BIOMIMETIC AQUATIC HAIR SENSORS FABRICATION

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Abstract
A fabrication scheme to realize a flow sensor array for operation in liquid which biomimics fish lateral line is presented. To keep advantages of differential capacitive readout [1] we have designed a process for fabrication of thin, fully supported, flexible membranes with electrodes beneath them, on top of a substrate to prevent electrode/liquid contact and strong damping effects associated with liquid filling the gap between capacitor electrodes (Figure 1).
Fluid flow produces a drag forces resulting in a torque around the base of the hair which deforms the membrane. The readout part consists of two separate electrodes sitting at the bottom side of the membrane and a common electrode which is actually the highly doped silicon substrate. The principle is the same as we use currently in our flow sensors biomimicking crickets' mechano¬sensory hairs operating in air [2].
The process flow (Figure 2) not only allows for highly controllable distance between counter electrodes but also provides the possibility to use SU-8 or SiRN (Silicon Rich Nitride) membranes. It begins with a DRIE step from frontside to define etch ports followed by oxidation process and 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 into it. 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 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 full yield (Figure 3).

References
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[2] M. Dijkstra et al., "Artificial sensory hairs based on the flow sensitive receptor hairs of crickets", J. Micromech. and Microeng, 15 (2005), 132-138.

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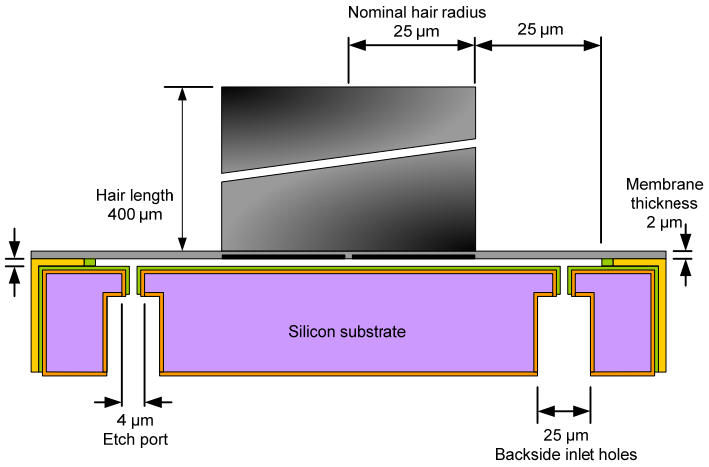

Figure 1. Artificial aquatic hair sensor schematic

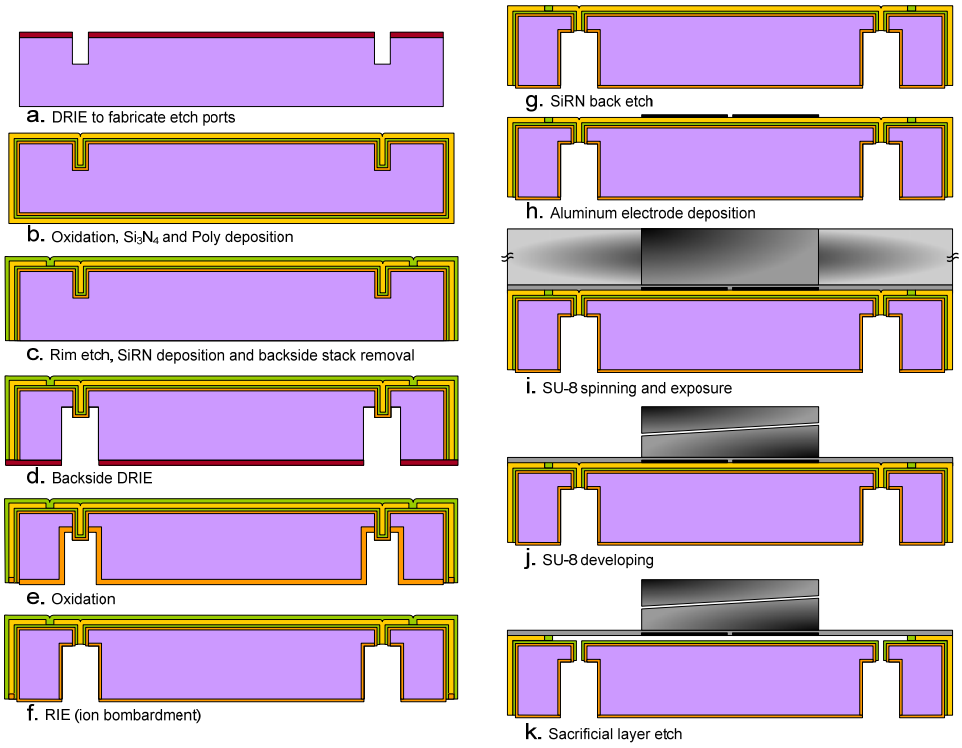

Figure 2. Process flow

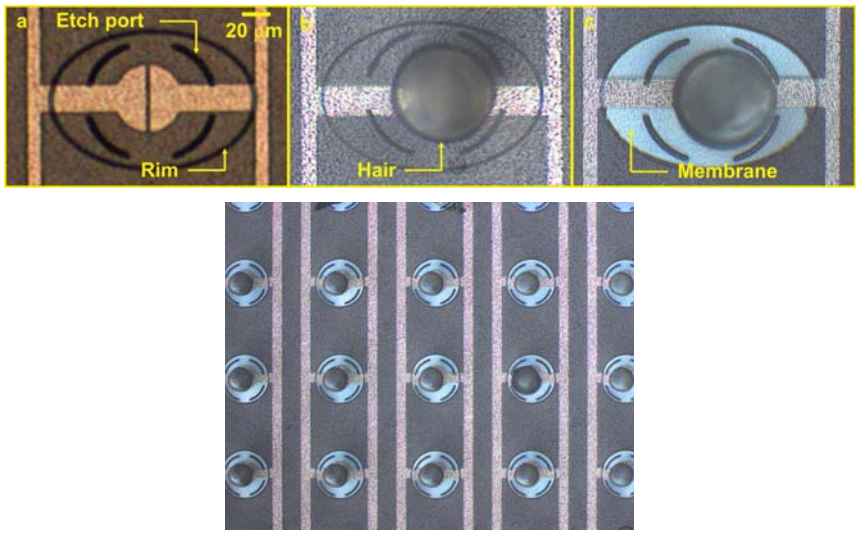

Figure 3. Optical image of a single membrane during fabrication (top), a microscopic image of membrane array (bottom)