HIGHLY SENSITIVE BIOMIMETIC FLOW SENSOR ARRAYS

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Abstract

In this paper, we report, to the best of our knowledge [1], the most sensitive artificial hair-based flow-sensor arrays operating in air, to date. Artificial hair sensors are bio-inspired from crickets' cerci, one of nature's best in sensing small air flows. The presented hair sensor arrays aim to realize higher sensitivity by means of model-based design optimizations and fabricated with advanced MEMS technologies. The presented artificial hair-sensor arrays display a clear figure-of-eight response and show remarkable sensitivities to oscillating air flows down to 0.85 mm/s that surpass noise levels even at 1 kHz operational bandwidths.

Crickets have a pair of abdominal appendages called cerci, comprising of numerous mechano-receptive hair sensors, which respond even to the slightest air movements (ca. 0.03 mm/s), effectively operating at thermal noise threshold [2]. Figures 1 and 2 show the magnified image of a cricket's cerci and the schematic representation of an artificial hair sensor, respectively. Each flow sensor has a suspended silicon nitride membrane with Aluminium electrodes with a long SU-8 hair mounted on its top. Air flows induce deflection on the SU-8 hair and consequently tilt the silicon nitride membrane, which is sensed by differential capacitive read-out.

Figure 3 show the experimental setup and the directionality measurements were done using a loudspeaker as the flow source and a lock-in amplifier was used to measure the amplitude and phase of the capacitive-based sensor response. The sensors were placed in a rotary stage. The sensor response was measured for every 10° of rotation at three different frequency settings of the flow source. Figure 4 shows a clear figure-of-eight response of the sensors, indicating a preferred directivity of the sensor arrays.

In conclusion, we report significant advancements of our artificial hair sensor arrays performing very close to the actual cerci of the crickets.

Word Count: 296

References

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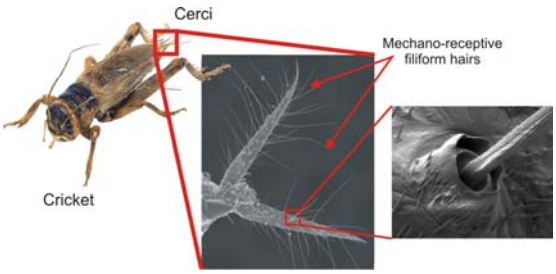

Figure 1: Crickets' cerci containing numerous mechano-receptive filiform hairs. [Courtesy: G. Jeronimides, University of Reading, UK]

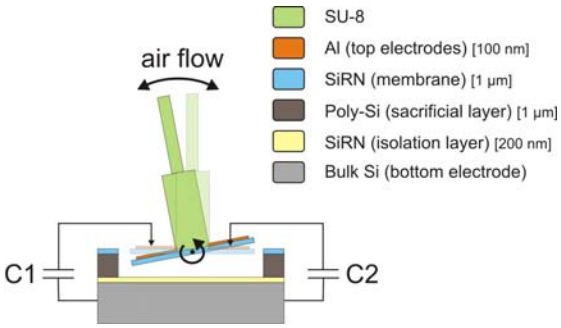

Figure 2: Schematic representation of an artificial flow sensor with differential capacitive flow sensing upon flow-driven membrane tilts.

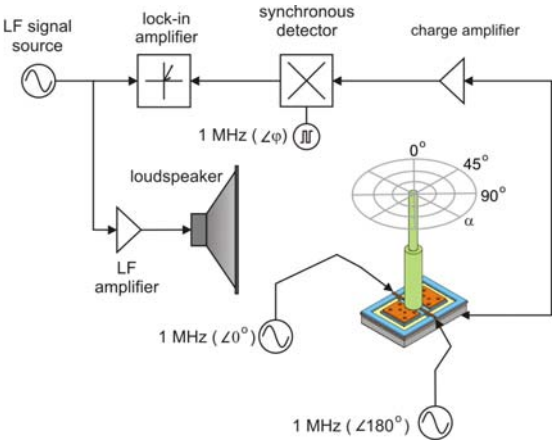

Figure 3: Measurement setup for the acoustic flow characterization of the sensor arrays.

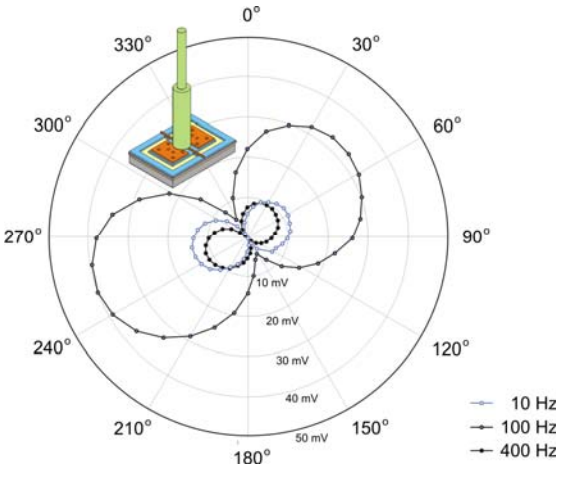

Figure 4: Directivity acoustic measurements on the flow sensor arrays at three different frequencies.