Enhancement of Technology Readiness Level of Piezoresistive 2D $PtSe_2$ Pressure Sensors on CMOS Circuits and on Wafer Scale

Sebastian Lukas[1]
Nikolas Dominik[2], Arne Quellmalz[3,4], Nico Rademacher[5], Sofía Cruces[1], Michael Gross[1], Eva Desgué[6], Stefan Heiserer[2], Maximilian Prechtl[2], Oliver Hartwig[2], Cormac Ó Coileáin[2], Tanja Stimpel-Lindner[2], Pierre Legagneux[6], Arto Rantala[7], Juha-Matti Saari[7], Miika Soikkeli[7], Georg S. Duesberg[2], Max C. Lemme[1,5]
[1]Chair of Electronic Devices, RWTH Aachen University, 52074 Aachen, Germany, [2]Institute of Physics & SENS Research Centre, University of the Bundeswehr Munich, 85577 Neubiberg, Germany, [3]Division of Micro- and Nanosystems, School of Electrical Engineering and Computer Science, KTH Royal Institute of Technology, 100 44 Stockholm, Sweden, [4]In2great Materials AB, 113 24 Stockholm, Sweden, [5]AMO GmbH, Advanced Microelectronic Center Aachen, 52074 Aachen, Germany, [6]THALES R&T, 91767 Palaiseau, France, [7]VTT Technical Research Centre of Finland Ltd, FI-02044 VTT, Espoo, Finland
sebastian.lukas@eld.rwth-aachen.de

In recent years, 2D materials have been studied as sensing materials in microelectromechanical systems (MEMS), such as pressure sensors, microphones, or accelerometers, due to their extraordinary mechanical and electronic properties. [1,2] Here, we report on substantial progress in the utilization of platinum diselenide ($PtSe_2$) as suspended piezoresistive membranes with only ~60 nm polymer support layers in small-footprint, high-sensitivity gas pressure sensors. The pressure sensors employ few-nanometer thin, large-scale-synthesized $PtSe_2$ from thermally assisted conversion (TAC), molecular beam epitaxy, or metal-organic chemical vapor deposition. The thin films' electrical and piezoresistive properties are characterized and correlated with their performance in the sensors, revealing dependencies on both the piezoresistive membrane diameter and the piezoresistive gauge factor of the $PtSe_2$. Furthermore, the potential for sensor devices with very small dimensions is demonstrated by downscaling the sensor layout and significantly enhancing the area-normalized sensitivity. The small-footprint $PtSe_2$ sensors are fabricated on commercially acquired CMOS substrates and the sensor read-out is performed through the CMOS circuitry. [3,4] Lastly, TAC synthesis of $PtSe_2$ is scaled up to 100 mm wafers. $PtSe_2$ transfer as well as subsequent sensor device fabrication is performed on 150 mm wafer scale using a modified wafer-bonding-based transfer approach [5] and stepper lithography for $PtSe_2$ and metal contact structuring. The approach results in high yields of suspended $PtSe_2$ membranes with up to 100 µm diameter in highly-sensitive pressure sensors and showcases the possibility of integrating the technology into commercial MEMS manufacturing.

Acknowledgements: The authors acknowledge funding from the German BMBF through ForMikro-NobleNEMS (16ES1121), from the European Union through Graphene Flagship Core 3 (881603) and VITAL-SENSE (dtec.bw via NextGenerationEU), from the DFG through 2D-NEMS (LE 2441/11-1), and from the French ANR through 2DonDemand (ANR-20-CE09-0026).

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Figures

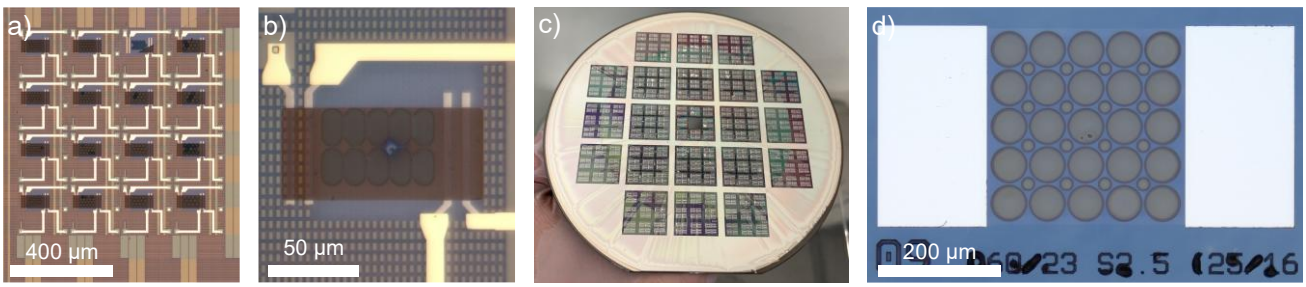

Figure 1: (a-b) $PtSe_2$ pressure sensors on CMOS chip. (c-d) $PtSe_2$ pressure sensors on 150 mm wafer.