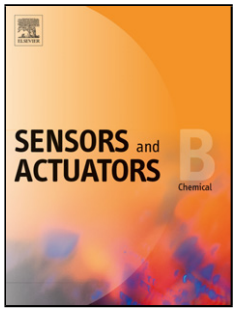

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PII: S0925-4005(16)30776-6
DOI: http://dx.doi.org/doi:10.1016/j.snb.2016.05.091
Reference: SNB 20250

To appear in: *Sensors and Actuators B*

Received date: 21-2-2016
Revised date: 6-5-2016
Accepted date: 17-5-2016

Please cite this article as: Rodrigo Sarlo, Joseph S Najem, Donald J Leo, Flow Field Sensing with Bio-inspired Artificial Hair Cell Arrays, *<![CDATA[Sensors & Actuators: B. Chemical]]>* (2016), http://dx.doi.org/10.1016/j.snb.2016.05.091

Flow Field Sensing with Bio-inspired Artificial Hair Cell Arrays

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Abstract. The hair cell is a biological sensor that uses microscopic hair-like structures to detect delicate motions of surrounding fluid. Inspired by this principle, an artificial hair cell (AHC) sensory method based on bio-membrane transducers is developed for airflow sensing. One-dimensional arrays built from modular AHC units measure local velocity at different points in a flow profile. Each of the AHC units uses thinly extruded glass fibers as mechanical receptors of air velocity. Hair vibrations are converted to current via hydrogel-supported (lipid bilayers) by virtue of their mechanosensitive properties. The AHC outputs are combined into one channel, requiring a demultiplexing operation to recover individual hair cell information. This is achieved by tuning each AHC hair length to a unique frequency response and recovering individual sensor information based on the frequency content of the signal. The method is entitled Tuned Frequency Response Encoding (TFRE). When several AHC units are excited simultaneously by an airflow, the resulting signal is a superposition of each sensor's individual response. The excitation at each sensor is reconstructed from the frequencies that appear in the combined output. This technique was inspired by how organisms use hair cells with tuned responses to mechanically process flow stimuli. It takes advantage of a novel AHC's high signal-to-noise ratio (compared to other membrane-based AHCs) and linear output response to flow velocity. Initial tests with linear arrays of three AHCs show success in estimating the *shape* of the velocity profile from an air source that varies in position and intensity. However, temporal variations in some cases in membrane size affect sensitivity properties and make accurate flow *velocity* estimation difficult. Nevertheless, under stable conditions, the measured velocity profiles match closely with theoretical predictions. The implementation of the array sensing method demonstrates the sensory capability of bilayer-based AHC arrays, but highlights the difficulties of achieving consistent performance with biomolecular materials.

Keywords: artificial hair cell; droplet interface bilayer; array; cell membrane; frequency response; airflow