BIOLOGICAL MEASUREMENTS OF C. ELEGANS TOUCH SENSITIVITY WITH MICROFABRICATED FORCE SENSORS

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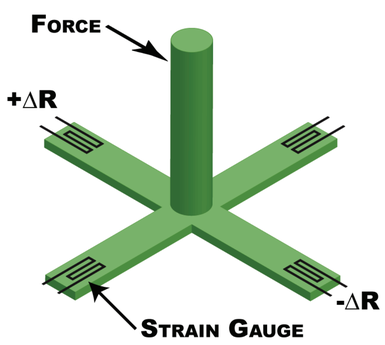
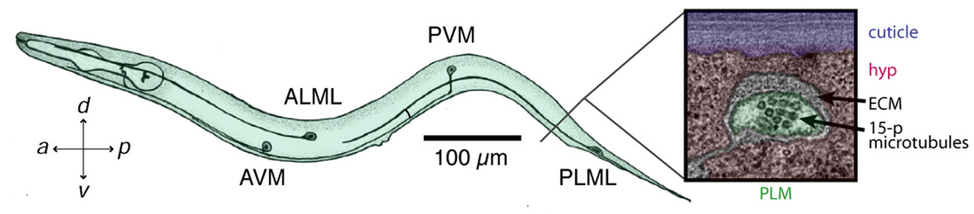
Introduction

Mechanical forces regulate many of the basic processes of life: embryonic development, bone growth and locomotion among many others. Touch sensation, the rapid transduction of force by sensory neurons, is studied in the model organism *C. elegans*.



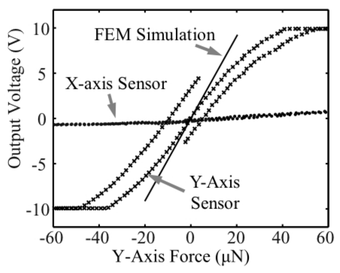
Although the ionic currents induced by touch via mechanosensitive ion channels have beeen measured, the forces experienced by *C. elegans* in natural movement have been difficult to quantify to date. The application of relevant forces during physiological experiments will improve our ability to model mechanotransduction in *C. elegans*.

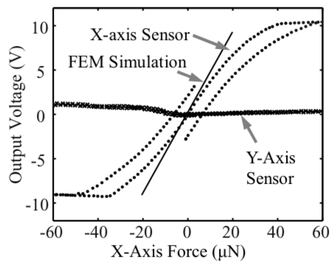


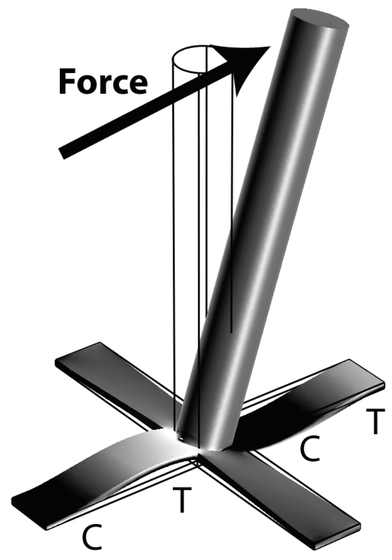
Source: Goodman, *Mechanosensation*, Wormbook (2006)

Device Characterization

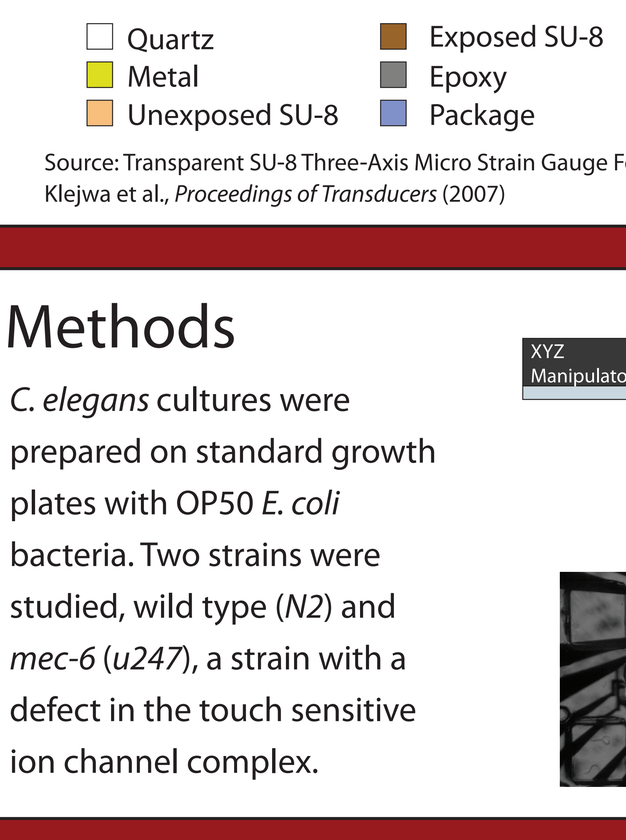
Devices were characterized using a calibrated piezoresistive cantilever. Measurements were taken with a Wheatstone bridge circuit, two-stage amplification (10,000x gain) and a bias voltage of 1V. Sensitivity was found to be 0.34±0.07V/μN (n=3) for 200μm long cantilever arms.





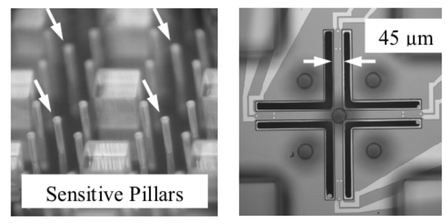


Fabrication



(a) Sputter Cr/Au adhesion layer and spin 5μm SU-8 on quartz.
(b) Pattern cantilever arms and metal.
(c) Deposit and pattern strain gauges.
(d) Deposit and expose SU-8 pillar layer. Wafer saw from the backside.
(e) Develop SU-8 and release in HF.
(f) Glue device to package and wire bond.

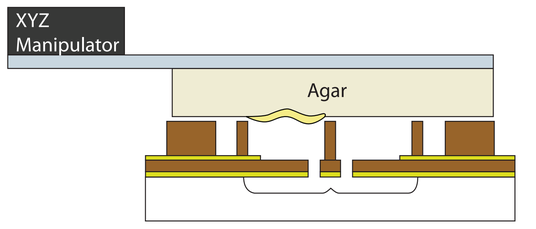
Devices were fabricated with 200, 300, 400 and 500μm long cantilever arms. Force pillars were 350μm tall and 70μm in diameter.

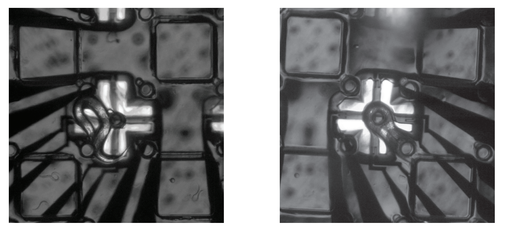


Source: Transparent SU-8 Three-Axis Micro Strain Gauge Force Sensing Pillars for Biological Applications, Klejwa et al., *Proceedings of Transducers* (2007)

Methods

C. elegans cultures were prepared on standard growth plates with OP50 *E. coli* bacteria. Two strains were studied, wild type (*N2*) and *mec-6* (*u247*), a strain with a defect in the touch sensitive ion channel complex.

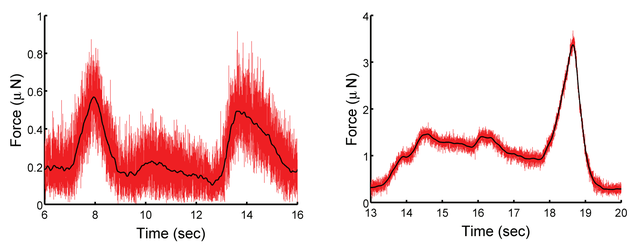


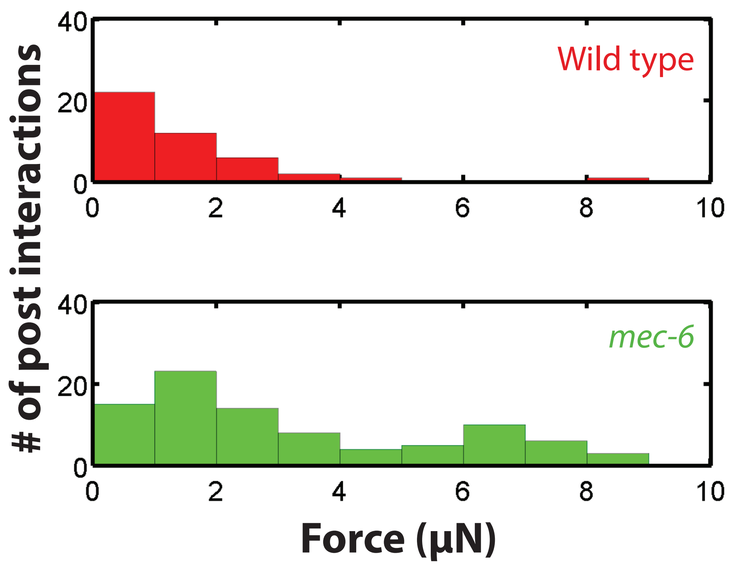


Results

The mean forces exerted by wild type and *mec-6* while moving through their environment were found to be 2.5 and 4.7μN, respectively. Most forces were exerted by the side of the worm during locomotion rather than a nose touch event. These results are similar in magnitude to the forces found to induce a physiological response in touch receptor neurons. Additional data is required to characterize nose touch. The source of the bimodal force distribution for *mec-6* is currently unknown and being explored.

(Right) Typical plots of total measured force vs. time. The first plot shows two ~500nN forces and the second shows a single 3.5μN peak.





Conclusion

The force interactions between C. elegans and its environment were directly measured using a microfabricated force sensor. Future work will include increasing device resolution and analyzing force as a function of the behavioral response to touch.

Acknowledgements

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