Bioinspired E-skins

Presented by: Jonathan Appiagyei

A new approach to tactile sensing

SENSORS

A hierarchically patterned, bioinspired e-skin able to detect the direction of applied pressure for robotics

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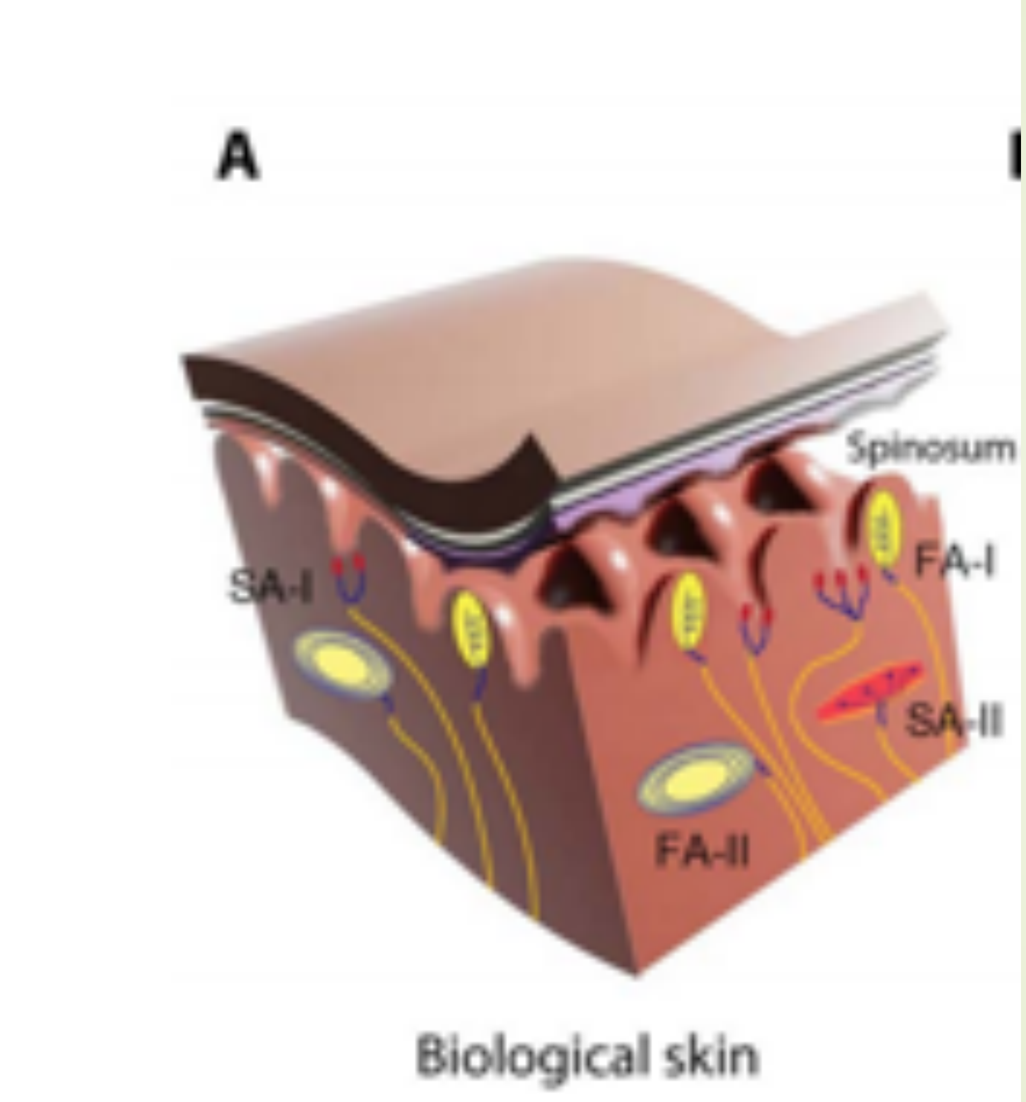
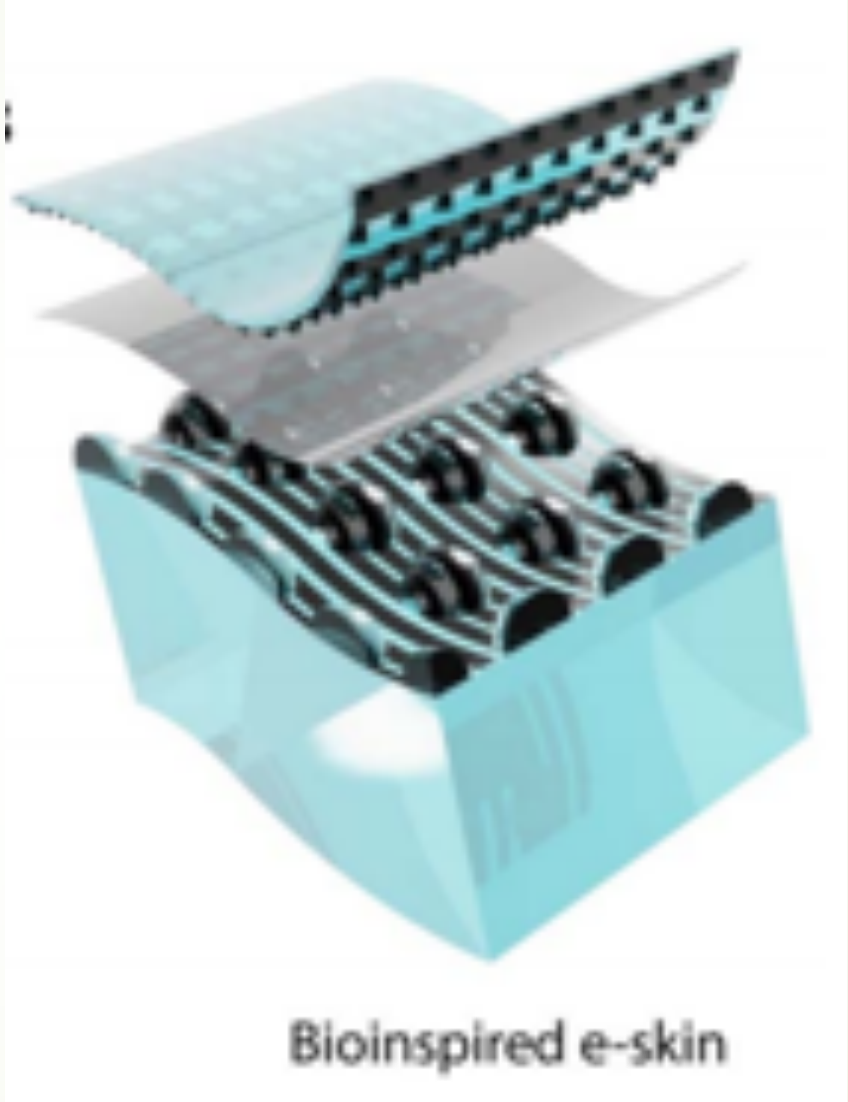
The goal is to mimic human skin structure

- Four types of receptors lie in a structure called the spinosum
- The FA-I and FA-II receptors quickly measure dynamic forces and vibrations
- The SA-I and SA-II receptors measure static pressures over slower time scales



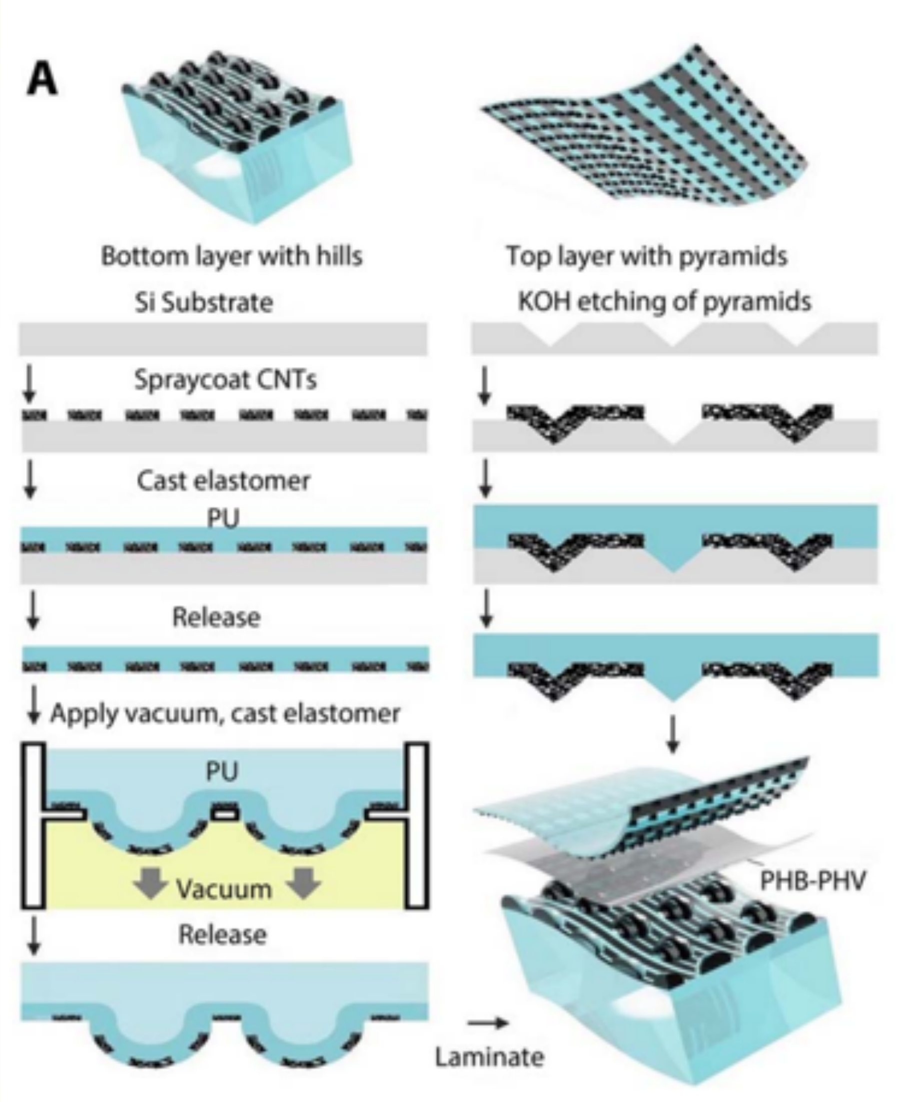
The e-skin below replicates the spinosum

- This e-skin in particular is able to measure both normal and shear forces
- Blue material is polyurethane
- Black objects in top layer are carbon nanotubes
- Grey layer is a dielectric
- Bottom silver devices are electrodes

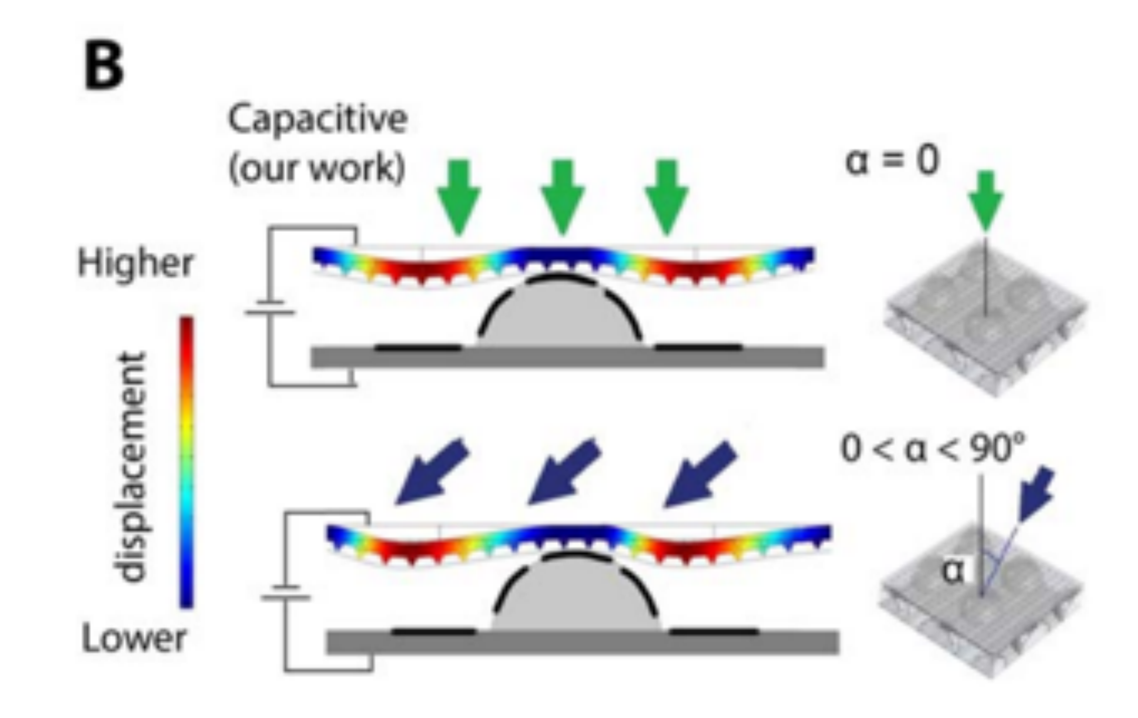


Each hill has multiple capacitors

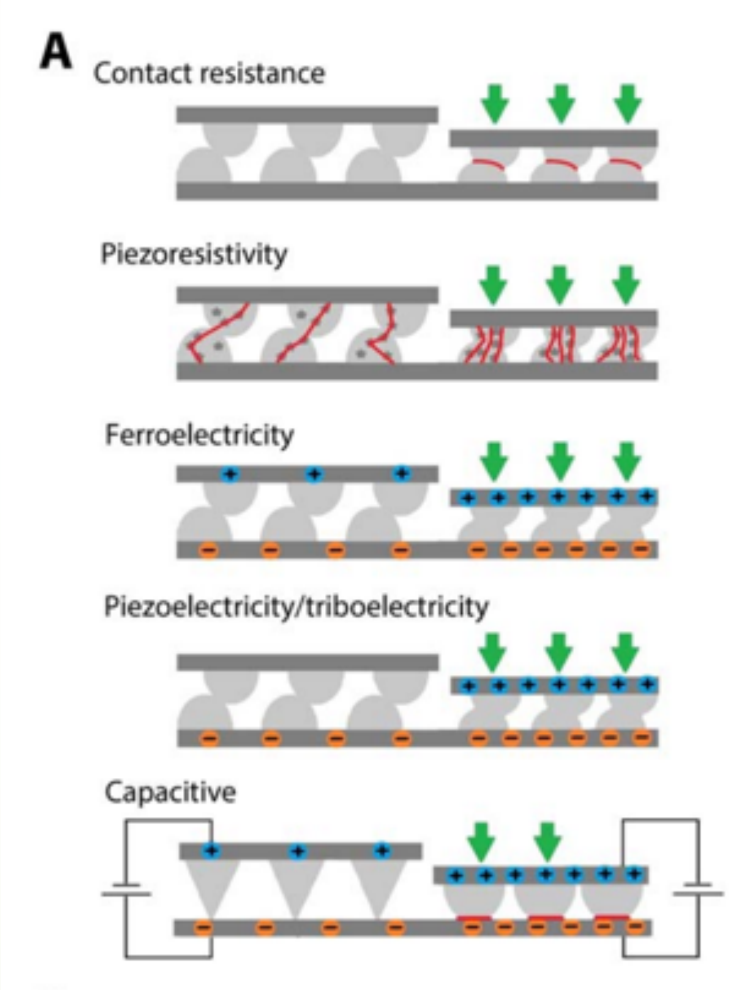
- 26 capacitors on each ridge
- 1 capacitor at the top, 4 on the slopes, 4 on the corners, and 16 surrounding the hill



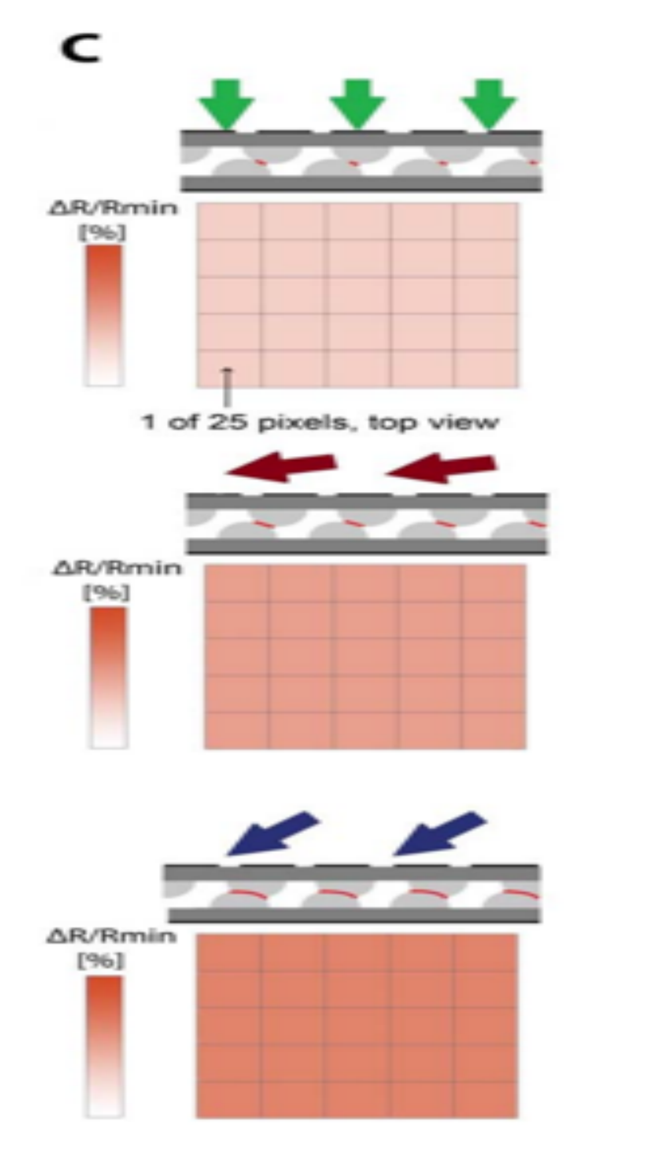
The result is a sensor with greater sensing

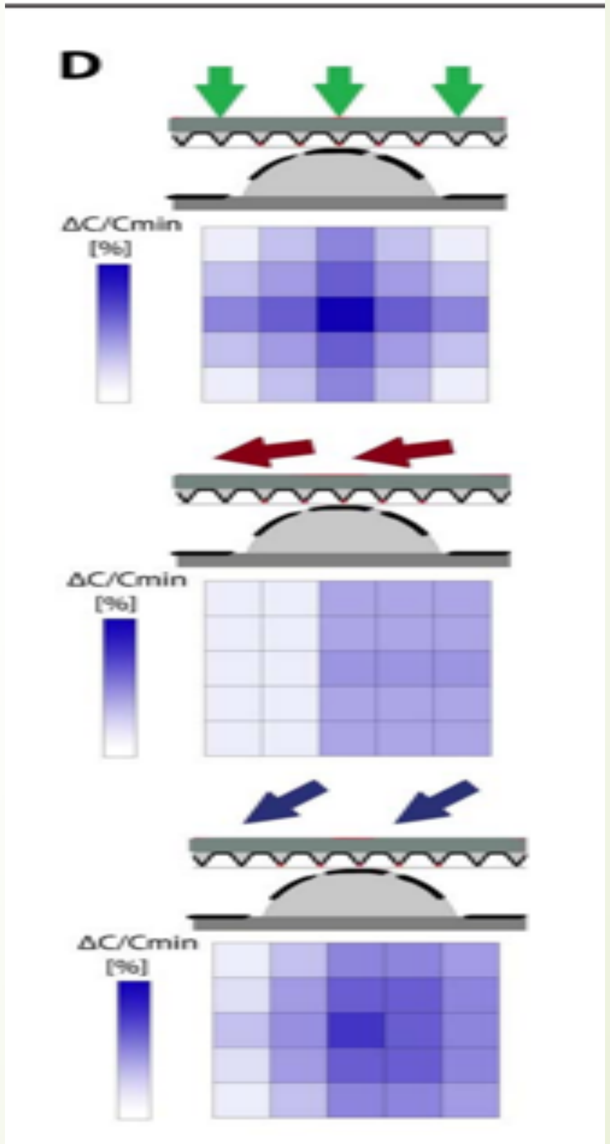


Below are typical approaches to tactile sensing

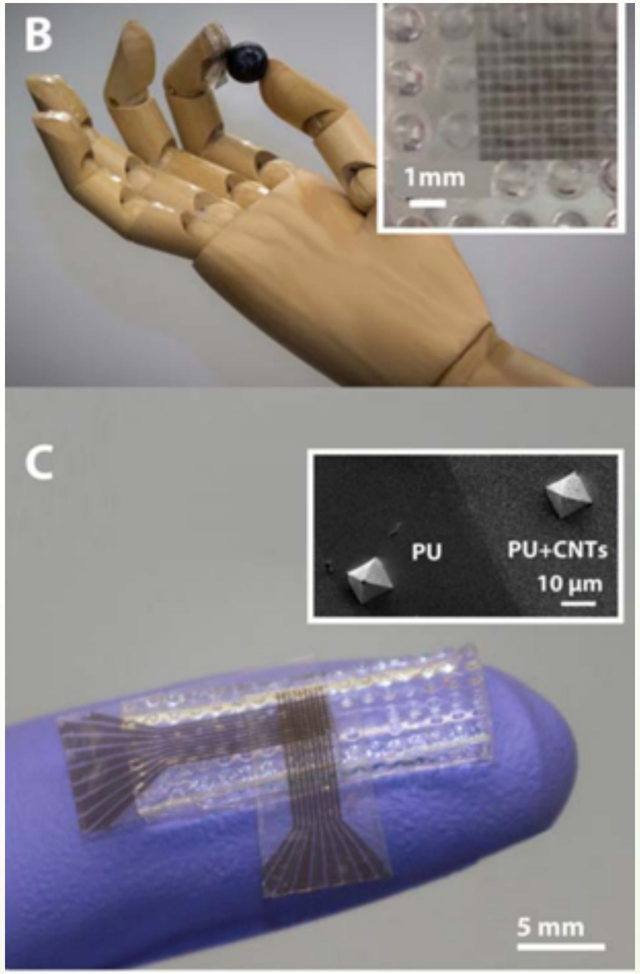


Typical approaches offer less resolution



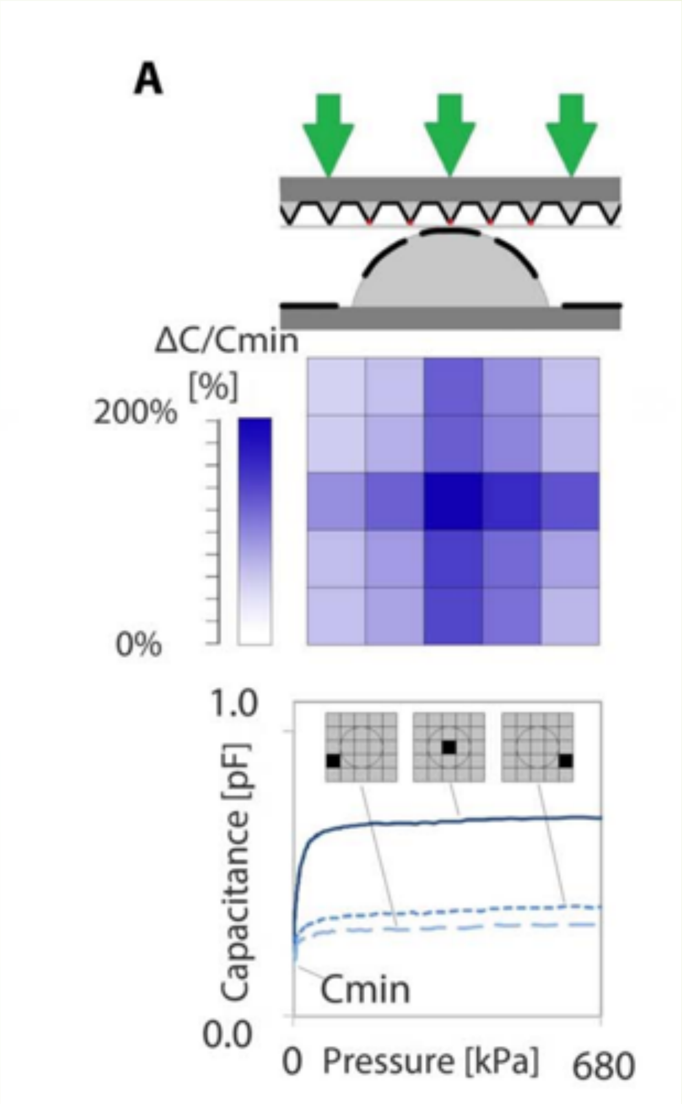


Here are close-up views of the skin



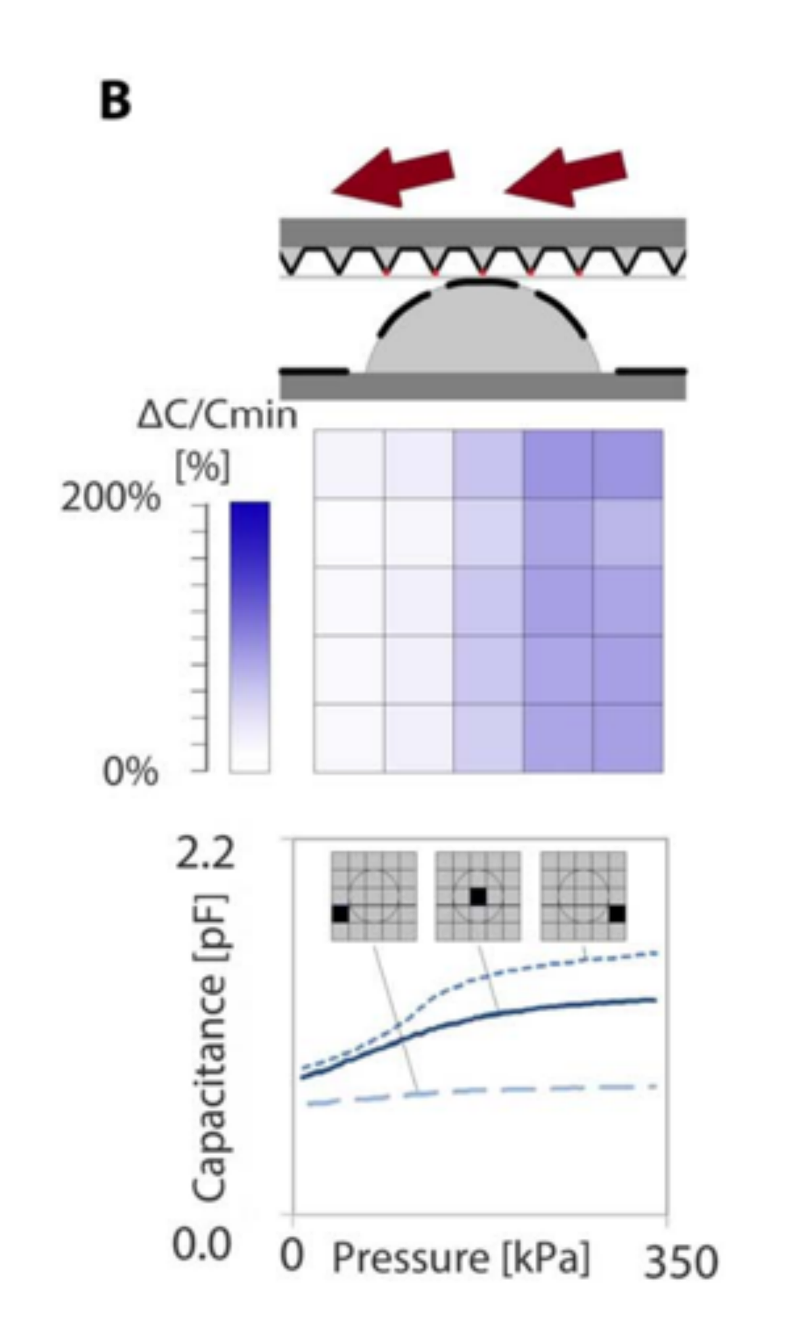
This example shows readings from applying a normal force

- Each pyramid is 30um away(center-to-center) from the other
- 7000kPa of force applied



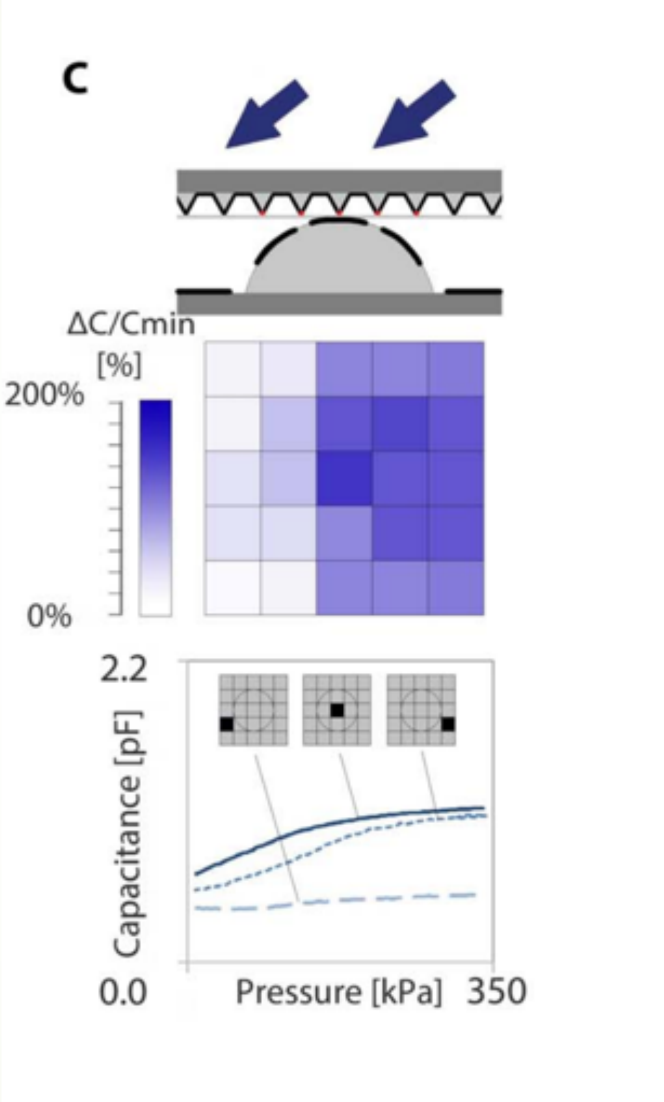
A shear force and a normal force is applied to this ridge

- 5kPa-10kPa applied



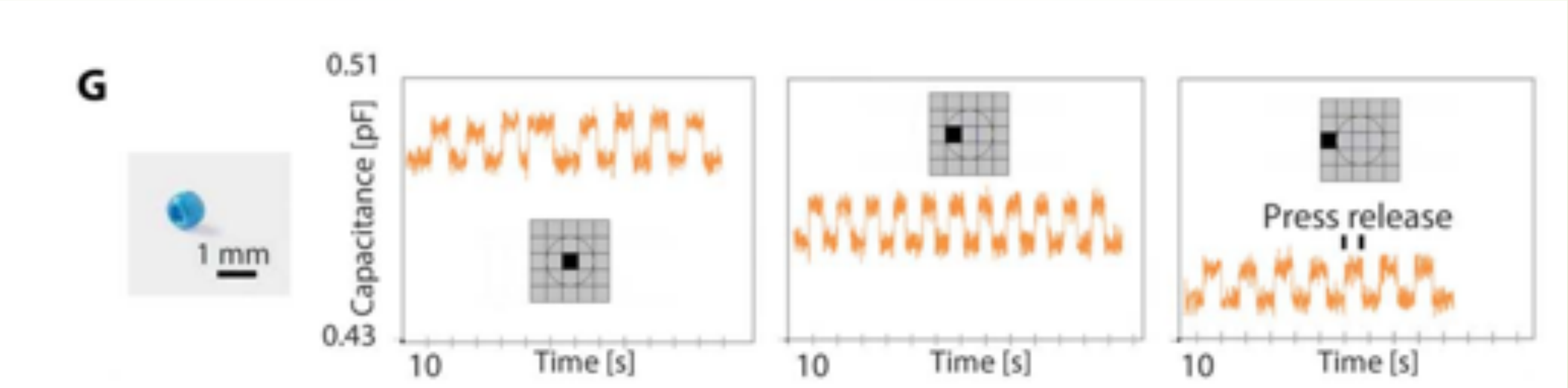
Applied here is a tilt force

- 340kPa of force was applied

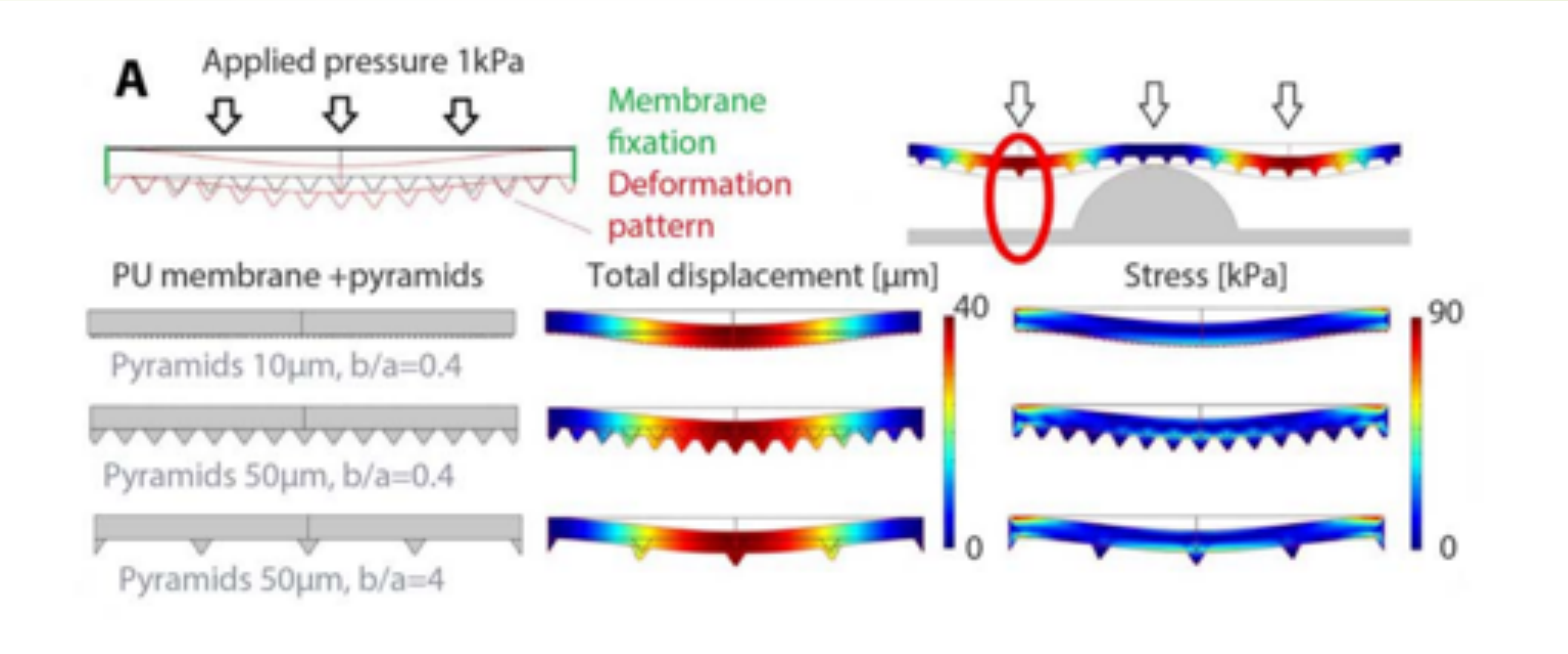


Observed is the signal response from a bead

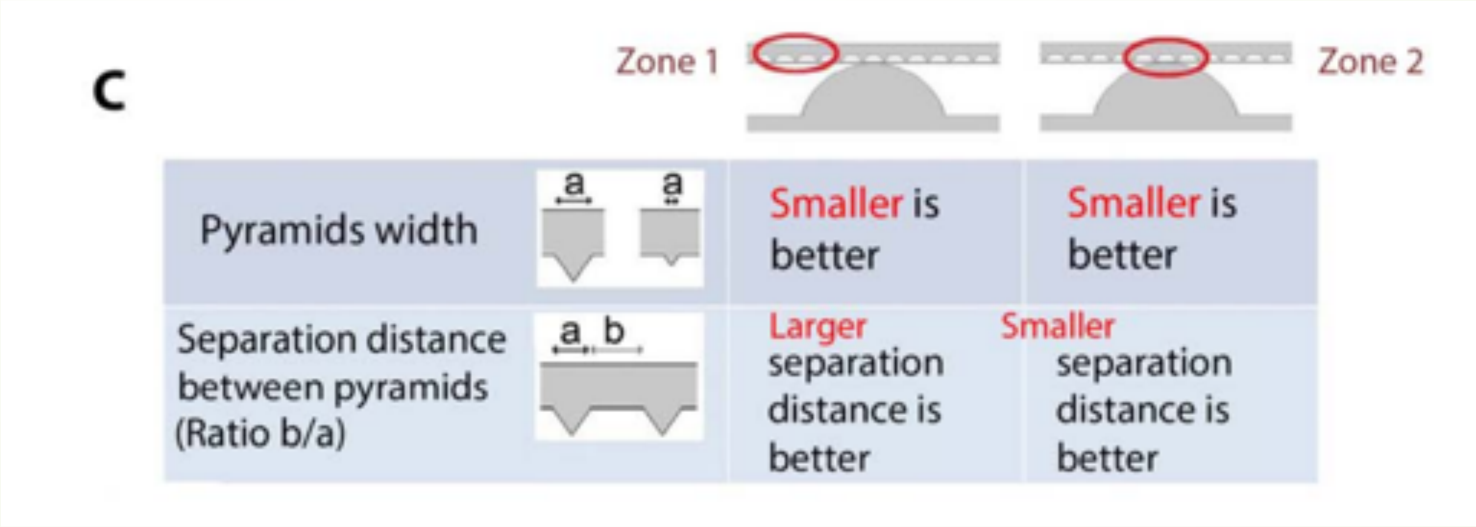
- A bead was removed and grabbed over and over



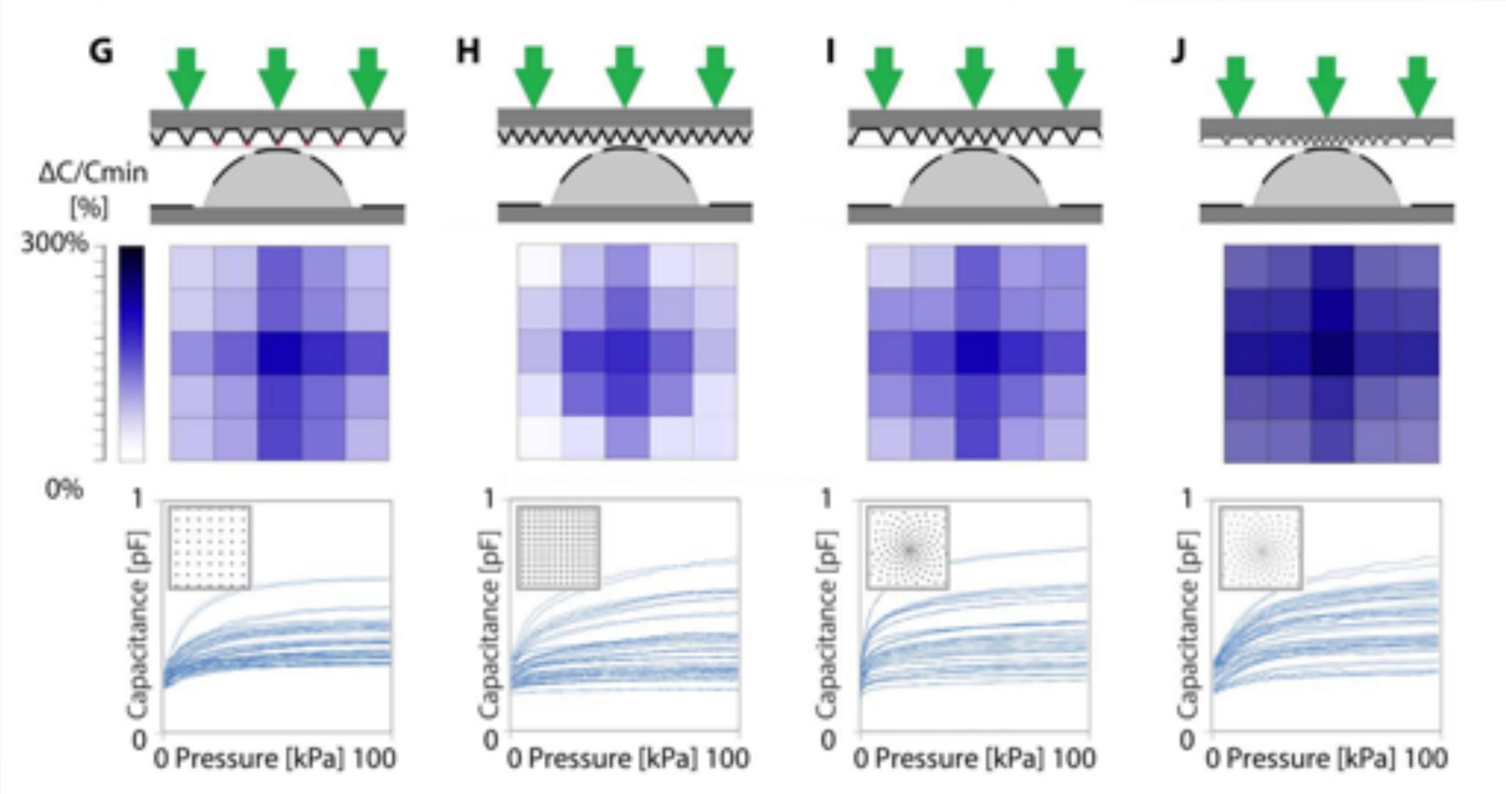
Changing pyramid size and distancing yields different results



Different regions have different sizing ideals

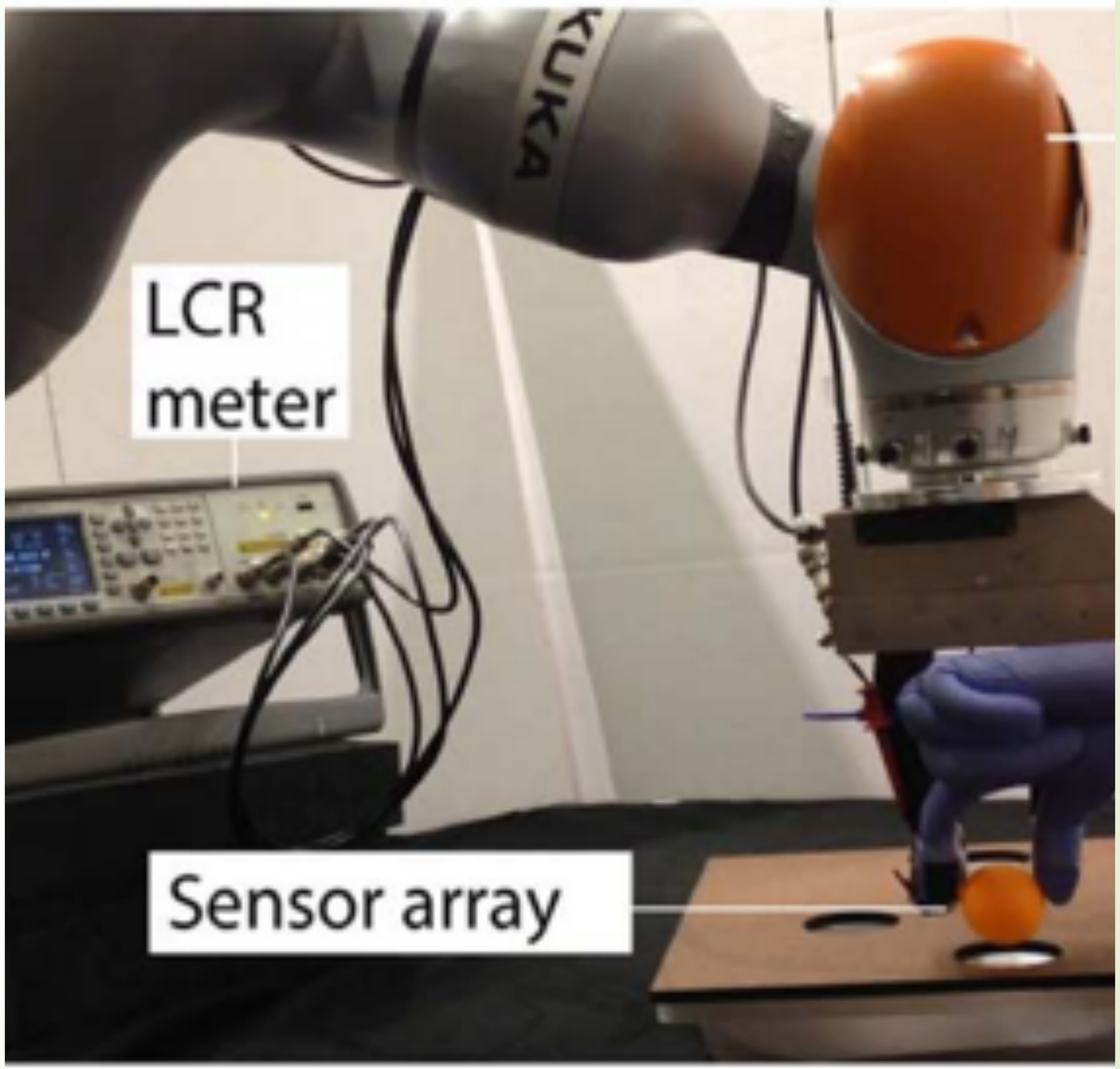


Spiral and orthogonal patterns were tested



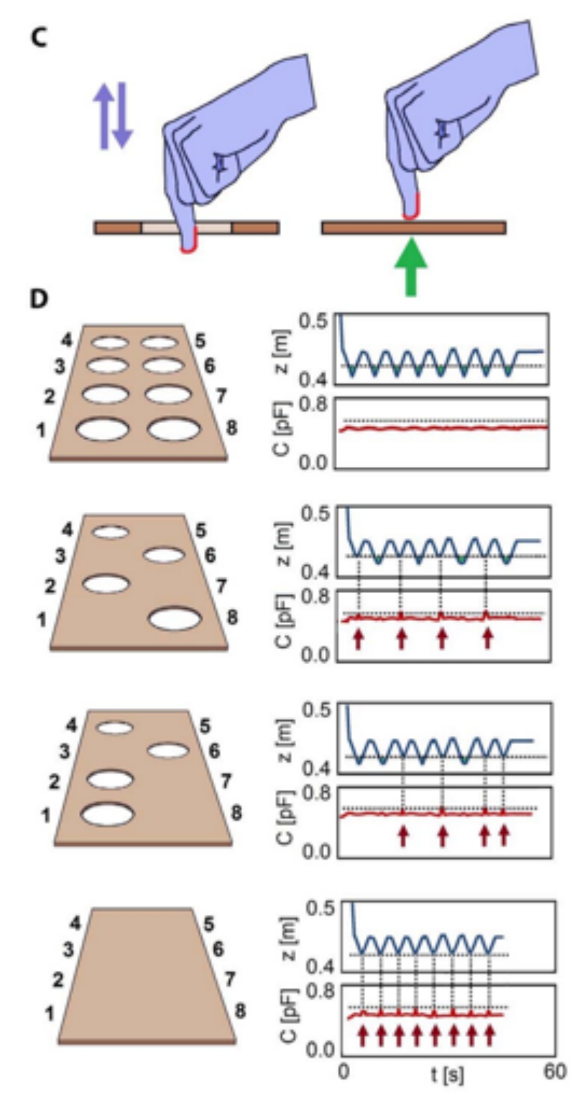
An experiment with the e-skin in action

- LCR meter measures signal response
- Board with/without holes



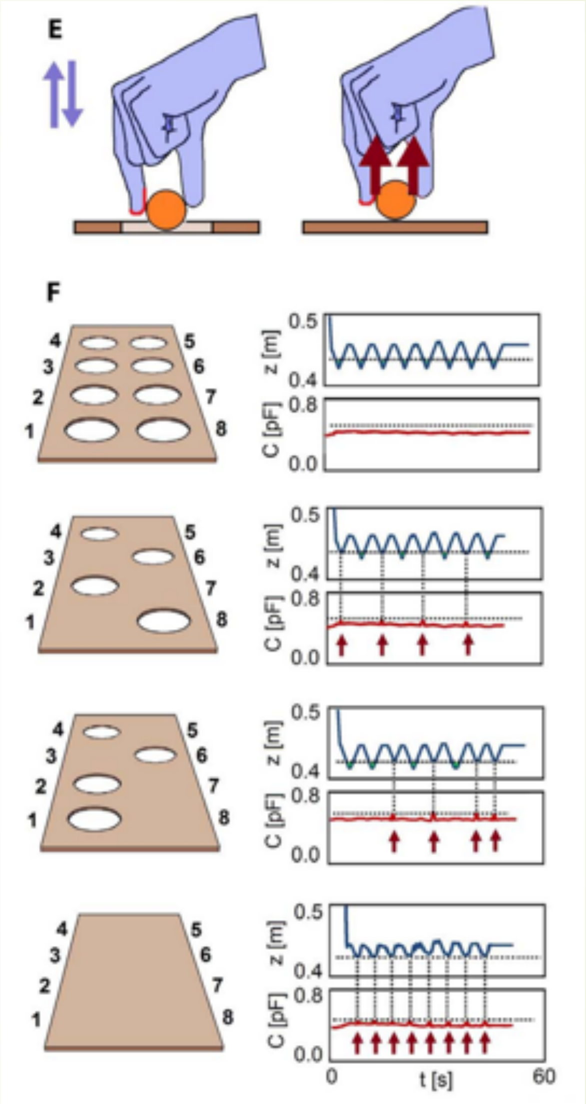
The hand experiment without the ball

- Green arrow represents normal force
- Red is the e-skin

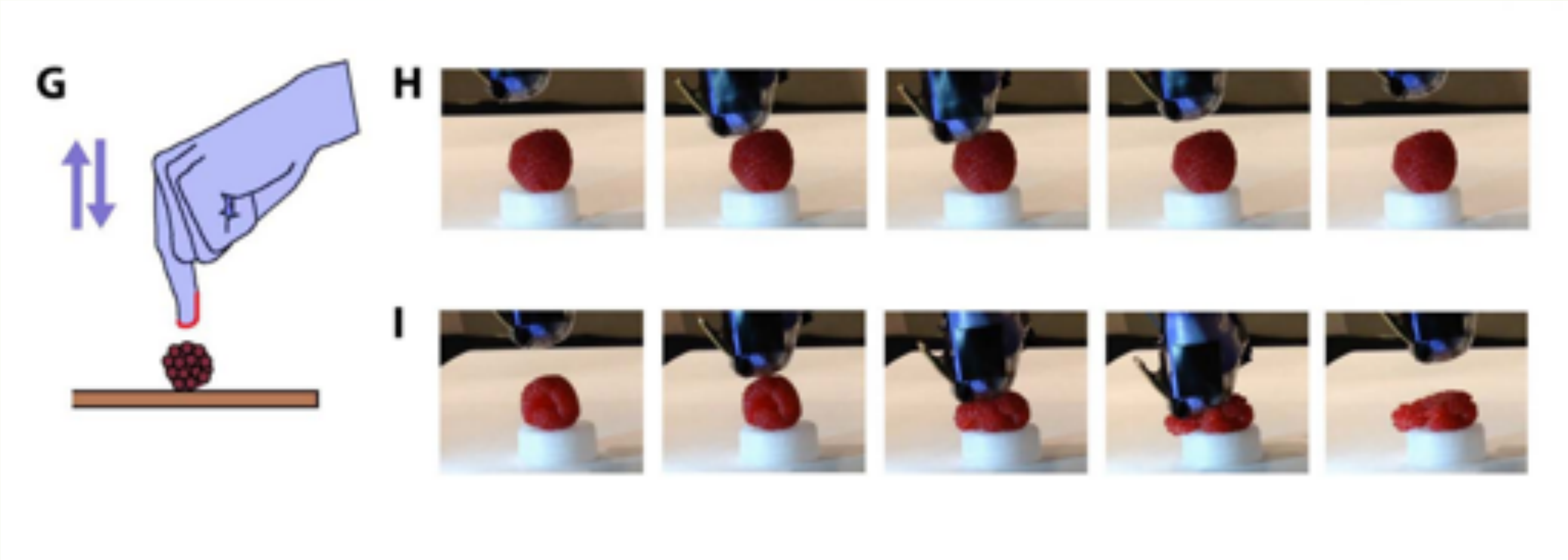


The hand experiment with a ball

- Red arrows represent the shear force



The e-skin is used to prevent the hand from crushing the raspberry



Emulating biological features in nature

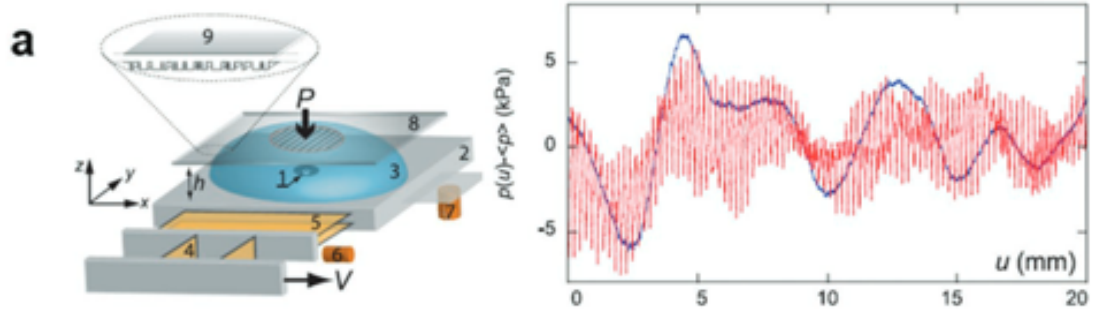
Mimicking Human and Biological Skins for Multifunctional Skin Electronics

*Youngoh Lee, Jonghwa Park, Ayoung Choe, Seungse Cho, Jinyoung Kim, and Hyunhyub Ko**

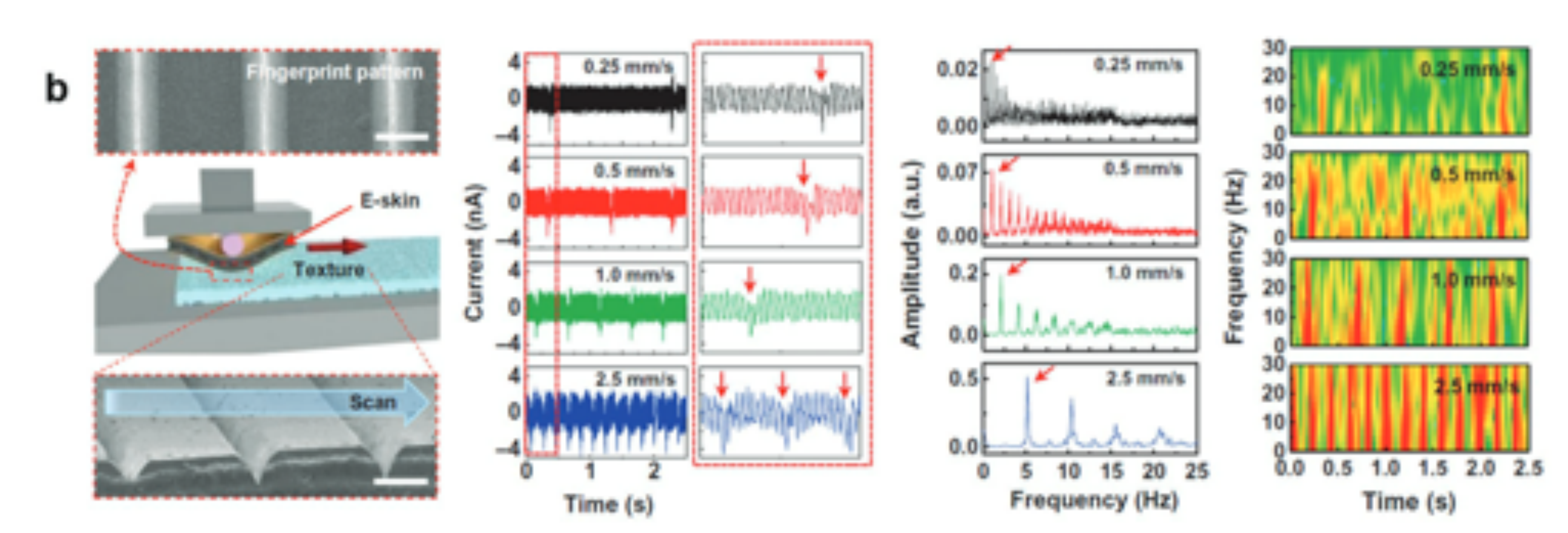
Fingerprint-Like Skin

Skins with ridges enhance the detection of vibrations

- MEMS based sensor
- Aids in high-frequency sensing

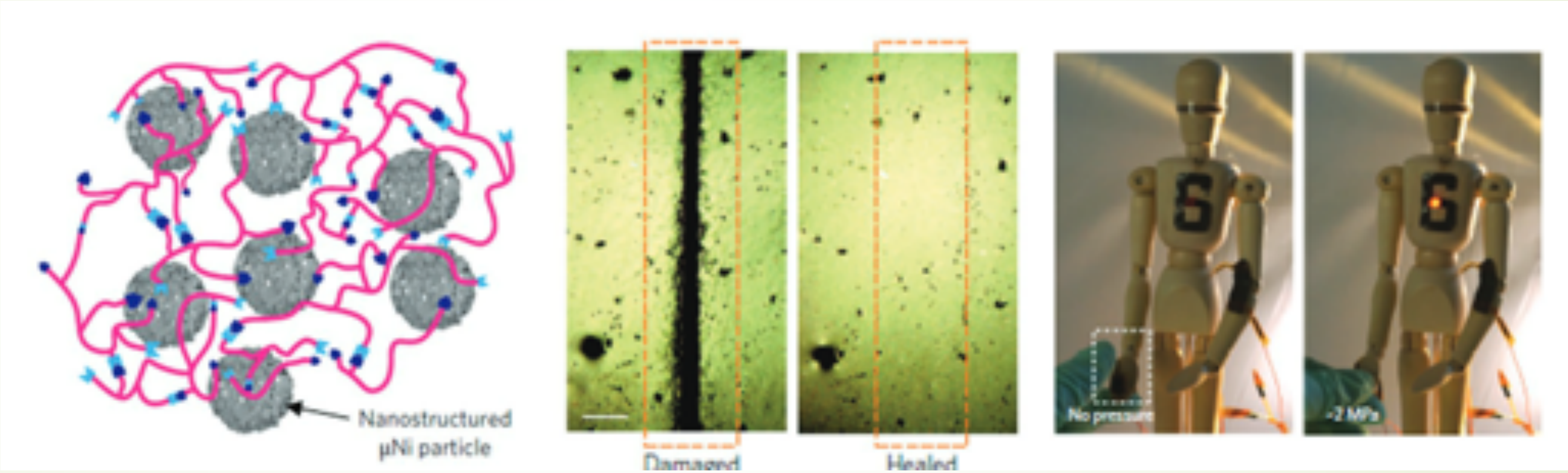


Piezoelectric sensors allow for flexible skins

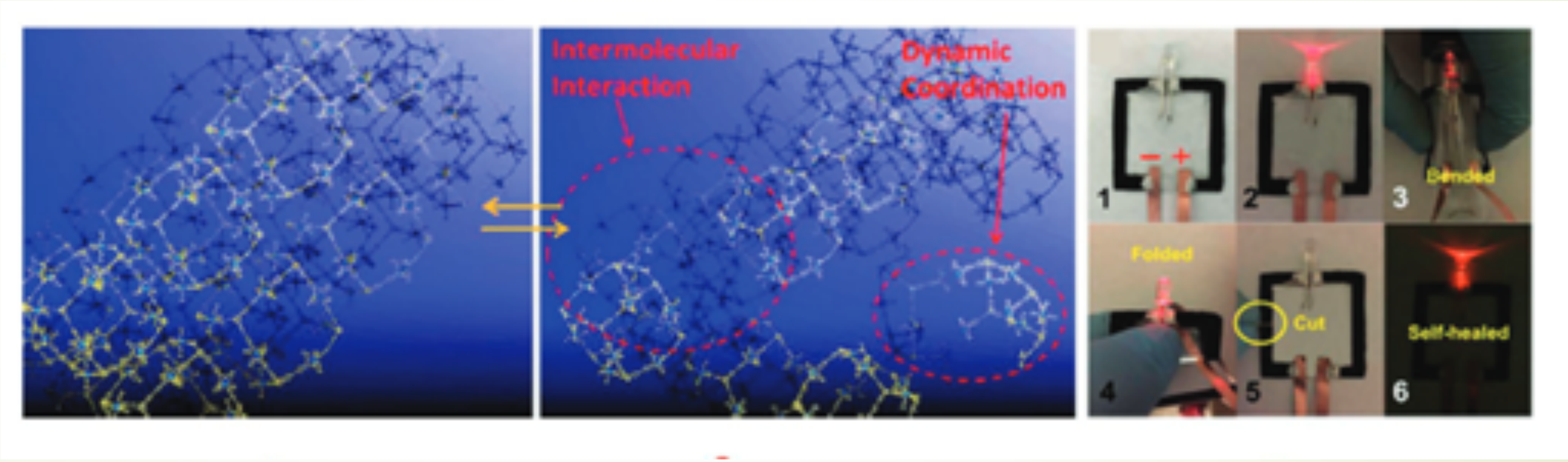


Self-Healing Skin

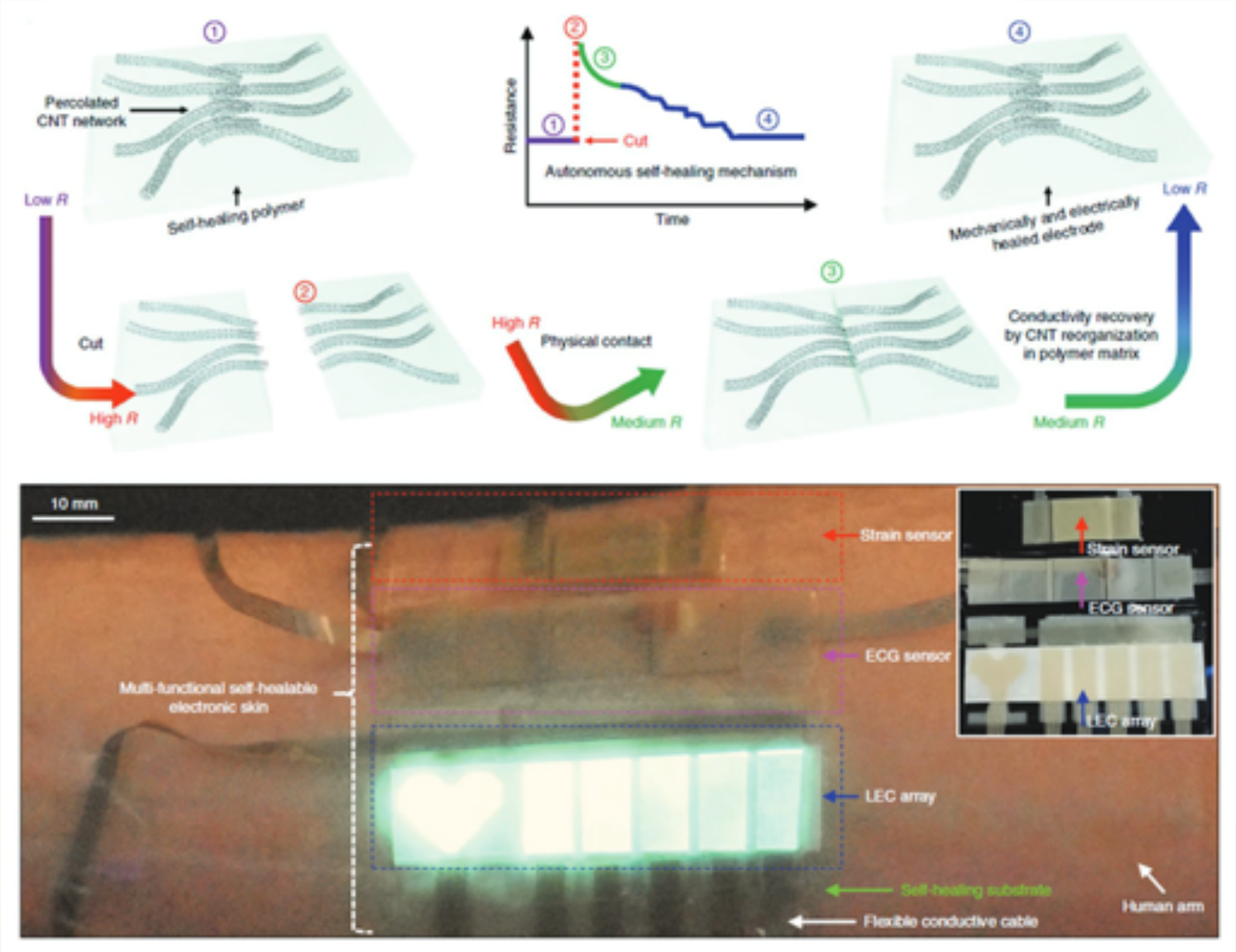
This skin uses a polymer to exploit hydrogen bonds for self-healing



This skin uses a supramolecular gel to heal



CNTs have also been experiment with in conductive self-healing skins

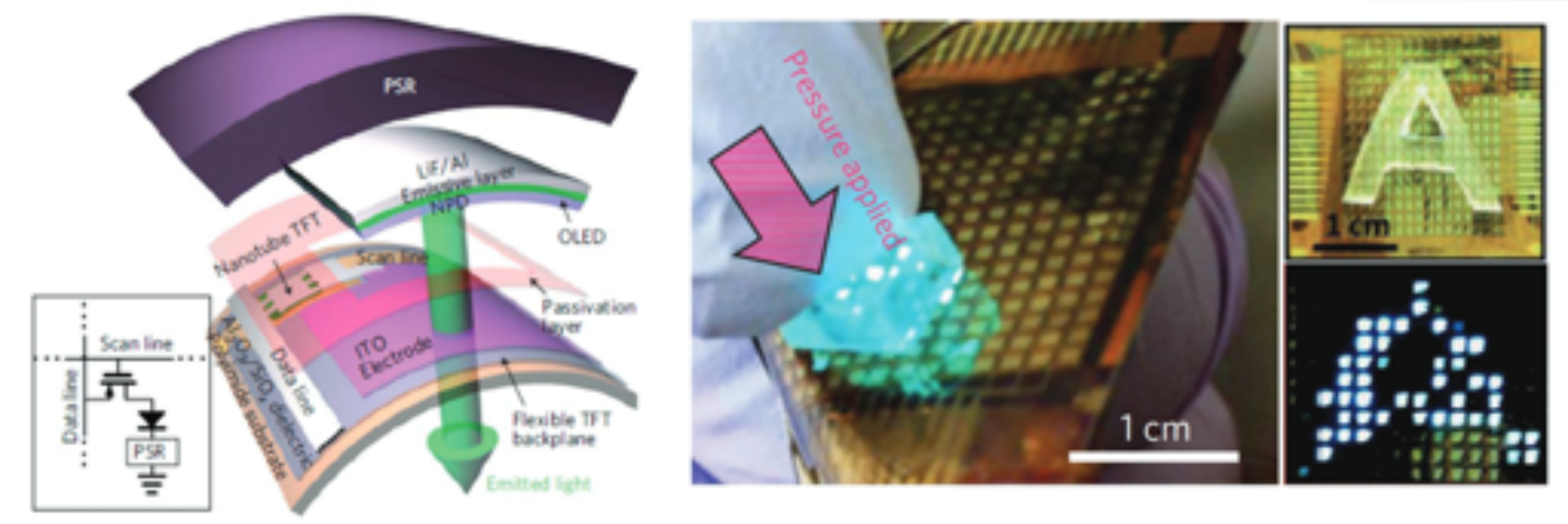


Response Visualization

There are various ways to exhibit illumination

- OLEDs and dyes have been used to show interactions with e-skins
- Electrochromic and thermochromic materials response to voltages differences and temperature
- The need for constant external power can be an issue (OLEDs e.g.)

An example of an OLED-based skin



A combination pressure and dyes can be used as well