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Organic Bio-Electronics: Health Care & Soft Robotics

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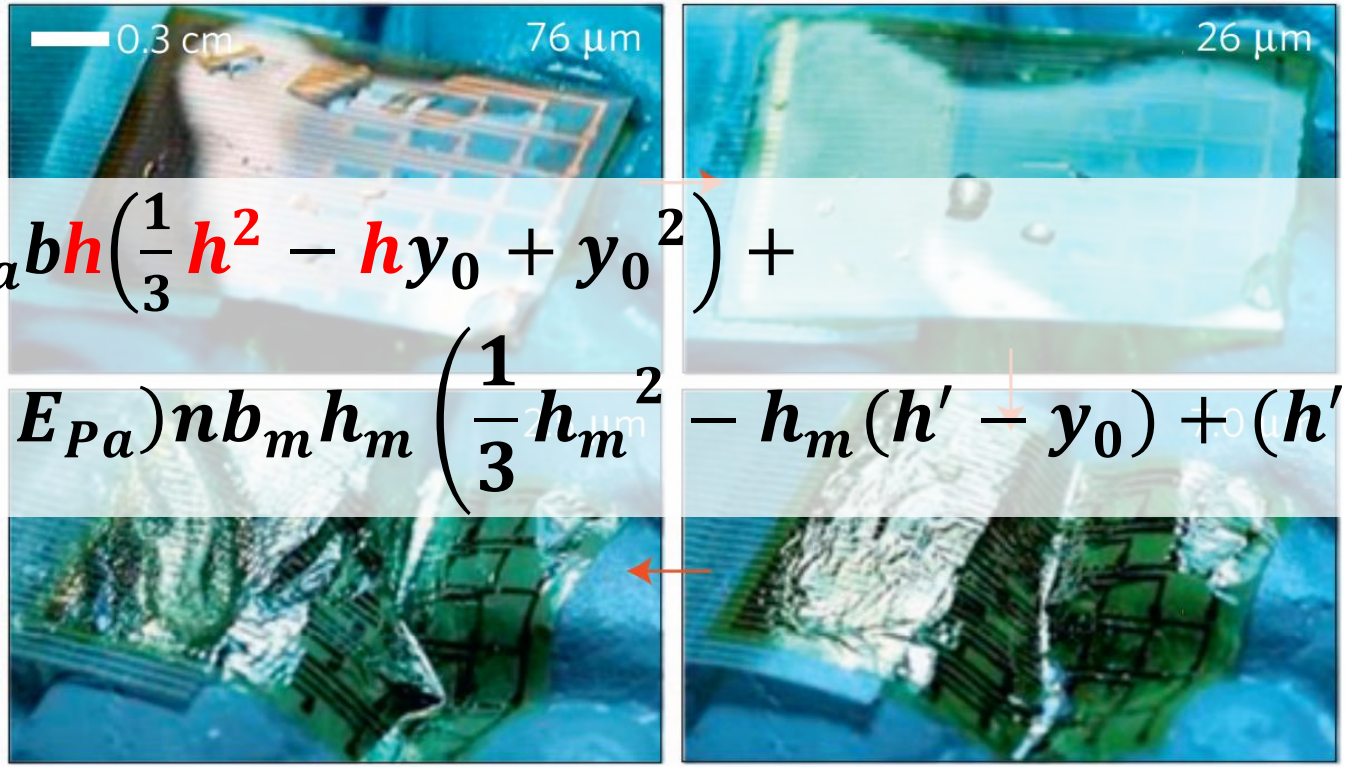
PURDUE
POLYTECHNIC

BACKGROUND

- Health monitoring equipment is getting smaller
- We want more comfortable, less obstructive monitoring
- Closer sensing to source of signal → higher SNR
- Deployment on skin is desired (to minimize stress and patient discomfort, and to maximize signal fidelity)

BENDING STIFFNESS

- On-skin deployment requires electronics to be ultra-thin, conformal, flexible, and biocompatible[1]
- Bending stiffness (radius) ∝ film thickness cubed[2]



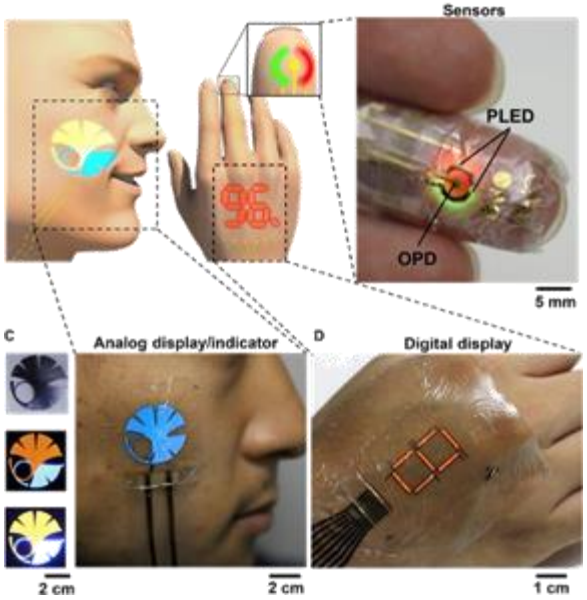
$$EI = E_{Pa} b h \left(\frac{1}{3} h^2 - h y_0 + y_0^2 \right) +$$

$$(E_{Au} - E_{Pa}) n b_m h_m \left(\frac{1}{3} h_m^2 - h_m (h' - y_0) + (h' - y_0)^2 \right)$$

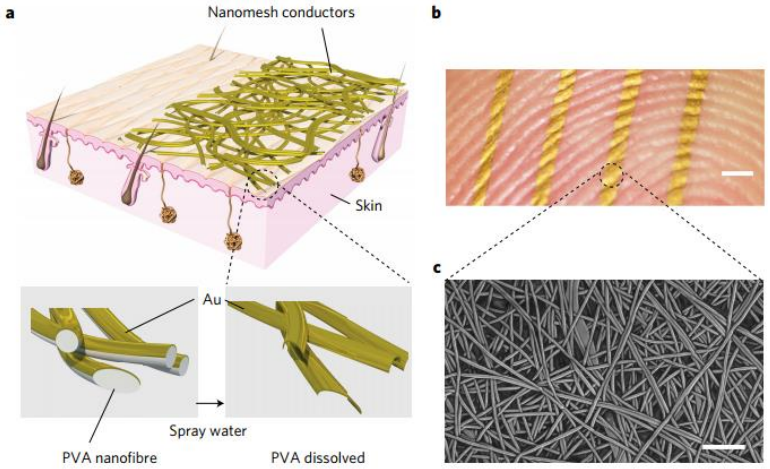
[1] M. Irimia-Vladu, *et al.*, Adv. Funct. Mater. **20**, 4069 (2010).
[2] D.-H Kim, *et al.*, Nature Mat. **9**, 511 (2010).

SKIN THIN ELECTRONICS

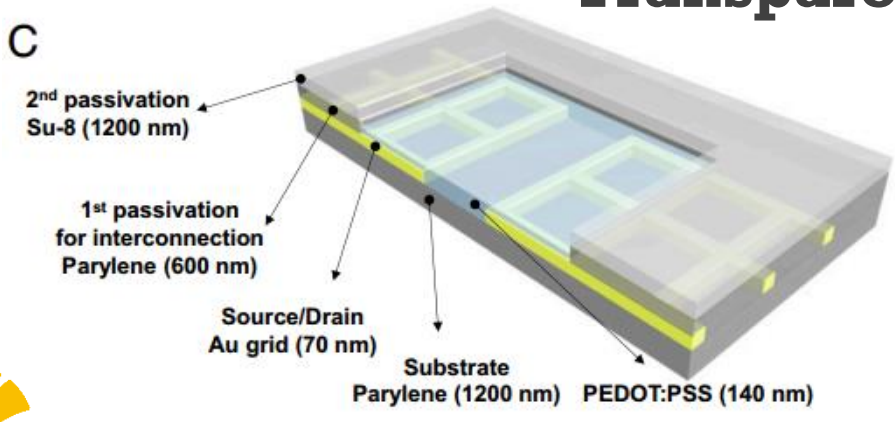
Photonic skin[3]

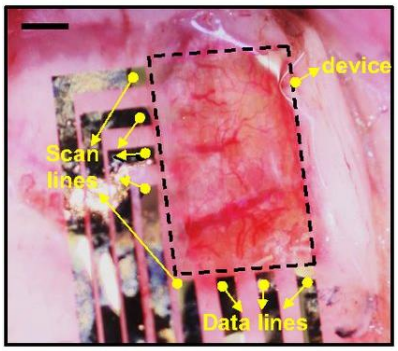


Mesh Electronics[4]



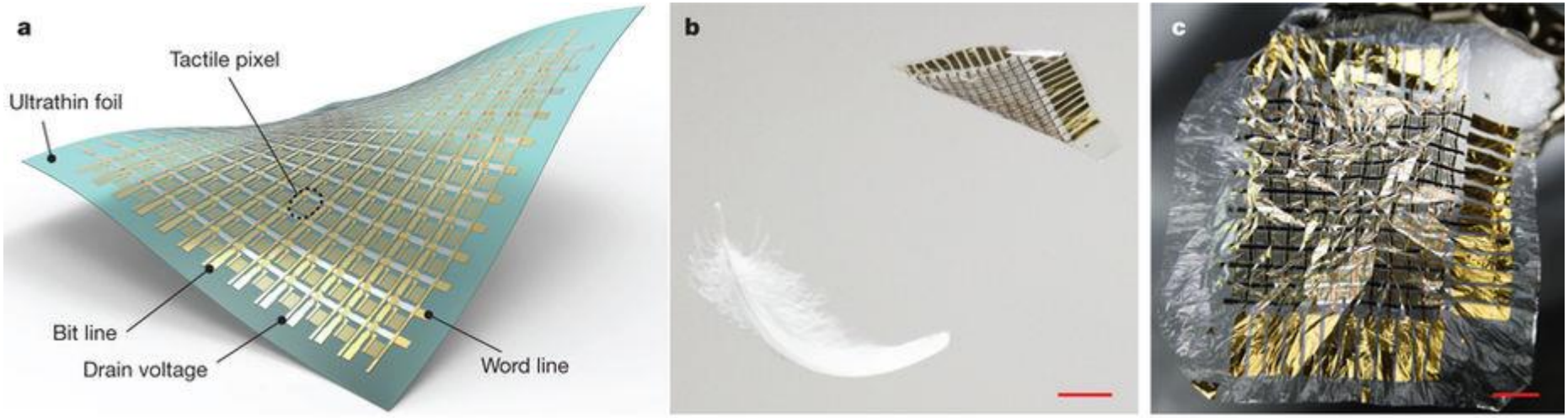
Transparent OECTs[5]





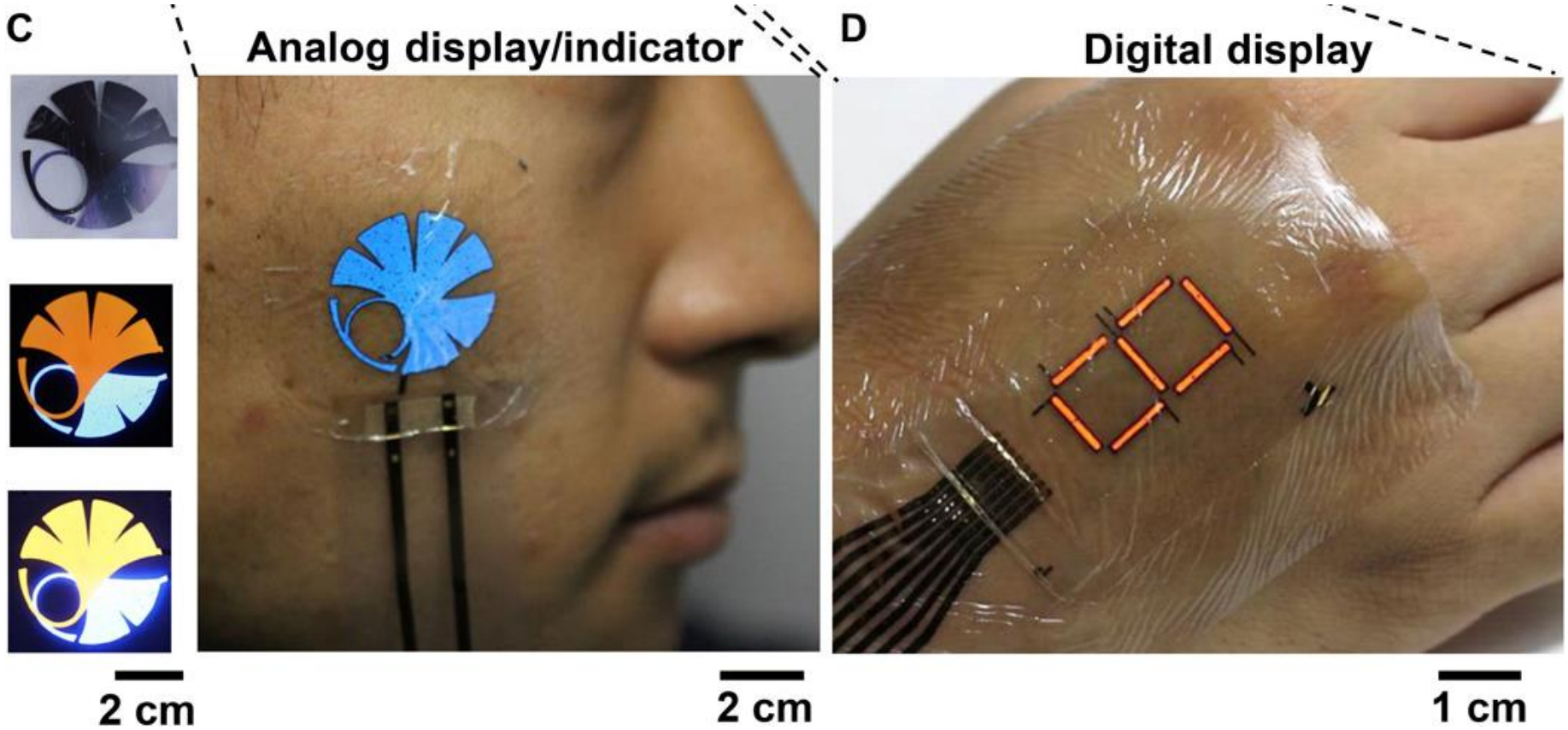
[3] Yokota, *et al.*, Science Advances, **2**, 4 (2016).
[4] Miyamoto, *et al.*, Nat. Nano, **12**, 907-913 (2017).
[5] Lee, *et al.*, PNAS **114**, 40 (2017).

BIO-ELECTRONICS



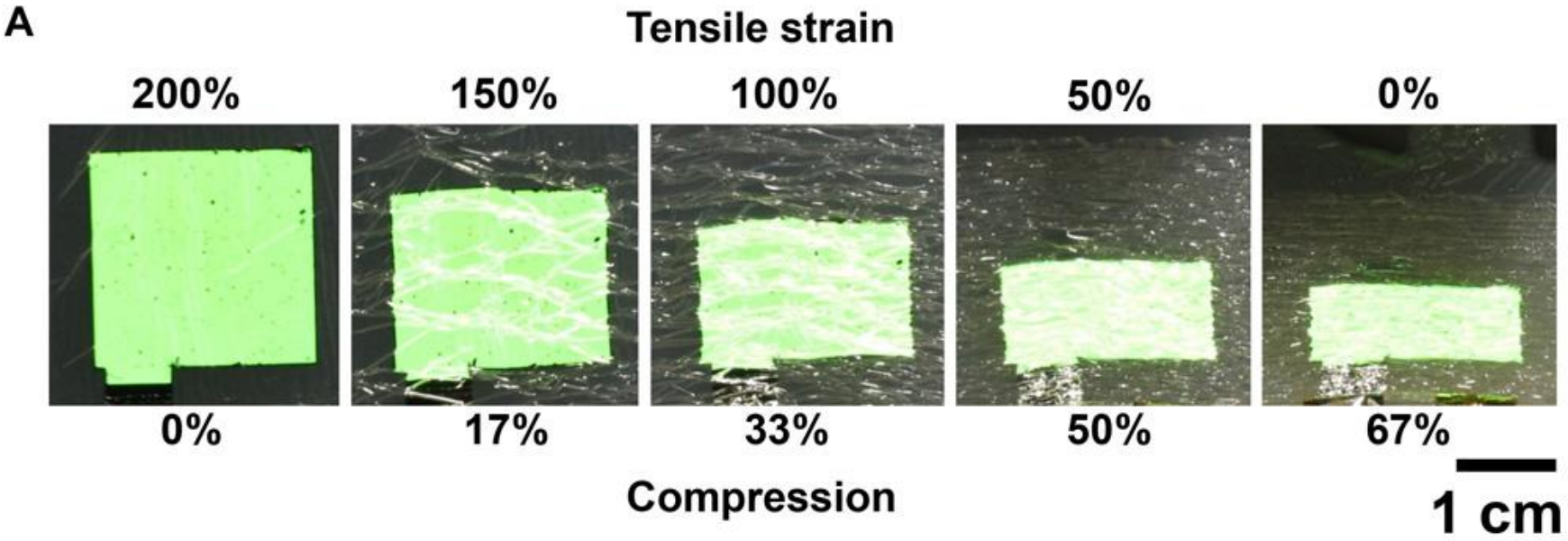
[6] Kaltenbrunner, *et al.*, Nature **499**, 458–463 (2013).
https://www.youtube.com/watch?v=y-kyN1-crCI

ORGANIC DISPLAYS



[3] Yokota, *et al.*, Science Advances, **2**, 4 (2016).
https://www.youtube.com/watch?v=sixMVCYALmM

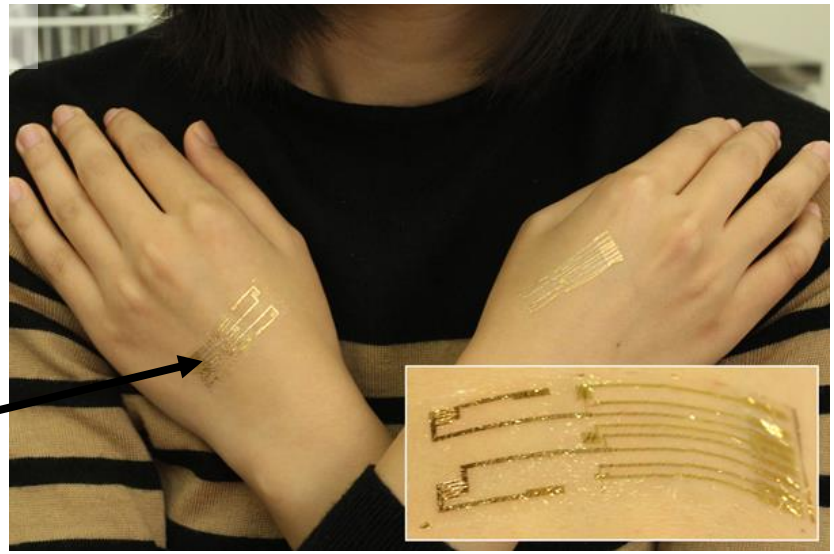
ORGANIC DISPLAYS

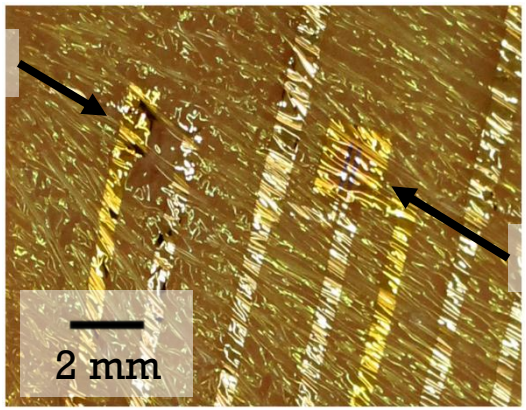


[3] Yokota, *et al.*, Science Advances, **2**, 4 (2016).

300 nm THIN ELECTRONICS

- I (**2016**) fabricated imperceptible electronics that are **< 300 nm** thick[7]
- Ultra-flexible (bent 100x)
- Ultra-conformable (~1.5 μm)
- Ultra-light (< 0.7 g m^{-2})
- Bio-compatible (> 10 hrs)

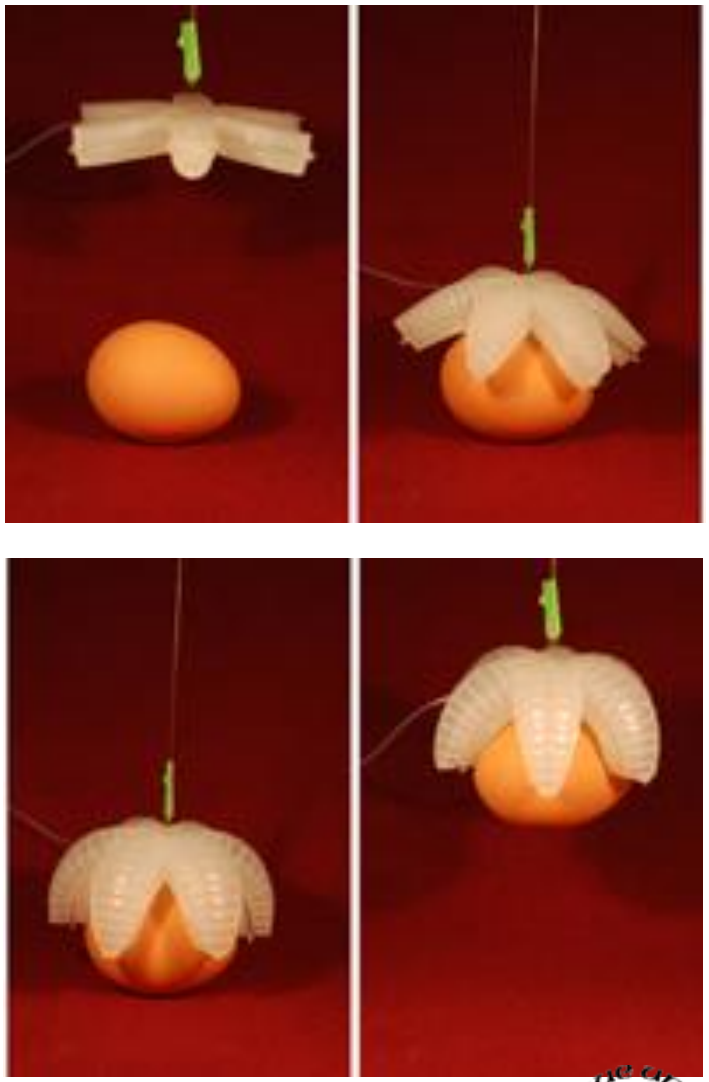




[7] Nawrocki, *et al.*, Adv. Ele. Mater. **1500452**, (2016).

SOFT ROBOTICS

- Highly compliant materials, similar to those found in living organisms
- Draws heavily from the way in which living organisms move and adapt to their surroundings
- Allow for increased flexibility and adaptability for accomplishing tasks, and improved safety when working around humans
- Potential use in the fields of medicine and manufacturing



* Courtesy of George Whitesides from Harvard
https://www.youtube.com/watch?v=2DsbS9cMOAE

PhD POSITION: OPENING

- PhD position
  - Preferably with MS
  - Experience in:
    - Fabrication
    - And/Or
    - Electrical Computer Eng
- Postdoc (with own funding)
- Great school
- Great project
- Contact me:

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THANK YOU