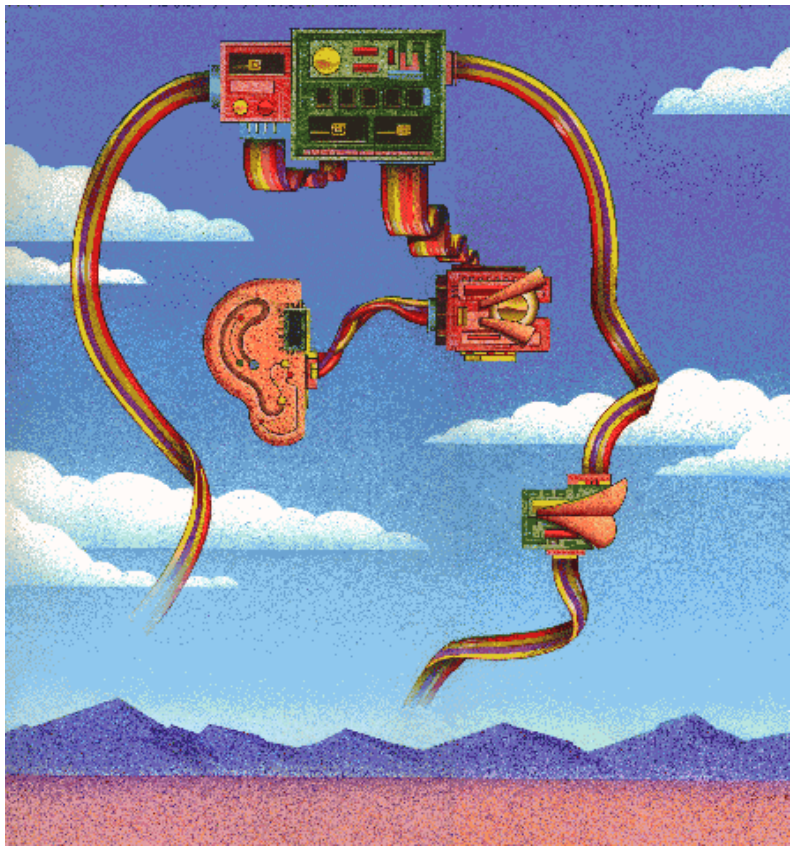
Nanogram Soccer Robocup



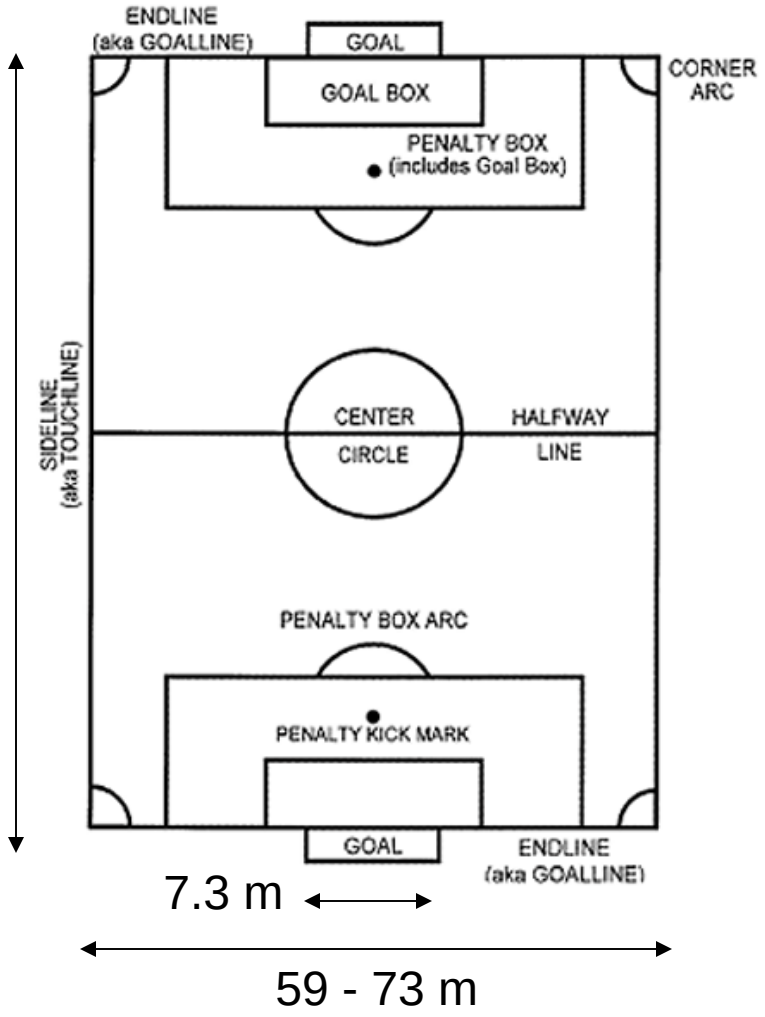
Andreas G. Andreou

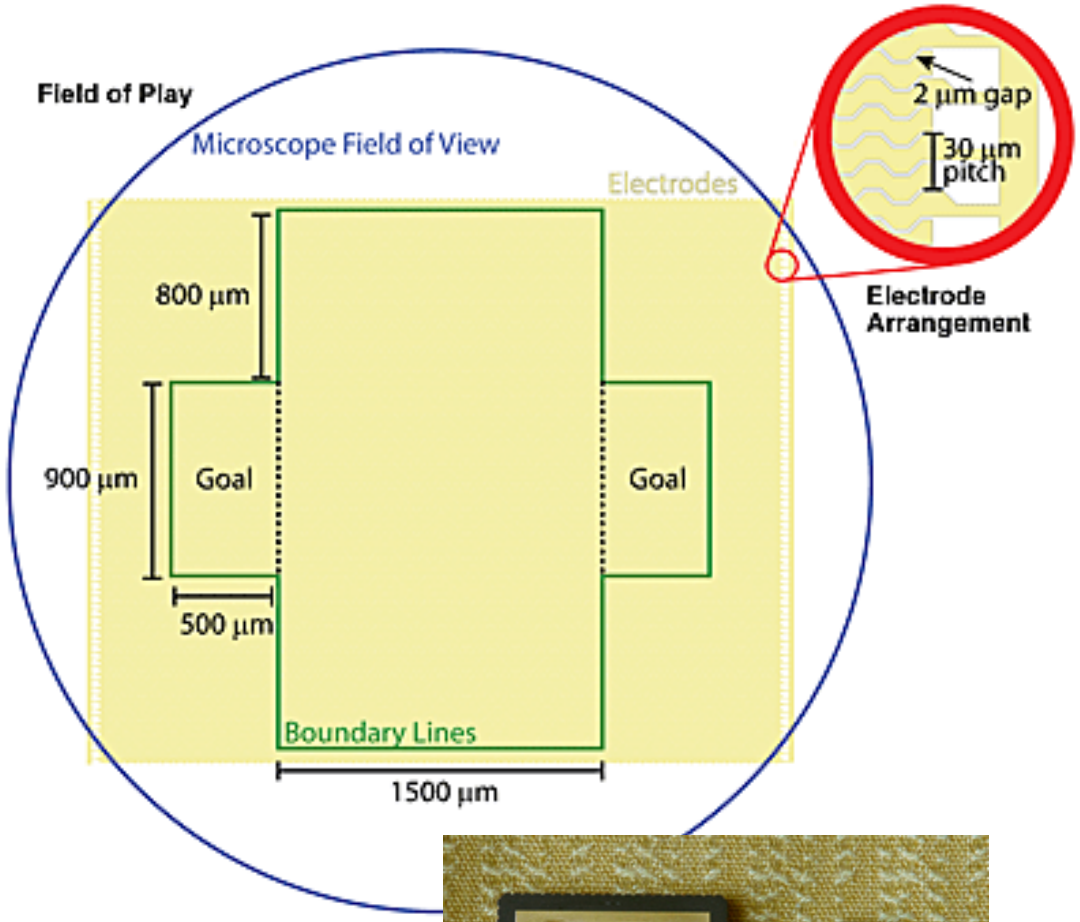
agagroup@olympus.ece.jhu.edu

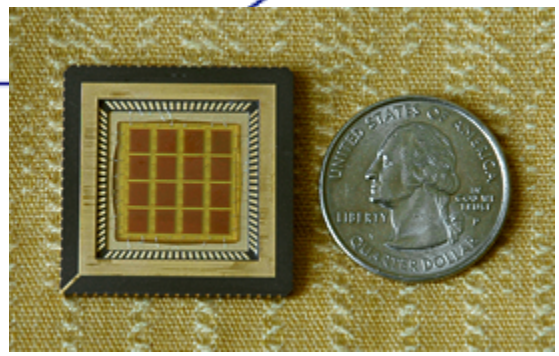
Electrical and Computer Engineering and
Whitaker Biomedical Engineering Institute
Johns Hopkins University

The field

100 – 110 m







http://www.nist.gov/public_affairs/calmed/robocup_photos.html#ball

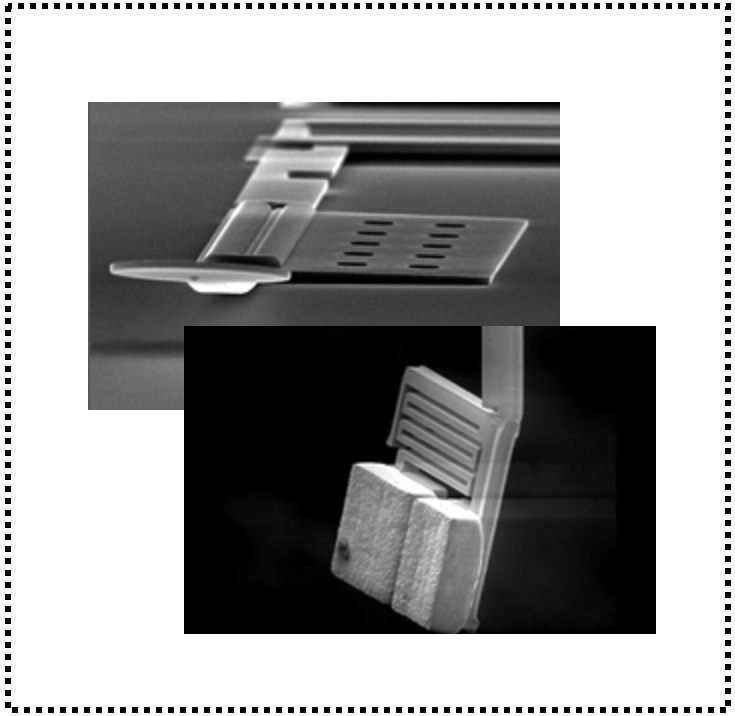
The soccer players and balls

3D

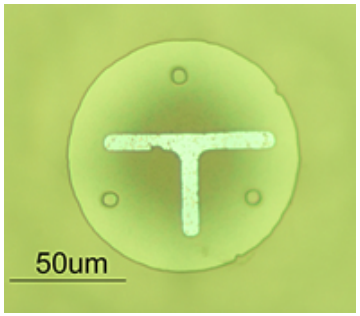
68-70cm
410-450g

1.5m

2D



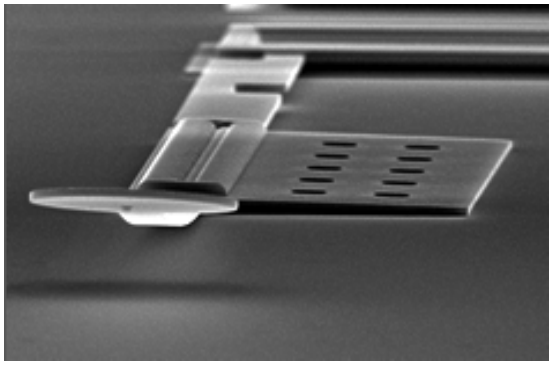
200 um

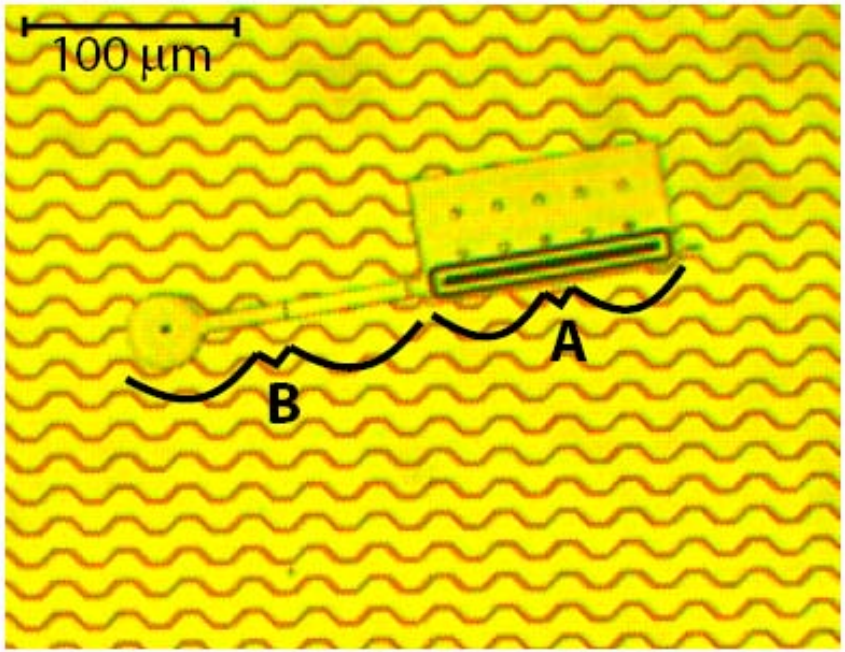


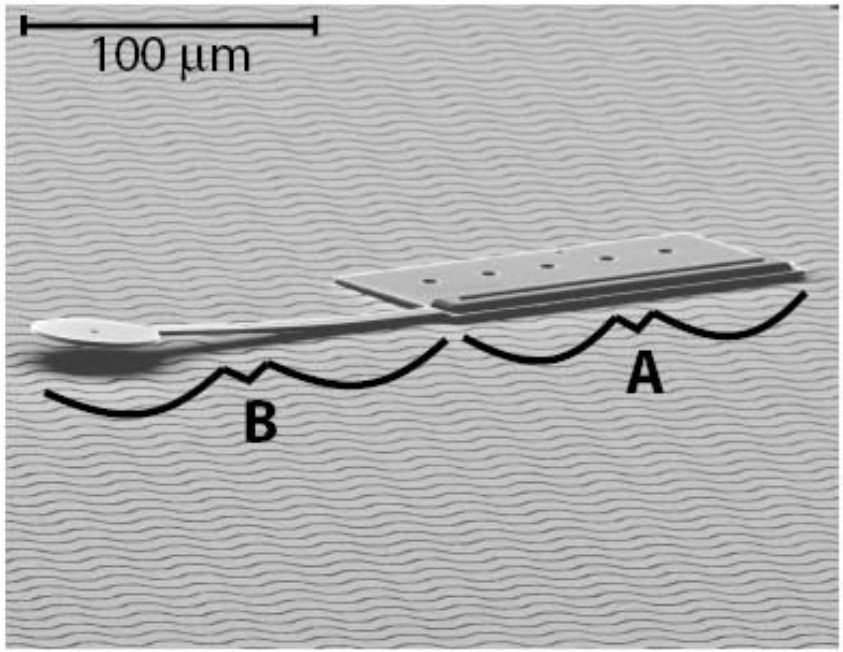
Diagrams and Figures that follow from:

Craig McGray PhD Dissertation 2005

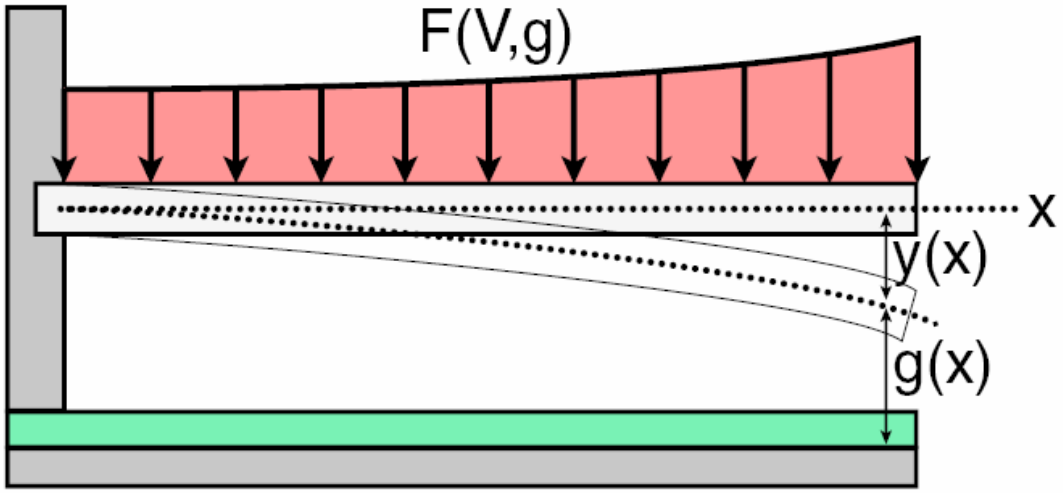
Player I (Dartmouth/USNA)





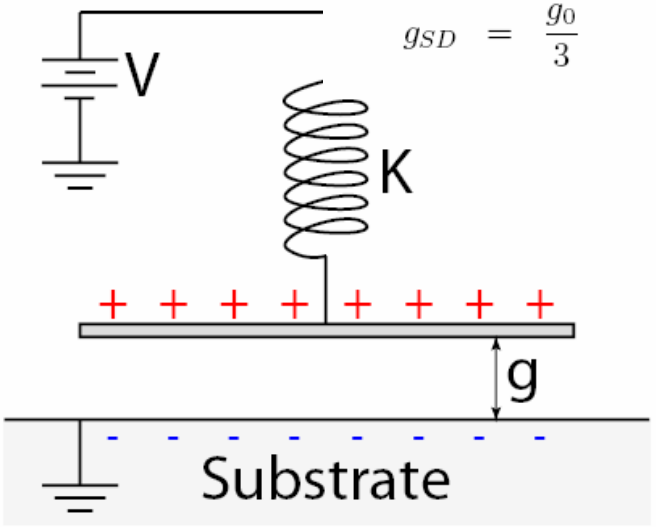


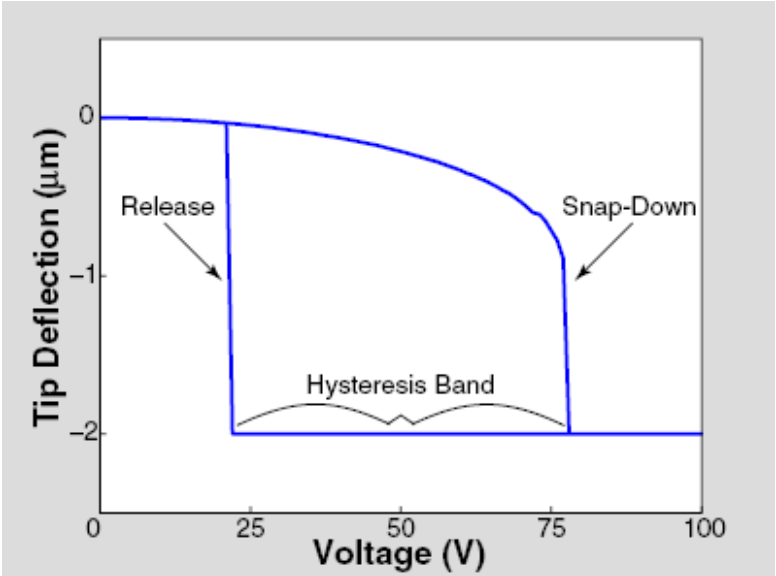
The actuation principle



$$V_{SD} = \sqrt{\frac{8Kg_0^3}{27\epsilon_0 A}}$$

$$g_{SD} = \frac{g_0}{3}$$





$$K = \frac{8EI}{L^3}$$

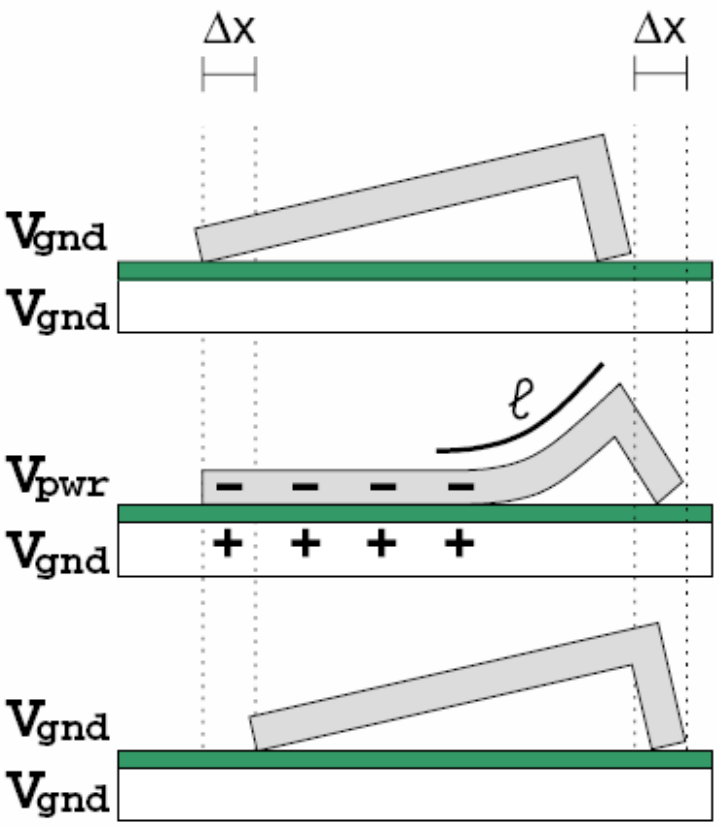
$$V_{SD} = \sqrt{\frac{64EIg_0^3}{27\epsilon_0 L^4 w}}$$

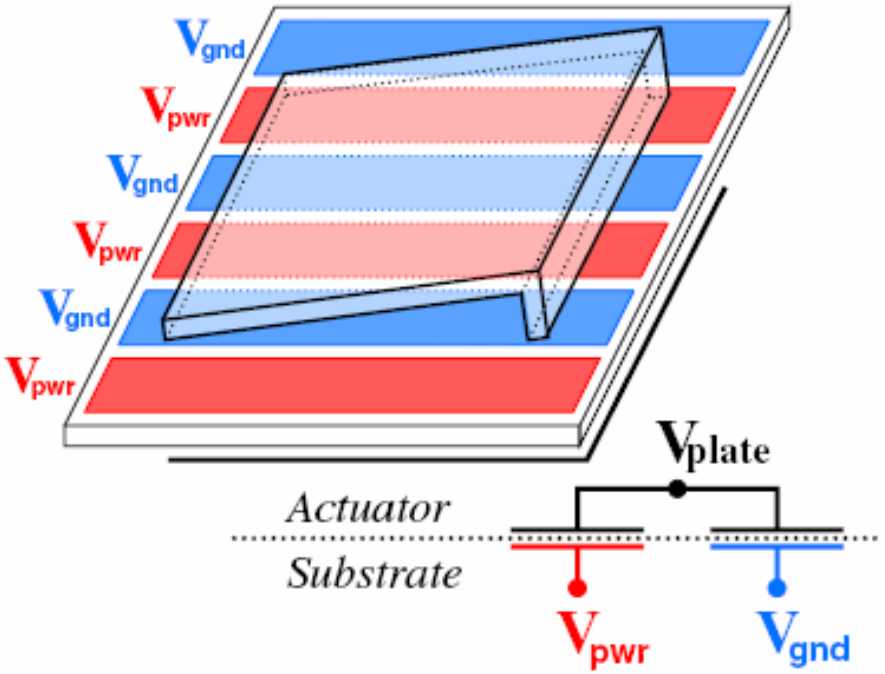
$$V_R = \sqrt{\frac{16EIg_1^2(g_0 - g_1)}{\epsilon_0 L^4 w}}$$

V_{SD}: snap down voltage

V_R: release voltage

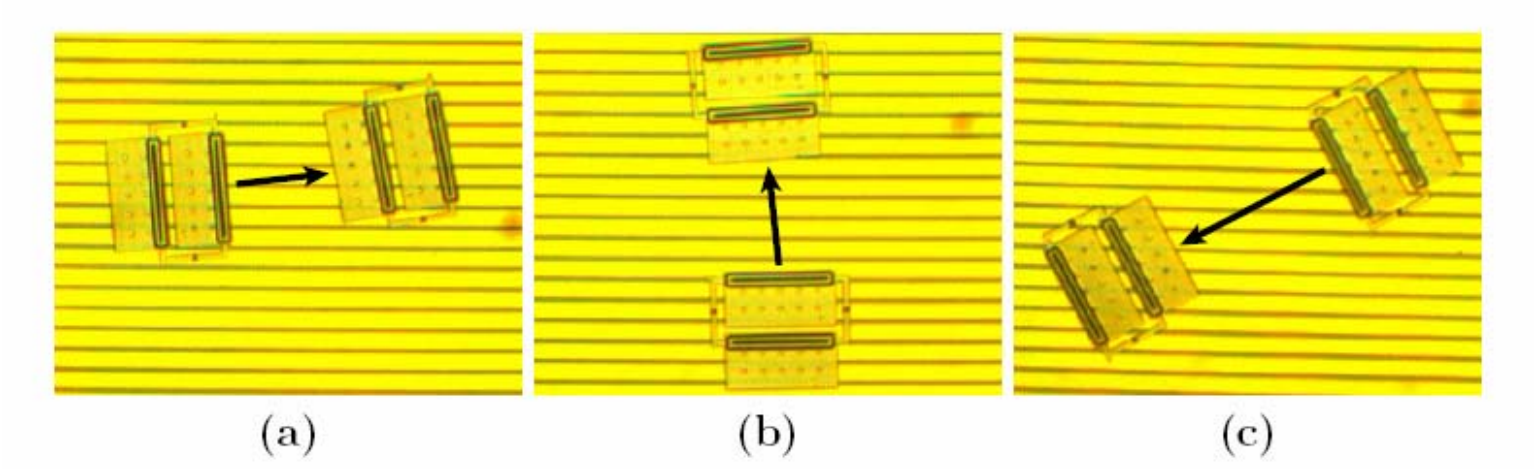
Scratch drive actuator

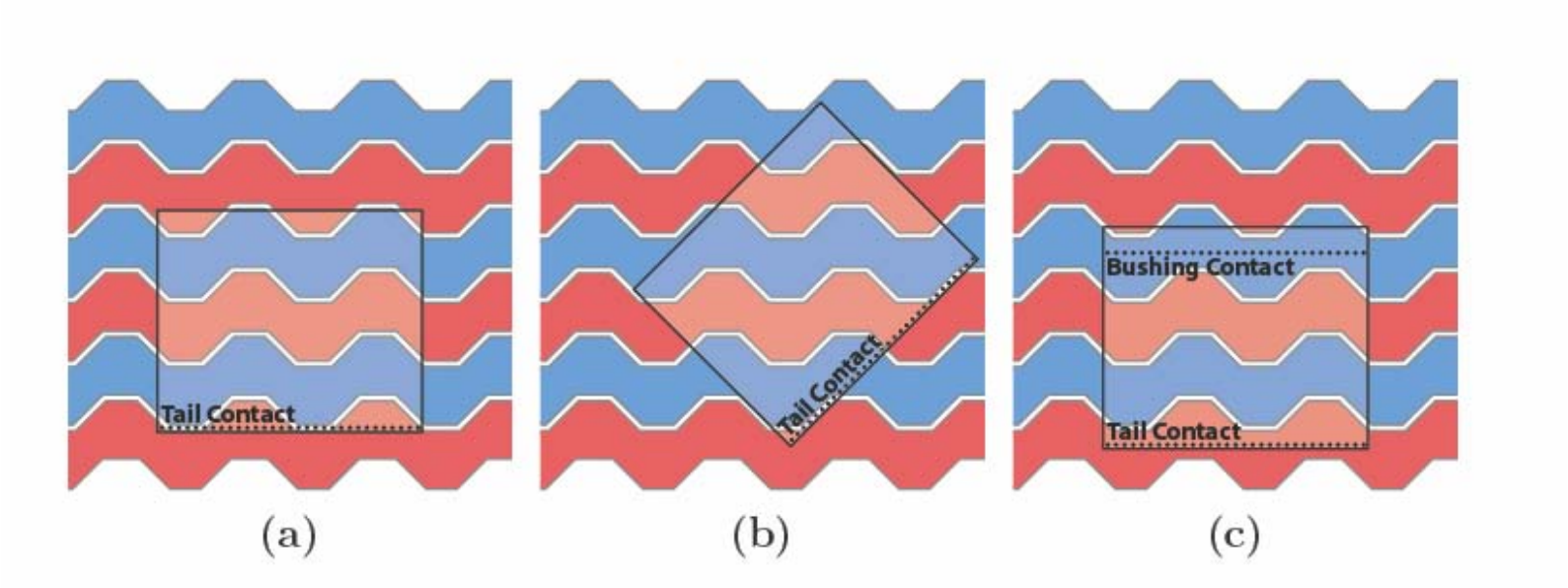




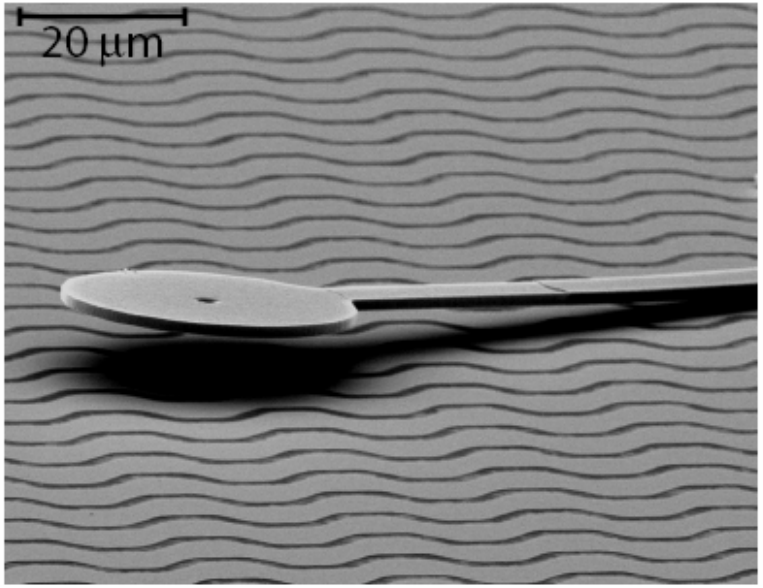
$$V_{plate} = \frac{V_1 C_1 + V_2 C_2}{C_1 + C_2}$$

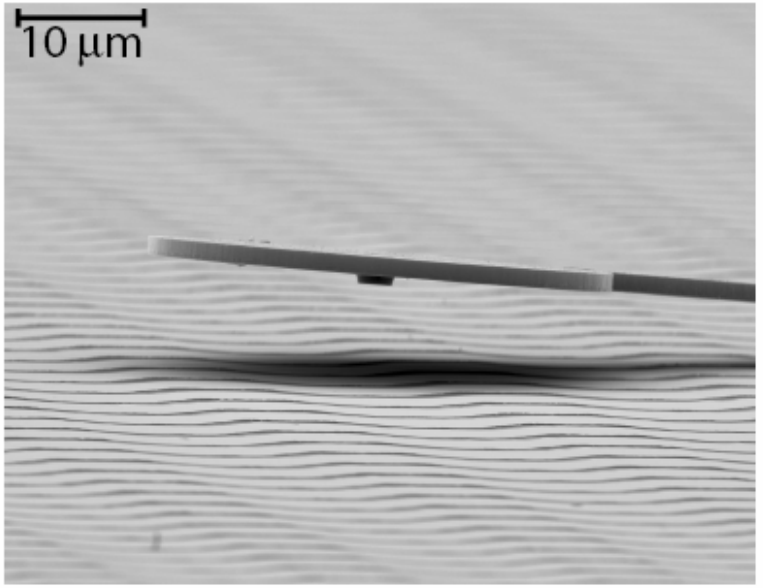
Untethered locomotion and electrode design



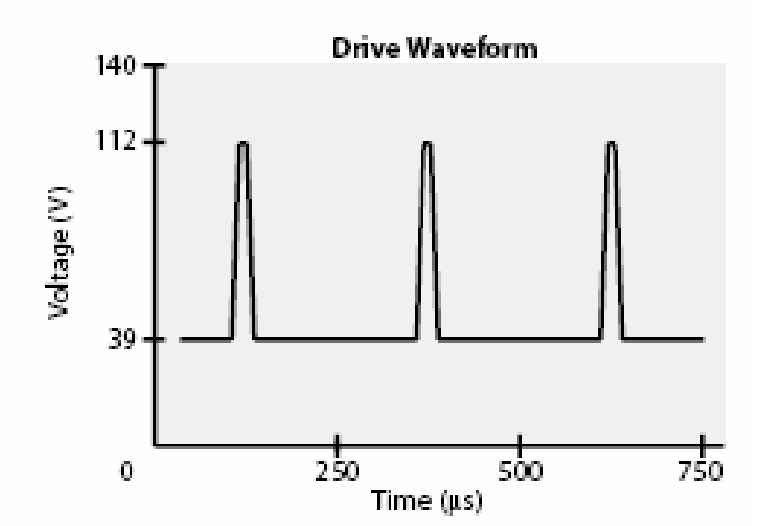


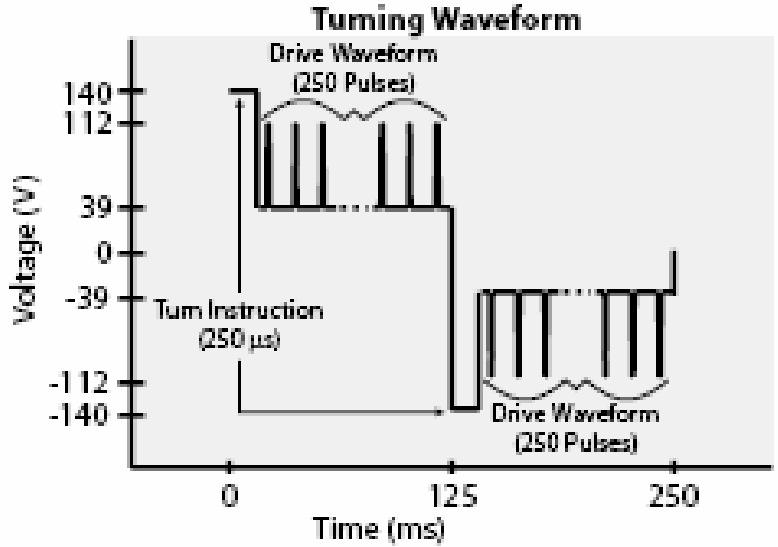
Steering



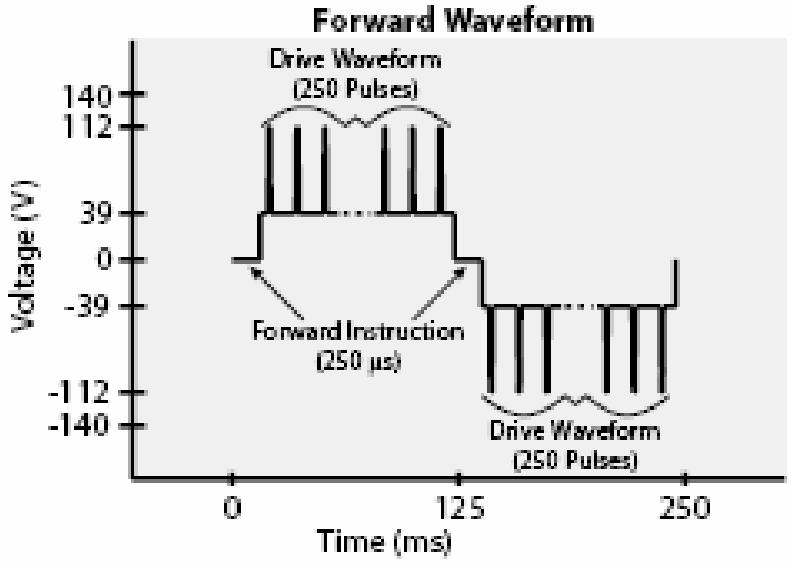


Driving waveform design

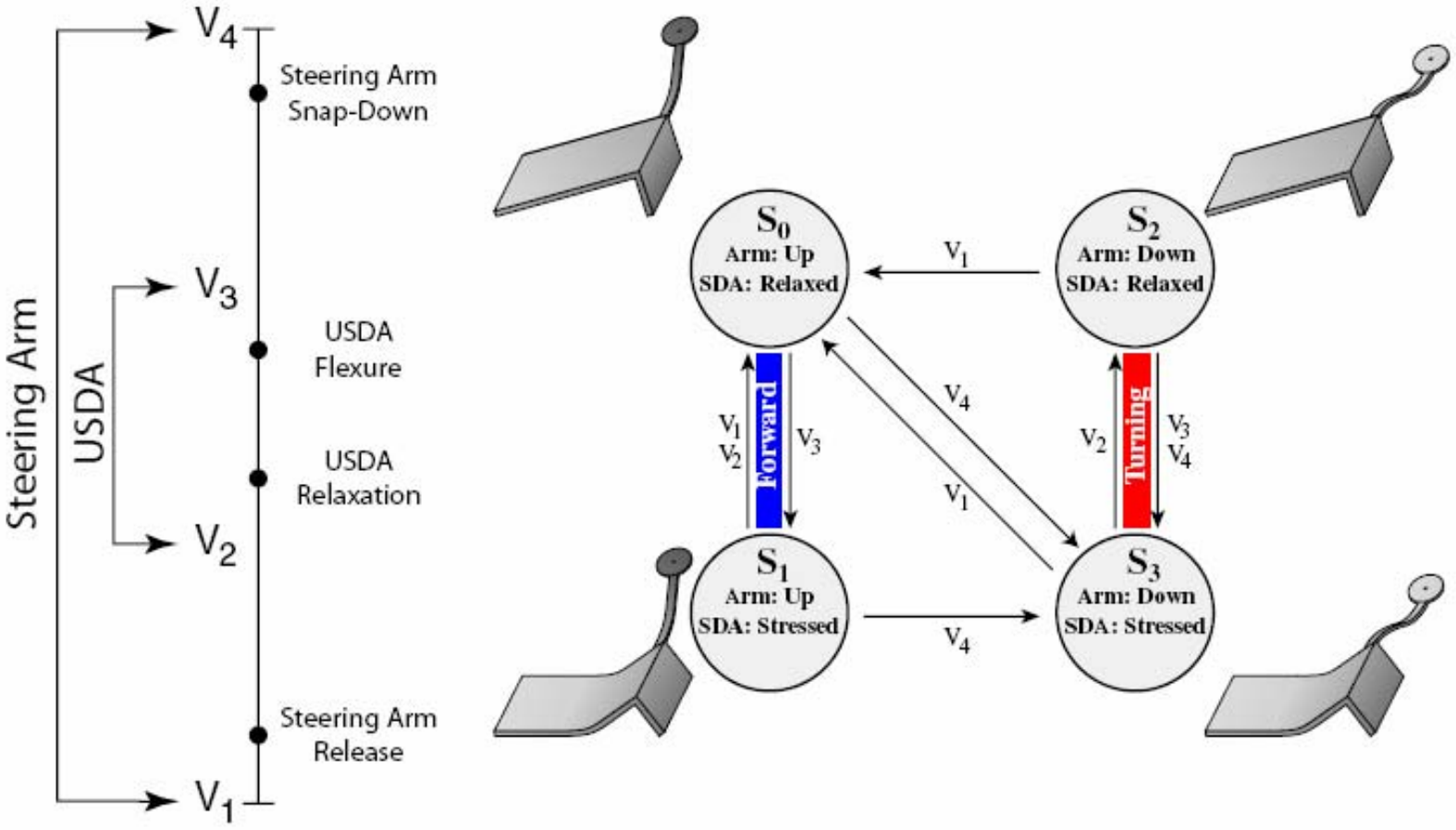




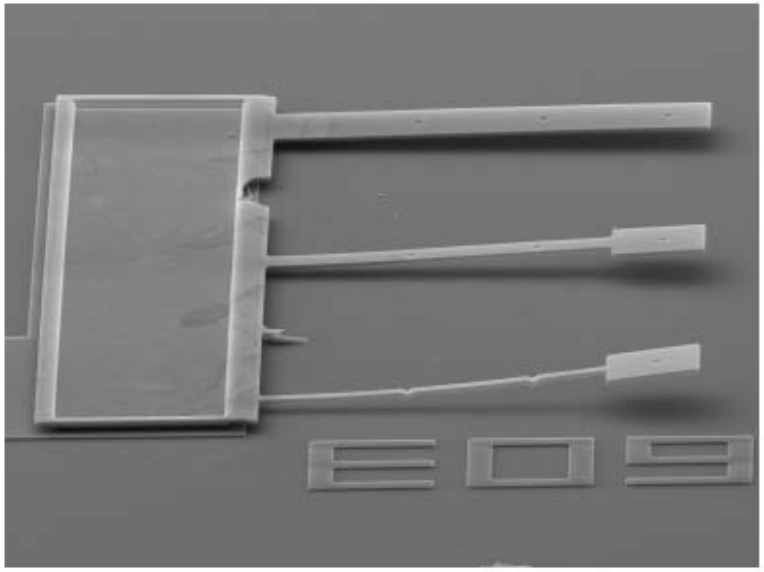
Drive positive and negative voltages to avoid actuator charging

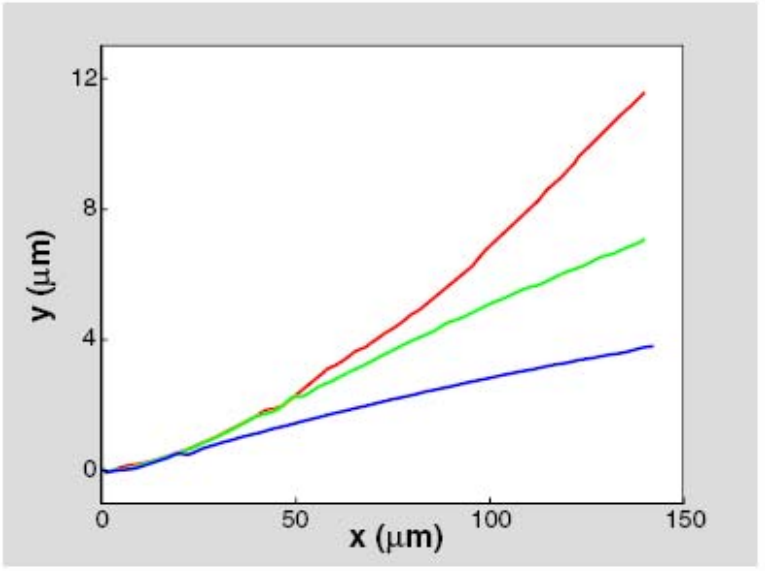


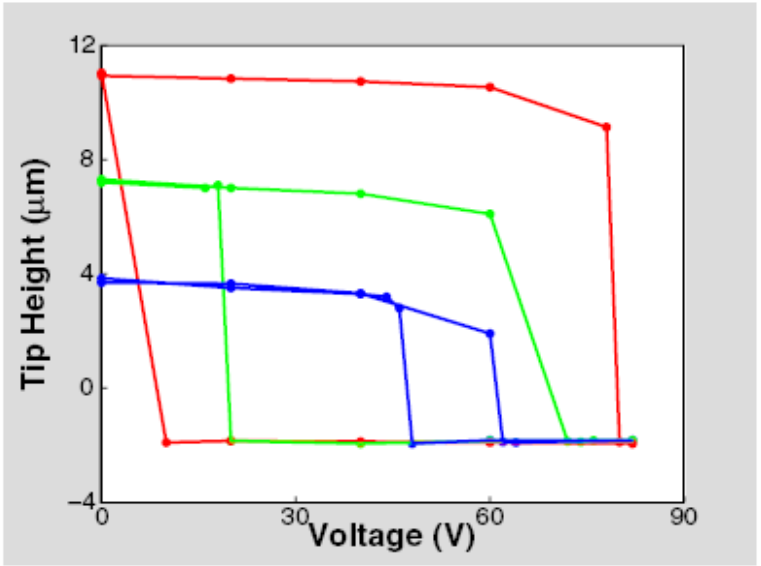
Scratch Drive Actuator (SDA) states



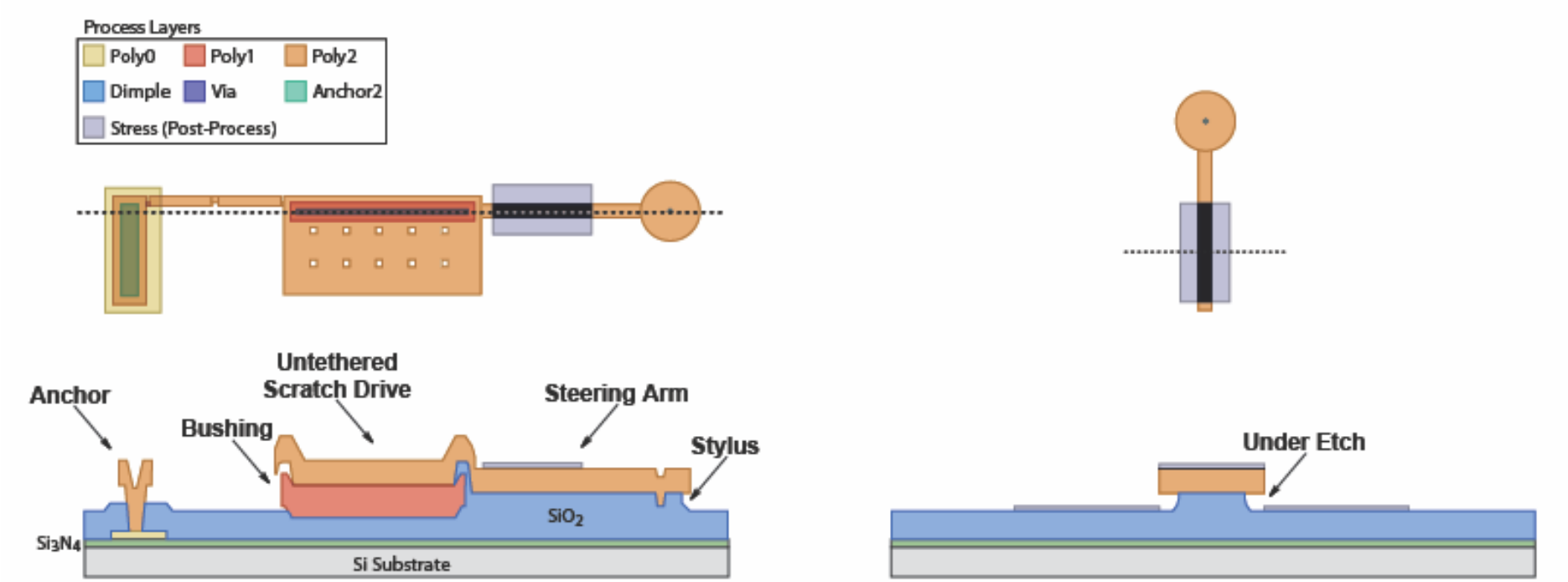
MEMS state machine



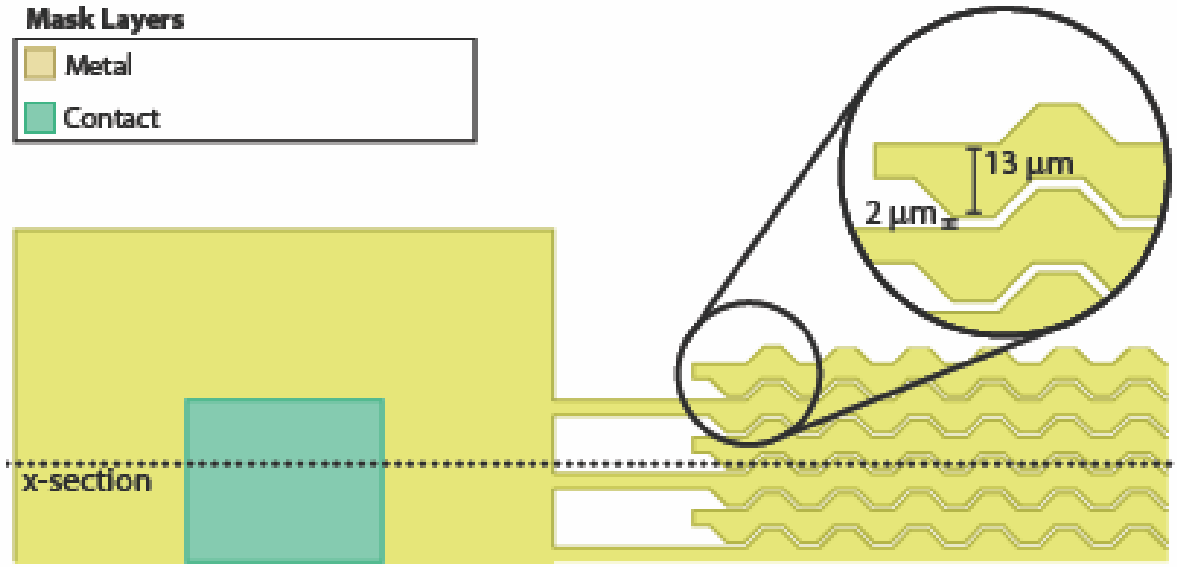


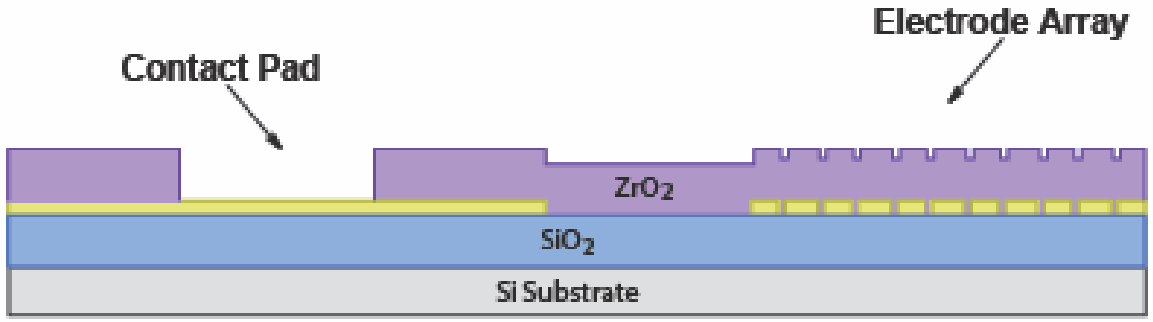


Microfabrication

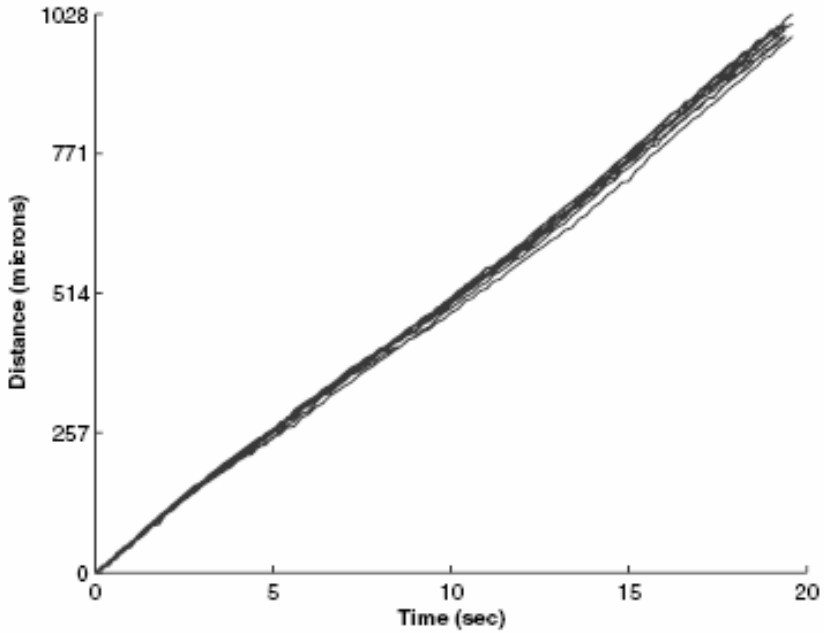


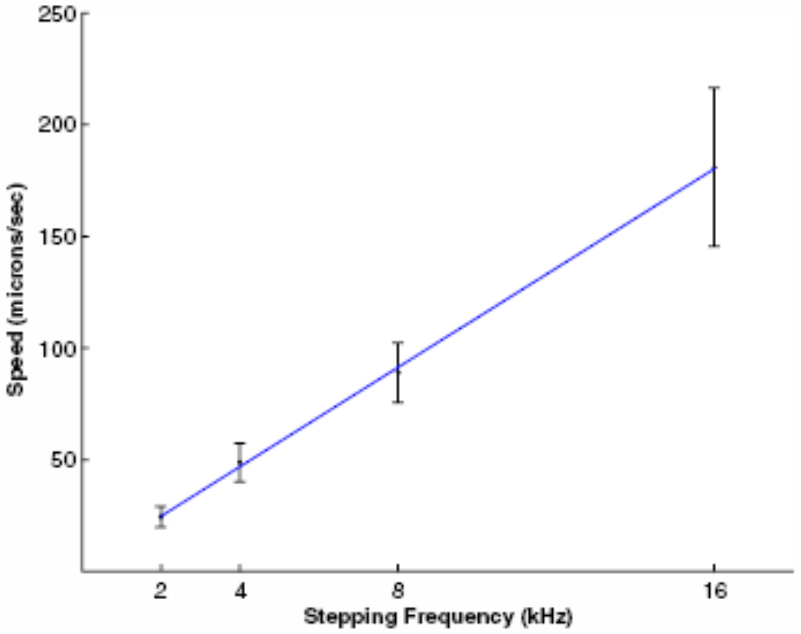
Playing field fabrication





Device characterization





Actuator paths