A fabrication scheme for biomimetic aquatic hair sensors

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A fabrication scheme to realize a flow sensor array for operation in liquid which biomimics fish lateral line is presented. The configuration enables differential capacitive sensing upon rotation of the metal electrodes under the membrane due to deflection of a receptive hair by drag force of the fluid flow. The capacitive readout provides high sensitivity, low power consumption and electrostatic softening ability [1]. Prevention of electrode/liquid contact and elimination of the chance of electrolysis and short circuiting are essential in the design and have been fulfilled with a fully supported membrane with electrodes underneath. The gap between two counter electrodes can be tuned by the thickness of a sacrificial polysilicon layer to optimize the sensor for the highest sensitivity considering the static downward deflection of the membrane due to pressure difference. An optimized DRIE process to access a sacrificial layer from the backside of the wafer provides a suitable procedure to realize dense arrays of hair sensors. The shape and length of SU-8 hairs can also be optimized for higher drag force and therefore more mechanical deformation of the membrane which leads to higher device sensitivity.
The process flow not only allows for highly controllable distance between counter electrodes but also provides the design freedom to either use SU-8 or SiRN (Silicon Rich Nitride) membranes. It begins with a DRIE step from the frontside to define etch ports followed by oxidation of the Si surface followed by Si_3N_4 deposition which acts as an etch/oxidation stop. Then poly-silicon, as sacrificial layer, is deposited and the device area is defined by trench-etching. This is followed by a SiRN layer deposition. Afterwards, vias are etched to access etch ports, followed by oxidation to protect sidewalls during sacrificial layer etch. For SiRN membranes electrical connections are formed by heavily doped poly silicon which stands the etch process. In case of SU-8 membranes the front SiRN is etched directionally and SU-8 spun on after electrode deposition. Using this procedure we have successfully realized arrays of fully supported membranes with very high yield.

[1] G. J. M. Krijnen et al., “Biomimetic micromechanical adaptive flow-sensor arrays”, in Proceedings of SPIE Europe Microtechnologies for the New Millennium, vol. 6592, pp. 6592-6608, 2007