath) showed a sensitivity of about 158 mV/V/bar, ~64 times higher than the stand-alone sensor.

Provided by IMEC

Citation: Imec demonstrates CMOS integrated poly-SiGe piezoresistive pressure sensor (2011, October 11) retrieved 25 April 2024 from https://phys.org/news/2011-10-imec-cmos-poly-sige-piezoresistive-pressure.html

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