

**SiGe MEMS Technology: a Platform Technology Enabling Different Demonstrators**

A. Witvrouw<sup>1</sup>, R. Van Hoof<sup>1</sup>, G. Bryce<sup>1</sup>, B. Du Bois<sup>1</sup>, A. Verbist<sup>1</sup>, S. Severi<sup>1</sup>, L. Haspeslagh<sup>1</sup>, H. Osman<sup>1</sup>, J. De Coster<sup>1</sup>, L. Wen<sup>2</sup>, R. Puers<sup>1,2</sup>, R. Beernaert<sup>3</sup>, H. De Smet<sup>3</sup>, S. Rudra<sup>4</sup>, D. Van Thourhout<sup>4</sup>

<sup>1</sup>Imec, Leuven, Belgium, <sup>2</sup>MICAS, KUL, Leuven, Belgium, <sup>3</sup>CMST, UGent, Zwijnaarde, Belgium, <sup>4</sup>Intec, UGent, Gent, Belgium

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 ~450°C above standard CMOS. Optional (optical, piezoresistive, probes,...) modules can be added depending on the functionality that is needed.

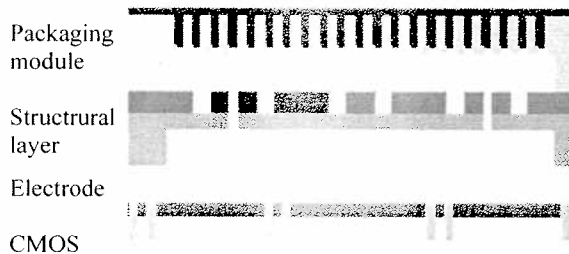


Figure 1: Above-IC SiGe MEMS platform

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].

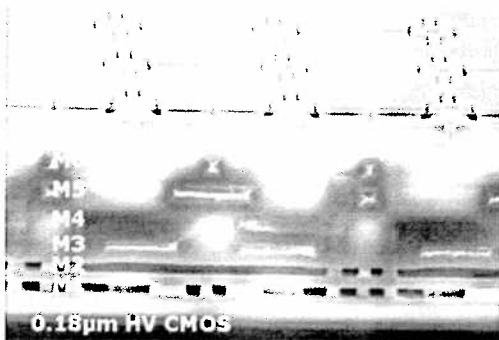


Figure 2: Cross-section of integrated mirror array, showing the mirrors (SG1, electrode and SG2, structural layer) on top of 6 layers of Al interconnect(M1-M6).

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

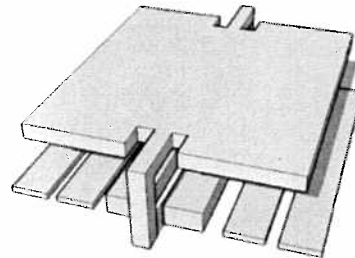


Figure 3: Novel Gemini mirror

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).

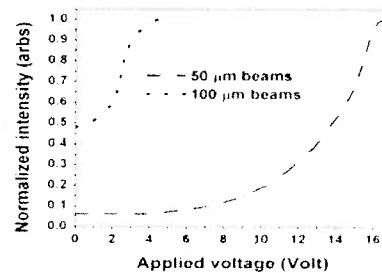


Figure 4: Change in 1st order diffraction intensity with actuation voltage

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 accelerometer show that this device can sense the gravitation projection to the main sensing axis with an average sensitivity of 0.5 mV/°.

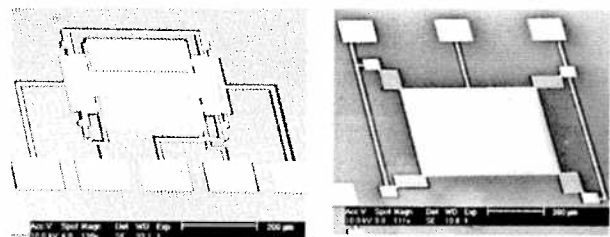


Figure 5: In-plane (left) and out-of-plane (right) SiGe accelerometer

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

REFERENCES

1. A. Schreurler et al., Proc. IEEE MEMS 07, 39 (2007).
2. A. Witvrouw et al., *JMEMS* **19** (1), 201, (2010).
3. J. Heck et al., *Microel. Eng.* **87**, 1198, (2010).
4. IWT-SBO project "GEMINI" ("Generic Electronics and Microsystems INtegration Initiative"), IWT-nr 60046,

- 1936 Diffusion and Interface Segregation of Phosphorus and Boron in Bulk Germanium and Germanium Nanomembranes  
T. Liu, C. Ndoye, and M. Orłowski
- 1937 SiGe MEMS Technology: A Platform Technology Enabling Different Demonstrators  
A. Witvrouw, R. Van Hoof, G. Bryce, B. Du Bois, A. Verbist, S. Severi, L. Haspeslagh, H. Osman, J. De Coster, L. Wen, R. Puers, R. Beernaert, H. De Smet, S. Rudra, and D. Van Thourhout
- 1938 Elastic Strain Engineering in Si Nanomembranes  
D. Paskiewicz, S. Scott, D. Savage, and M. Lagally
- 1939 Functionalized Back-End Devices for (Bi)CMOS Circuits  
C. Wenger, C. Walczyk, M. Lukosius, D. Wolansky, and P. Santos
- 1940 Epitaxial Growth of III-Nitrides on Silicon Substrates  
S. Degroote, M. Leys, K. Cheng, B. Sijmus, J. Derluyn, G. Borghs, and M. Germain
- 1941 High Quality Epitaxial Growth of GaAs<sub>y</sub>P<sub>1-y</sub> Alloys on Si<sub>1-x</sub>Ge<sub>x</sub> Virtual Substrates  
P. Sharma, M. Bulsara, and E. Fitzgerald
- 1942 Direct Heterointegration of III-V Materials on Group IV Substrates  
D. Ahmari
- 1943 Epitaxial Formation of Graphene on Si Substrates: From Heteroepitaxy of 3C-SiC to Si Sublimation  
M. Suemitsu
- 1944 Novel SiGe Source/Drain for Reduced Parasitic Resistance in Ge NMOS  
S. Raghunathan, T. Krishnamohan, and K. Saraswat
- 1945 Non-Contact and Non-Destructive Measurement of Ge and B Content in Si<sub>1-x</sub>Ge<sub>x</sub>/Si Using Very High Resolution Multiwavelength Raman Spectroscopy  
W. Yoo, T. Ueda, T. Ishigaki, and K. Kang
- 1946 X-ray Microdiffraction Study on Crystallinity of Micron-Sized Ge Films Selectively Grown on Si(001) Substrates  
K. Ebihara, S. Harada, J. Kikkawa, Y. Nakamura, A. Sakai, G. Wang, M. Caymax, Y. Imai, S. Kimura, and O. Sakata
- 1947 Interface Reaction and Rate Enhancement of SiGe Thermal Oxidation  
T. Shimura, Y. Okamoto, D. Shimokawa, T. Inoue, T. Hosoi, and H. Watanabe
- 1948 Misfit Stress Relaxation Mechanism in GeO<sub>2</sub>/Ge Systems: A Classical Molecular Simulation Study  
T. Watanabe, T. Onda, and I. Ohdomari
- 1949 Chemical Trend of Schottky-Barrier Change by Segregation Layers at Metal/Si Interfaces: First-Principles Study  
T. Nakayama, S. Sotome, and K. Kobinata
- 1950 III-V Photovoltaics: Recent Developments and Prospects  
N. Sosa, T. van Kessel, Y. Martin, and H. Hovel
- 1951 Ge/III-V Heterostructures and Their Applications in Fabricating Engineered Substrates  
Y. Bai and E. Fitzgerald
- 1952 Selective Epitaxial Growth of III-V Semiconductor Heterostructures on Si Substrates for Logic Applications  
N. Nguyen, G. Wang, N. Waldron, G. Winderickx, G. Brammertz, M. Leys, K. Lismont, J. Dekoster, R. Loo, M. Meuris, S. Degroote, M. Caymax, O. Féron, F. Buttitta, B. O'Neil, J. Lindner, F. Schulte, B. Schineller, and M. Heuken

# 218

Copyright © 2010 The Electrochemical Society  
All rights reserved. Published by The Electrochemical Society

This CD-ROM is protected by the United States copyright law, other copyright laws, and international treaties. Making copies of the CD-ROM for any reason is prohibited.

Individual articles may be downloaded for personal use; single printed copies may be made for use in research and teaching. Redistribution or resale of any material on the CD-ROM in machine-readable or any other form is prohibited. Reproduction of articles, beyond that permitted by copyright law, requires payment made to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923.

For classroom use fees contact CCC's Academic Permissions Service. Permission is granted to quote from the Meeting Abstracts with the customary acknowledgment of the source. To reprint a figure, table, or other excerpt requires permission from ECS in addition to the consent of one of the authors.



**The Electrochemical Society**

65 South Main Street, Pennington, New Jersey 08534-2839 USA

Tel 609 737 1902 • Fax 609 737 2743

Web [www.electrochem.org](http://www.electrochem.org)  
E-mail [ecs@electrochem.org](mailto:ecs@electrochem.org)

ISSN 2151-2035 (CD-ROM), ISSN 2151-2043 (online),  
ISSN 2152-8365 (USB), ISSN 1091-8213 (print)



# Las Vegas

218th ECS Meeting

October 10-15, 2010  
Nevada

## Meeting Abstracts MA 2010-02

*Click on any of the following links:*

**About this Disc or Device**

**Table of Contents**

**Help**