MODEL-BASED OPTIMIZATION OF TUNABLE, BIOMIMETIC HAIR SENSOR ARRAYS

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Abstract
Crickets have, quite often, been a subject of common interest to biologists and engineers. They have evolved with a pair of special flow-sensitive appendices called cerci with numerous mechano-receptive filiform hairs of different lengths, distributed on the surface. These filiform hairs are extremely sensitive to acoustic signals, down to thermal noise levels [1], enabling them to identify and escape from approaching predators. Each filiform hair has a mechano-sensitive neuron at its base which fires a neuro-signal whenever there is a flow-induced deflection on the hair. Inspired by crickets and making use of technical advancements in MEMS techniques, SU-8 based artificial hair sensor arrays were successfully implemented recently [2]. Ways to improve the sensitivity of these artificial hair sensor arrays have been demonstrated; increasing the hair length and arranging the sensors on an artificial cercus-like platform that can be assembled to facilitate 3D-flow sensing. In this work, we present a model for our biomimetic, artificial hair sensors, to analyze the sensitivity dependence on their structural and geometrical parameters. Based on this model, feasible design improvements to achieve an increased sensitivity are discussed and a figure of merit to evaluate sensor performance is defined. Also, we discuss the results of a novel approach to implement adaptive sensor arrays through DC-biasing based on the electrostatic spring-softening effect. Experimental results show a clear theoretical accordance and tunability of system's resonance frequency, providing opportunities for frequency focusing and selective sensitivity.

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.

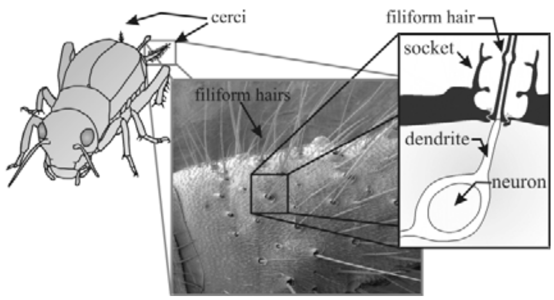

Figure 1. Mechano-receptive hairs found on cerci of crickets

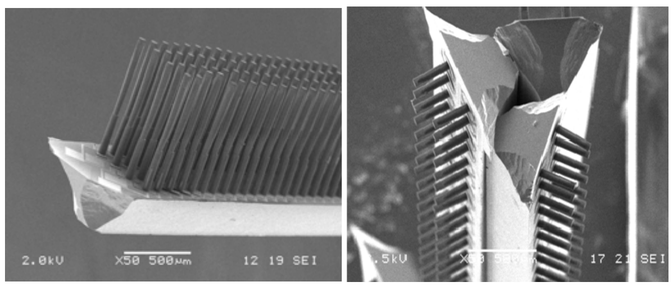

Figure 2. Biomimetic hair sensor arrays arranged on artificial cerci-like substrate

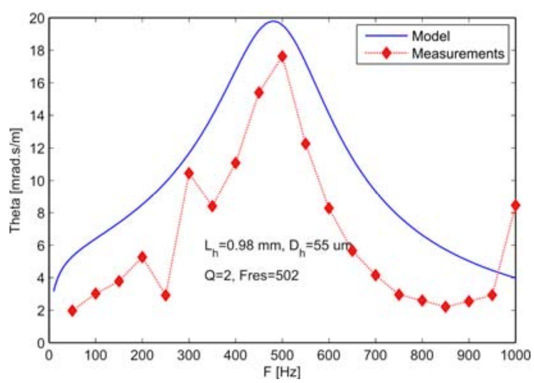

Figure 3. Measured (optically) and modeled normalized sensitivity of realized hair sensors Vs. frequency

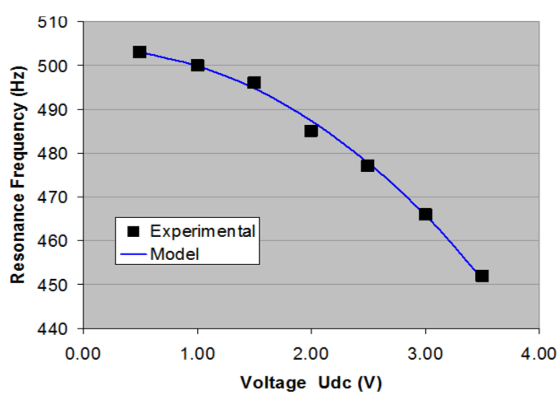

Figure 4. Tunability of the sensor's resonance frequency, depending on the applied DC-bias