Development of MEMS-based Pressure Sensor for Underwater Applications

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Introduction: Blind cave fish are capable of sensing flows and movements of nearby objects even in dark and murky water conditions with the help of array of neuromasts present on their bodies called lateral-lines. Mimicking it, an array of flexible pressure sensor mounted onto an aquatic vehicles enables the detection, identification and tracking of obstacles in underwater and also provides information about the surrounding flows which could help in reducing the vehicle's hydrodynamic drag.

Figure 1: Blind cave fish

Computational Methods: Due to the flow, a pressure difference is set between the atmosphere and membrane, resulting in bending of the diaphragm. The change in resistance can be read out as voltage. The relative change in resistance depends on the pressure as follows:

$$\Delta R / R = (7.22 * 10^{-27})P$$

where, P is the pressure difference across the diaphragm, ΔR is the change in resistance and R is the resistance.

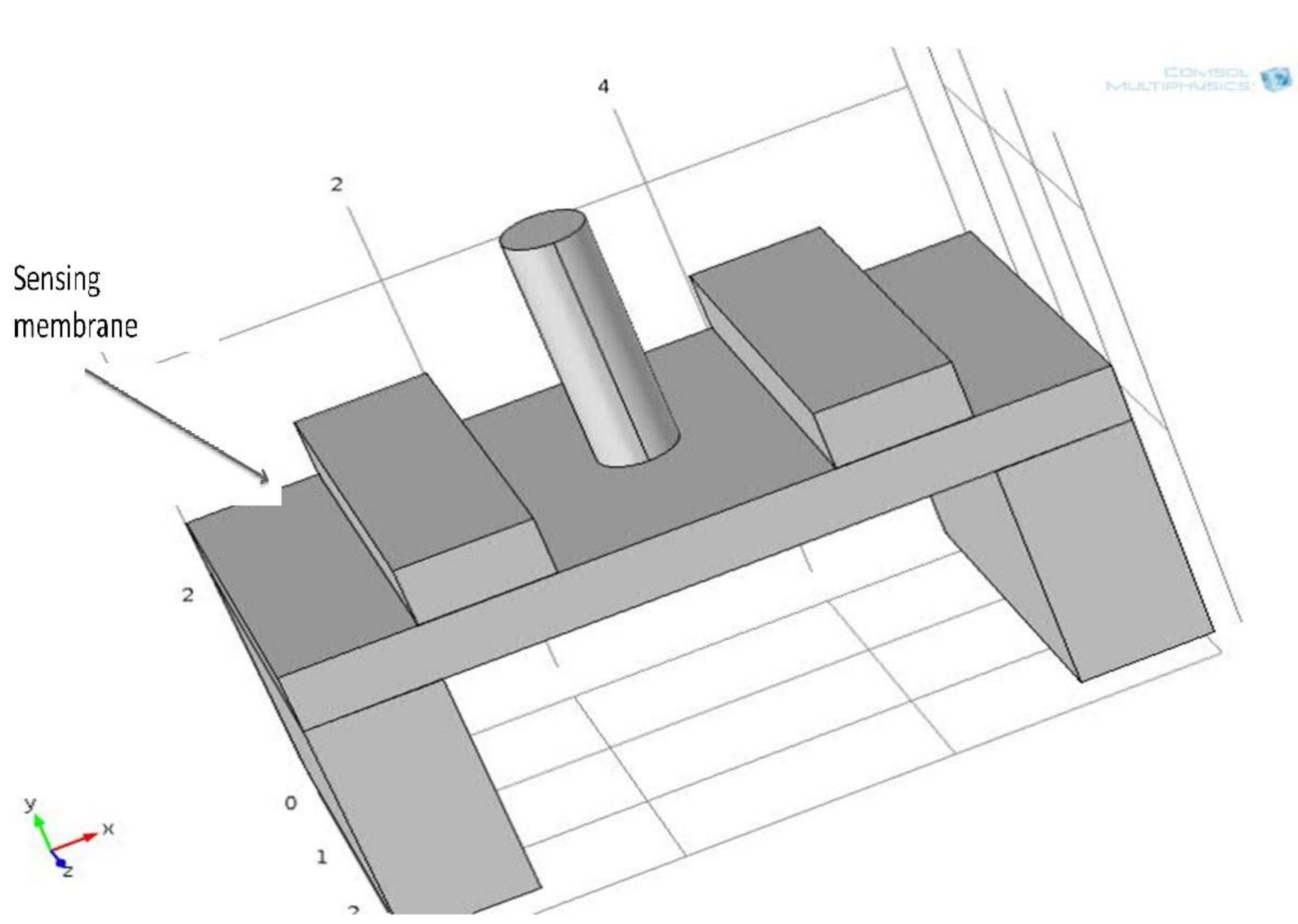

Figure 2. Pressure sensor

Results: The water flow sets a pressure difference which results in the displacement of diaphragm (Fig.3) and the maximum pressure is experienced at the sensing layer (Fig. 4). The velocity experienced by the sensor when a minimum of 5 N/m^2 and maximum of 1000 N/m^2 stress applied are $3.672*10^{-4}$ m/s and 0.0519 m/s respectively.

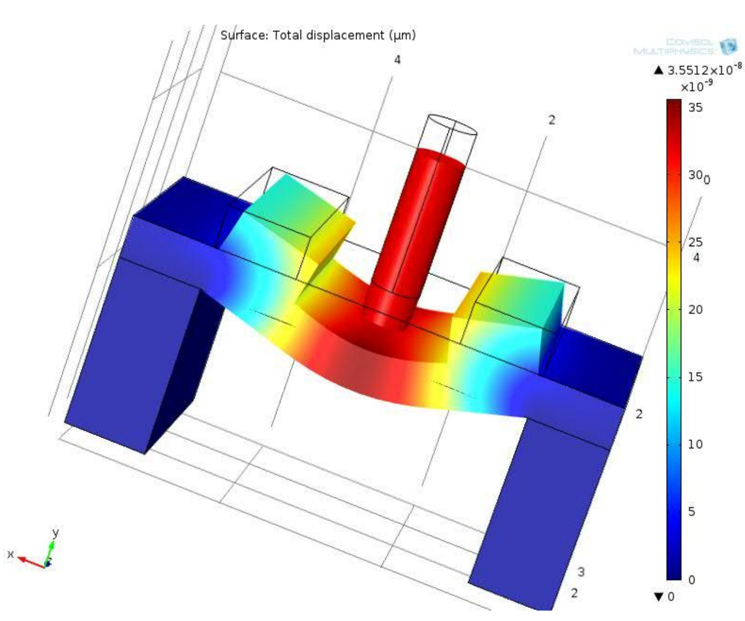

Figure 3. : Displacement of diaphragm

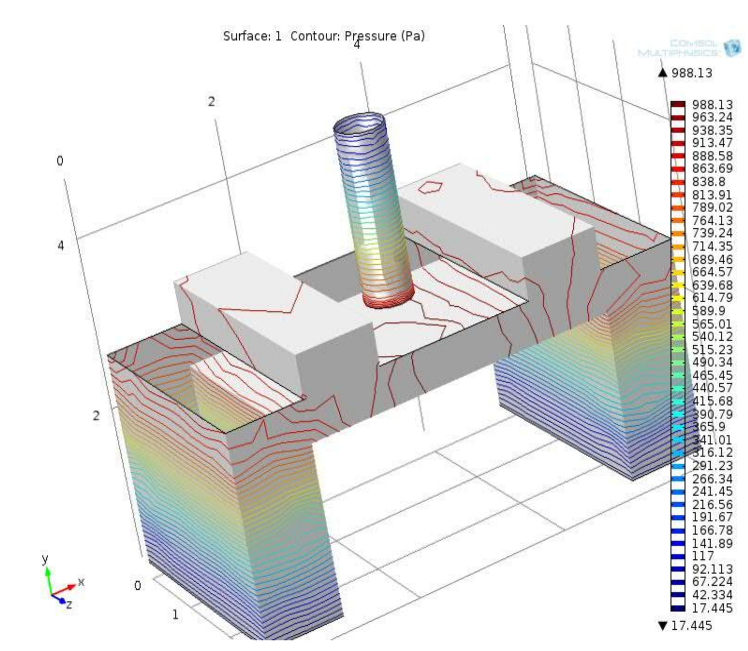

Figure 4. Pressure distribution over the sensor

Table1. change in velocity, relative resistance with stress

Boundary stress applied (N/m^2)	Velocity (m/s)	Relative Resistivity
1	$3.672*10^{-4}$	$3.546*10^{-6}$
10	$4.76*10^{-4}$	$9.223*10^{-6}$
20	$5.89*10^{-4}$	$1.628*10^{-5}$
50	$8.34*10^{-4}$	$3.745*10^{-5}$
75	$2.36*10^{-3}$	$5.509*10^{-5}$
100	$4.954*10^{-3}$	$7.273*10^{-5}$
500	0.0258	$3.586*10^{-4}$
1000	0.0519	$7.165*10^{-4}$

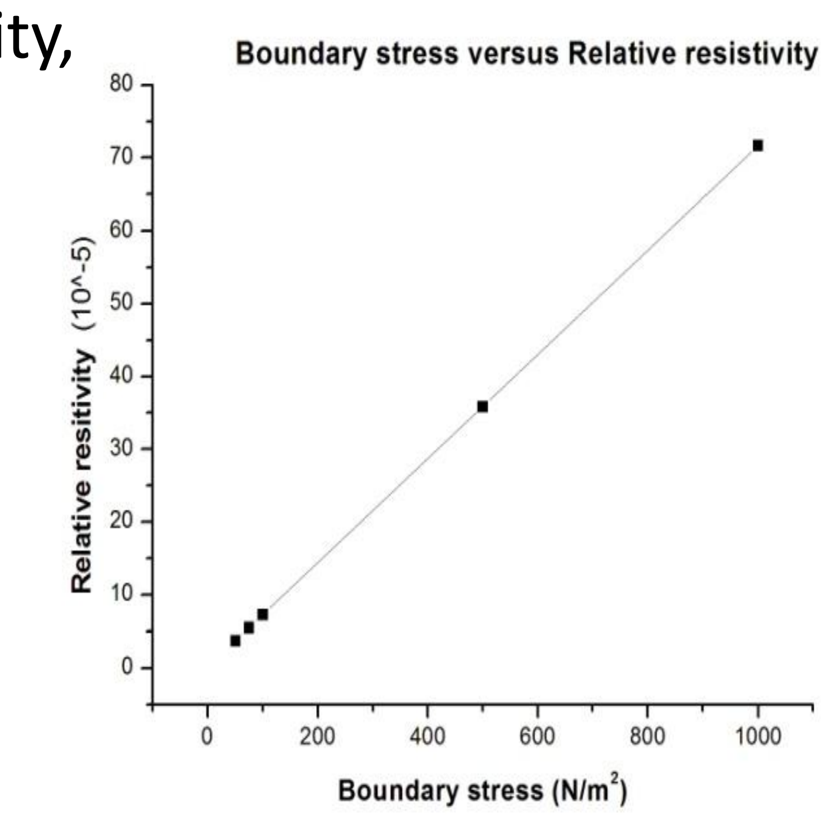

Figure 5 : Boundary stress vs relative resistivity.

Conclusion: Among the various conventional techniques, flexible MEMS based pressure sensor is found to be sensitive, safer, cost effective, mechanically stable and passive. The sensitivity ranges from 5 N/m^2 to 1000 N/m^2.

References:

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