Development of New Micro- and Nano- Bio- and Environmental SOI-Sensors in UCL

L. Moreno-Hagelsieb, R. Pampin, O. Bulteel, B. Olbrechts, N. André, B. Rue, J.-P. Raskin, D. Flandre

Research centre in micro- and nano-scale materials and electronics devices (CeRMiN) Université catholique de Louvain, Louvain-la-Neuve, Belgium

It is very well known that SOI-CMOS integrated circuits yield quasi-ideal properties for micropower and RF functionalities, as well as for high-temperature operation up to e.g. 350°C. In our laboratory, high-performance SOI sensors have also been developed. Recent experiments targeted, on one hand, thin-film silicon sensors such as high-efficiency UV-light photodiode (for $\lambda < 400$ nm, and very low dark current) or high signal-to-noise ratio Hall magnetic transducers, and on the other hand, physical/chemical sensors using micromachining technologies, that can be used in health monitoring, biological and environmental detections.

Our SOI technology has demonstrated optimal reliability vs. thermal insulation trade-off for microheater-based gas-flow smart sensors. Our microheater demonstrated a record low-power consumption of 25 mW only to reach 400°C. For gas composition measurements, a sensitive layer (typical a metal oxide) as well as interdigitated electrodes (Au or Pt) are further integrated above the microheater; while for flow sensors, thermopiles are implemented aside the membrane. For pressure sensors, high-sensitivity SOI MOS piezoresistors and CMOS ring oscillators have been demonstrated on 1 µm thin membranes.

To address the growing interest for 3-D out-of-plane micro-sensors and actuators, we have designed interdigitated capacitive thermal sensors made in aluminum over silicon nitride, released by etching the silicon of the SOI wafer. Long cantilevers curvatures were measured and characterized for various temperatures. Due to the thermal coefficients mismatch of the materials composing these multilayer cantilevers, large deflections can be observed and sensed via a capacitive or piezoelectric transducer.

In addition, very low-concentration DNA hybridization electrical detection has been achieved, with a limit of detection of 50 pM, compatible with CMOS low-cost and biological standard processes, using aluminum interdigitated structures protected with a thin anodic aluminum oxide, by three different electrical methods, i.e. capacitance and resonance frequency variation between fingers and by the MOS effect between the fingers and the substrate.

Finally, our technology allows MOS devices and multiple sensors to be integrated on the same chips, which opens the door to many new applications for higher performance and harsher environments at lower cost.