

# DEVELOPING THE ULTIMATE BIOMIMETIC FLOW-SENSOR ARRAY

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This contribution reports on the major developments and achievements in our group on fabricating highly sensitive biomimetic flow-sensor arrays. The mechanoreceptive sensory hairs of crickets are taken as a model system for their ability to perceive flow signals at thermal noise levels and, moreover, to extract spatio-temporal flow information of the surroundings. To reach our final goal, i.e., a flow camera consisting of biomimetic flow-sensor arrays, most of our efforts have been focusing on increasing the performance of the biomimetic flow sensors and reliability of the fabrication process, respectively, by sensor-model optimizations and by optimization of processing procedures and materials.

For reasons of high intrinsic sensitivity, low power dissipation and promising performance, our biomimetic sensors exploit capacitive read-out of the tilt of a membrane at its rotational axis owing to deflection of the drag-force receptive hair. Several actions have been undertaken to increase the performance of the sensor, namely by the development of different types of long, low-density hairs (by molding of hollow (silicon nitride) hairs and double exposure of SU-8) as well as by the construction of different types of suspensions in order to increase the drag-torque pick-up of the hair and to adjust the torsional stiffness of the suspension, respectively. Several adjustments have been made to the sensor in order to increase its sensitivity (down to  $0.85 \text{ mm}\cdot\text{s}^{-1}$ ), including a smaller inter-electrode gap and the use of low-stress aluminum electrodes.

Process optimizations have been done on several fabrication steps with respect to the etch rate, uniformity and selectivity, resulting in a reliable scheme for fabricating our sensors. The most significant optimizations include the wet etching of aluminium at room temperature using standard resist developer and isotropic etching of the sacrificial layer using  $\text{XeF}_2$ . Additionally, the fabrication scheme is adaptable in the sense that it allows the implementation of silicon-on-insulator (SOI) wafers with minor changes. SOI wafers can facilitate the fabrication separate of bottom electrodes in our future sensors. Separate bottom electrodes will reduce the parasitic capacitance present in our current devices, thereby increasing the sensitivity into the range that could offer the possibility to sense movements of individual hairs.

In conclusion, the significant advancements in sensor fabrication technology have been shown in this contribution. Future implementation of SOI technology will allow us to fabricate biomimetic flow-sensor arrays with higher sensitivities and more read-out functionalities than our previous generations of flow-sensor arrays.