M2794.007700 Smart Materials and Design

Example of Team project

March 7, 2017

Prof. Sung-Hoon Ahn (安成勳)

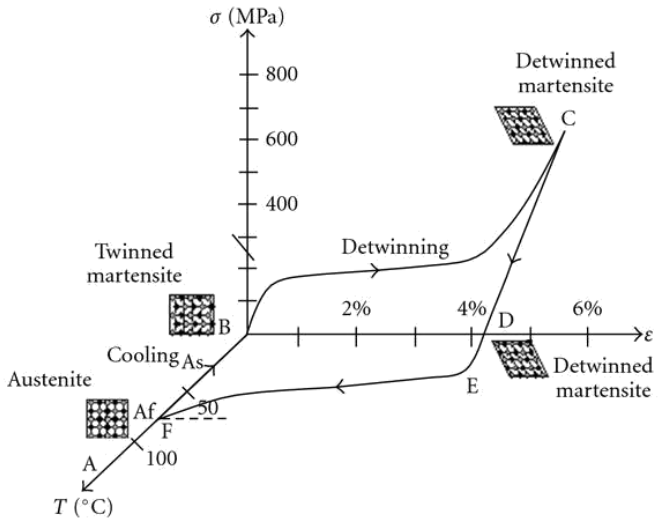
School of Mechanical and Aerospace Engineering
Seoul National University
http://fab.snu.ac.kr
ahnsh@snu.ac.kr

Advanced Smart Materials

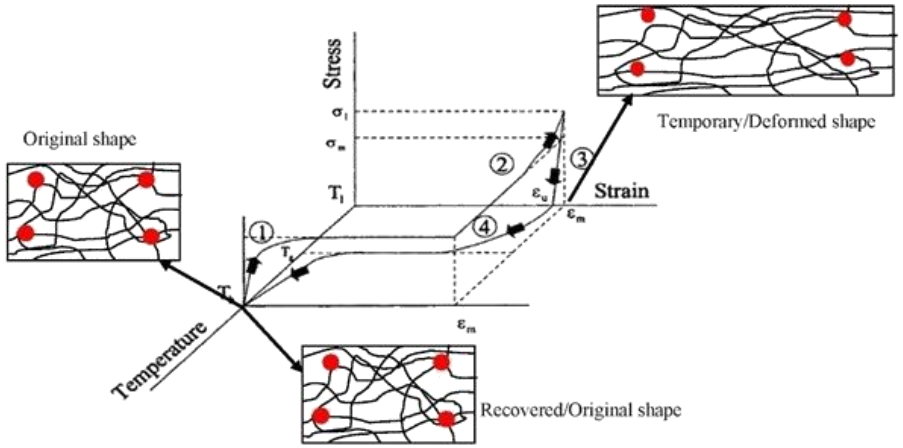
- Shape memory alloy (SMA) / Shape memory polymer (SMP)
- Piezoelectric materials
- Electro-active polymer
- Ionic polymer metal composites
- Hydrogel

Shape memory effect

Shape memory alloy

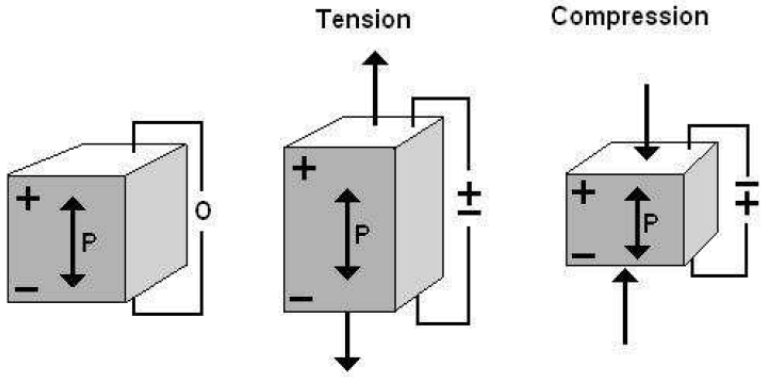


Shape memory polymer

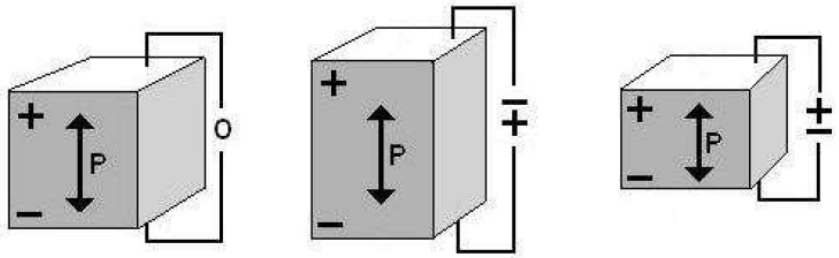


Piezoelectric effect

- **Direct piezo effect**
  - A mechanical stress on a material produces an electrical polarization



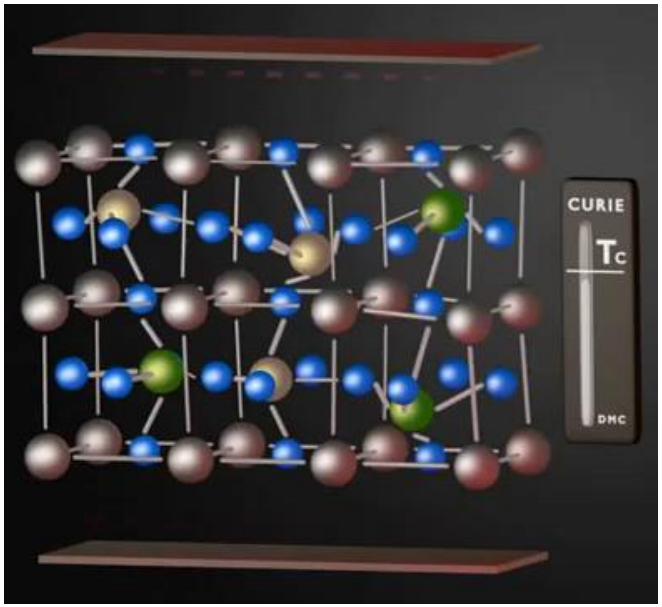
- **Converse (inverse) piezo effect**
  - An applied electric field in a material produces dimensional changes and stresses within a material



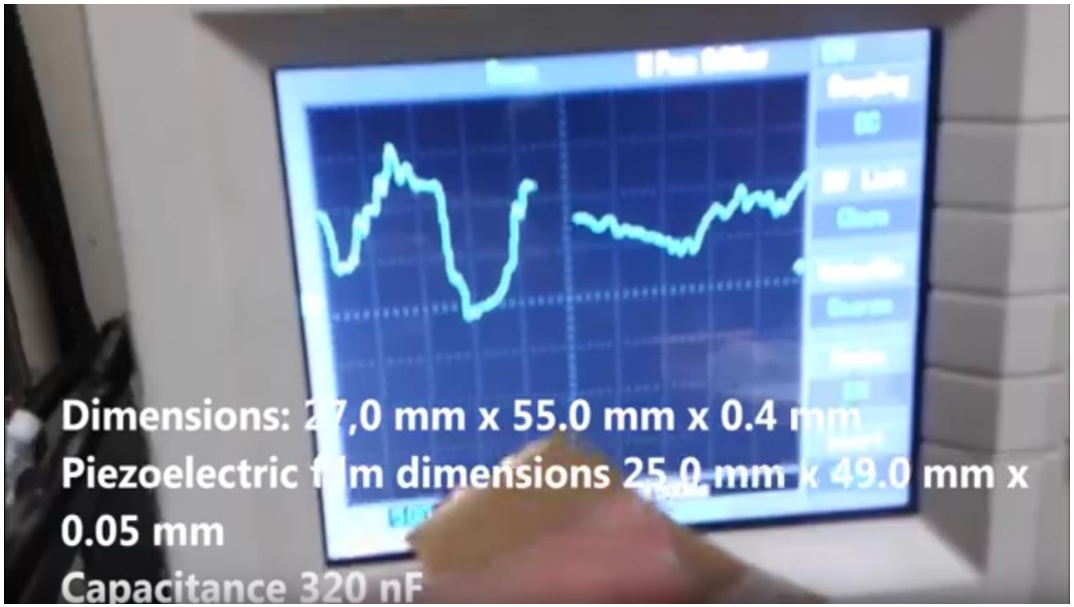
Piezoelectric materials

- Polymers
  - PVDF(polyvinylidene fluoride)
- Single crystals
  - quartz
  - $LiTaO_3$
  - $GaPO_4$
  - $La_3Ga_5SiO_{14}$ (Langasite)
- Ceramics
  - PZT
  - modified $PbTiO_3$
  - $Bi_4Ti_3O_{12}$ based materials
  - PMN-PT (relaxor composition)
- Composites
  - polymer-ceramic (PZT-polymer)
  - metal-ceramic (PZT-metal)

Piezoelectric actuator



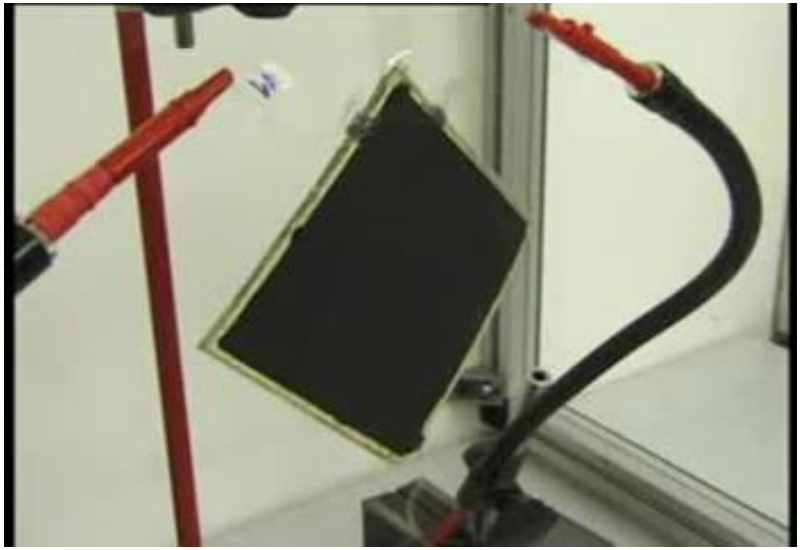
Principle of piezoelectric

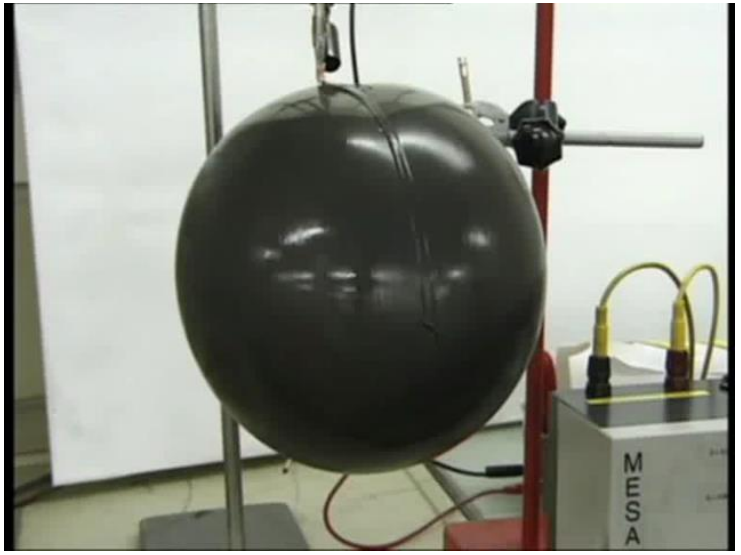


Piezoelectric sensor

Electroactive polymer (EAP)

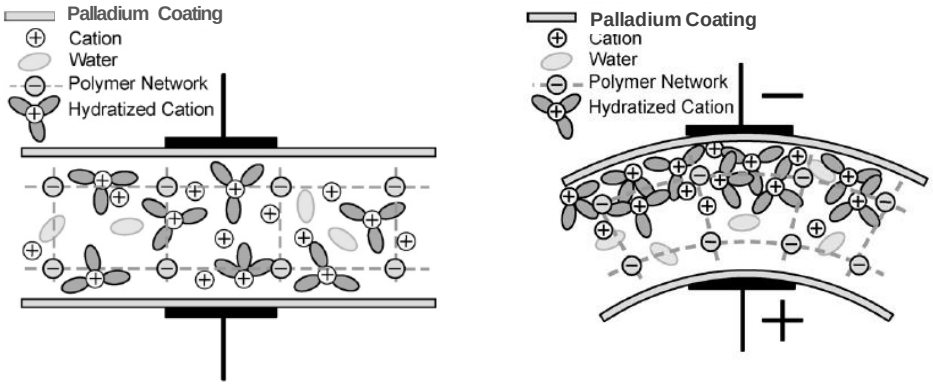
- Polymers that exhibits a change in size or shape when stimulated by an electric field
- Applications of this type of material are in actuators and sensors
- Large amount of deformation (some EAPs can exhibit up to a 380% strain)



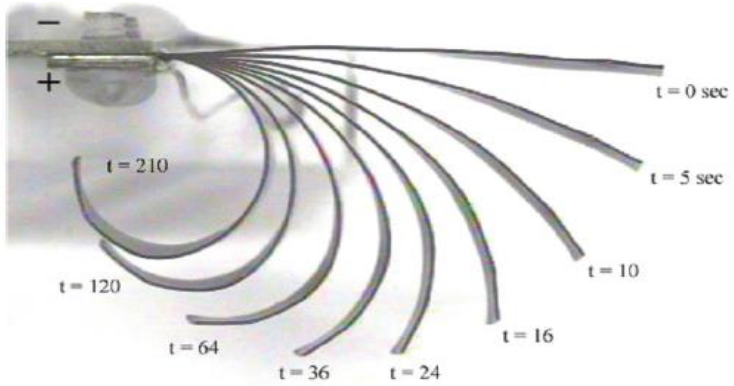


Ionic polymer metal composites (IPMC)

- **IPMC structure**
  - IPMC is consist of base ion exchange polymer and electrode metal
    - Platinum, Gold, Palladium, Silver and etc.
  - The metal electrode is formed by special chemical plating or physical treatments



Bending Mechanism of IPMC

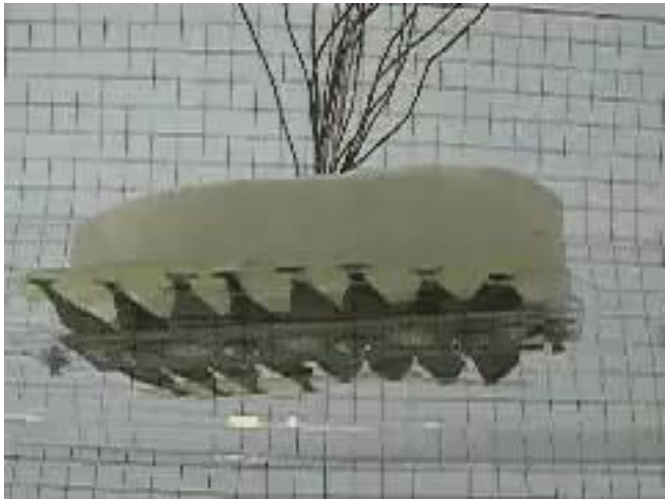


IPMC actuator (Nemat-Nasseret et al. 2003)

Ionic polymer metal composites (IPMC)

- Active actuators that shows large deformation by low applied voltage (1 ~ 2 V)
- Operate best in a humid environment
- Can be made as self-contained encapsulated actuators to operate in dry environments as well

Robotic jellyfish

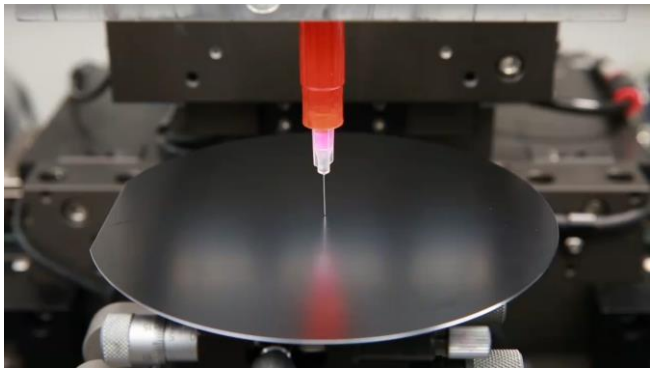


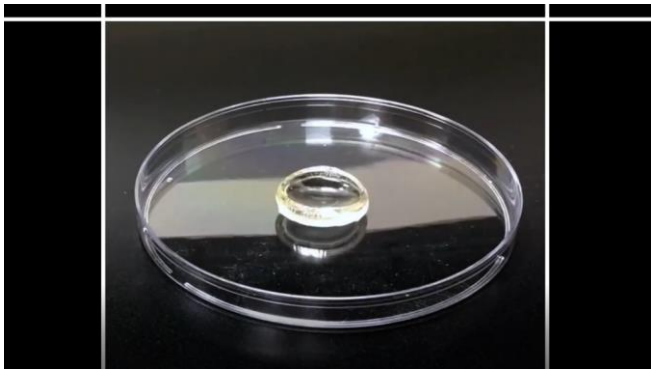
Ray-like robot

Hydrogel

- Three-dimensional network of hydrophilic cross-linked polymer
- Like a solid, hydrogels do not flow. Like a liquid, small molecules diffuse through a hydrogel
- Highly absorbent (90% water) natural or synthetic polymeric network

Applications of hydrogel





Examples of topics for team project

- **Social Responsibility**
  - Silver
  - QoLT (Quality of Life Technology – Rehab)
  - Appropriate technologies
  - Energy & Environment

- **Advanced Smart Material / Application**
  - Sports equipment
  - Bio-medical devices
  - Efficient mechanism
  - Soft Robotics
  - Kinetic Art / Architecture
  - 3D / 4D Printing
  - Light weight structure
  - Electro-chromic window

Engineering a second skin

- Silver / QoLT

MIT News : https://www.youtube.com/watch?v=AkpT5BihMio

Ingestible origami robot

- QoLT

MIT News : https://www.youtube.com/watch?v=3Waj08gk7v8&t=1s

Kinetic glove for rehab

- QoLT

Neofect : http://www.neofect.com/ko/product/rapael/

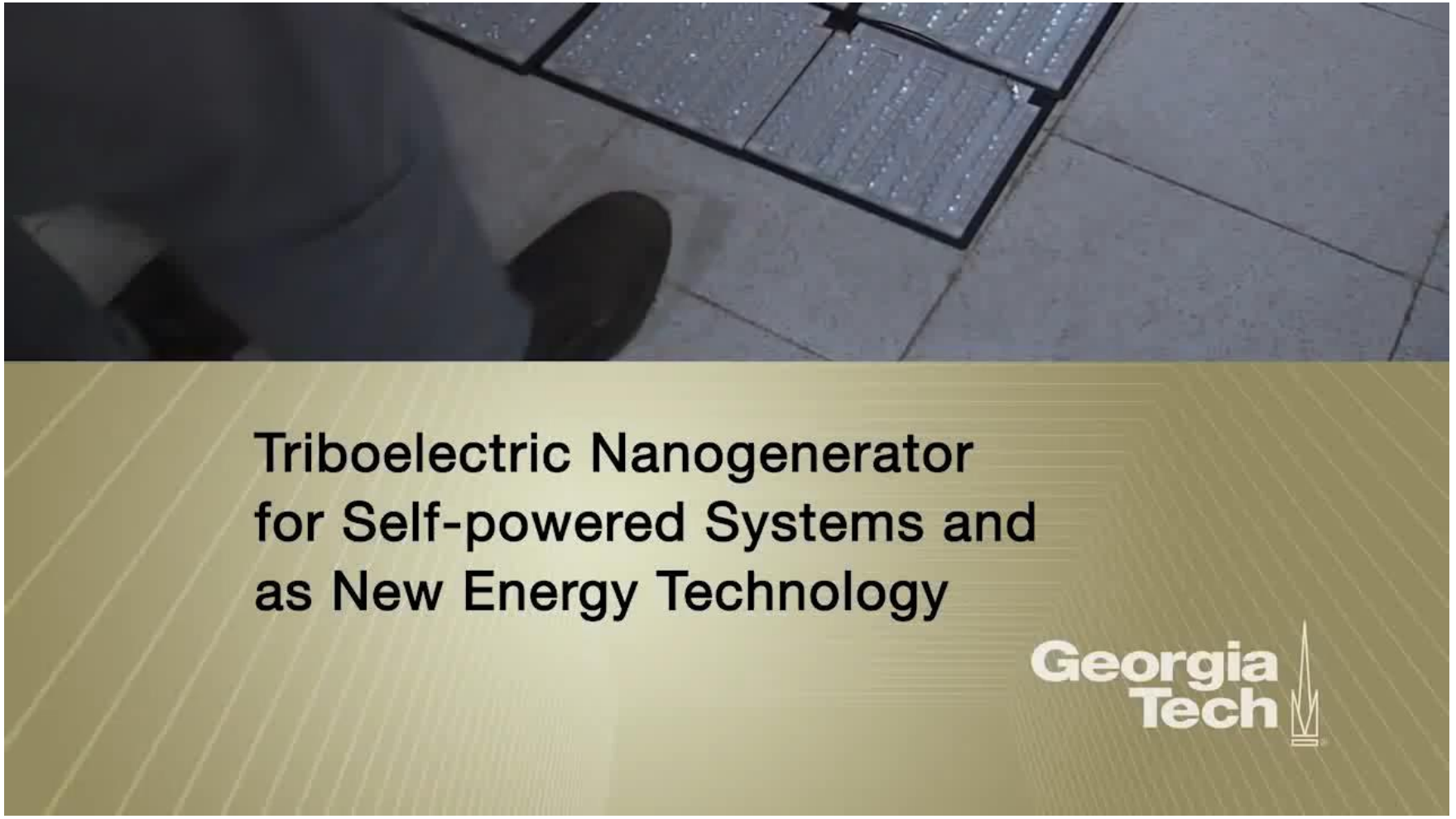
Liter of light

- Appropriate technologies

https://www.youtube.com/watch?v=o-Fpsw_yYPg

Energy harvester

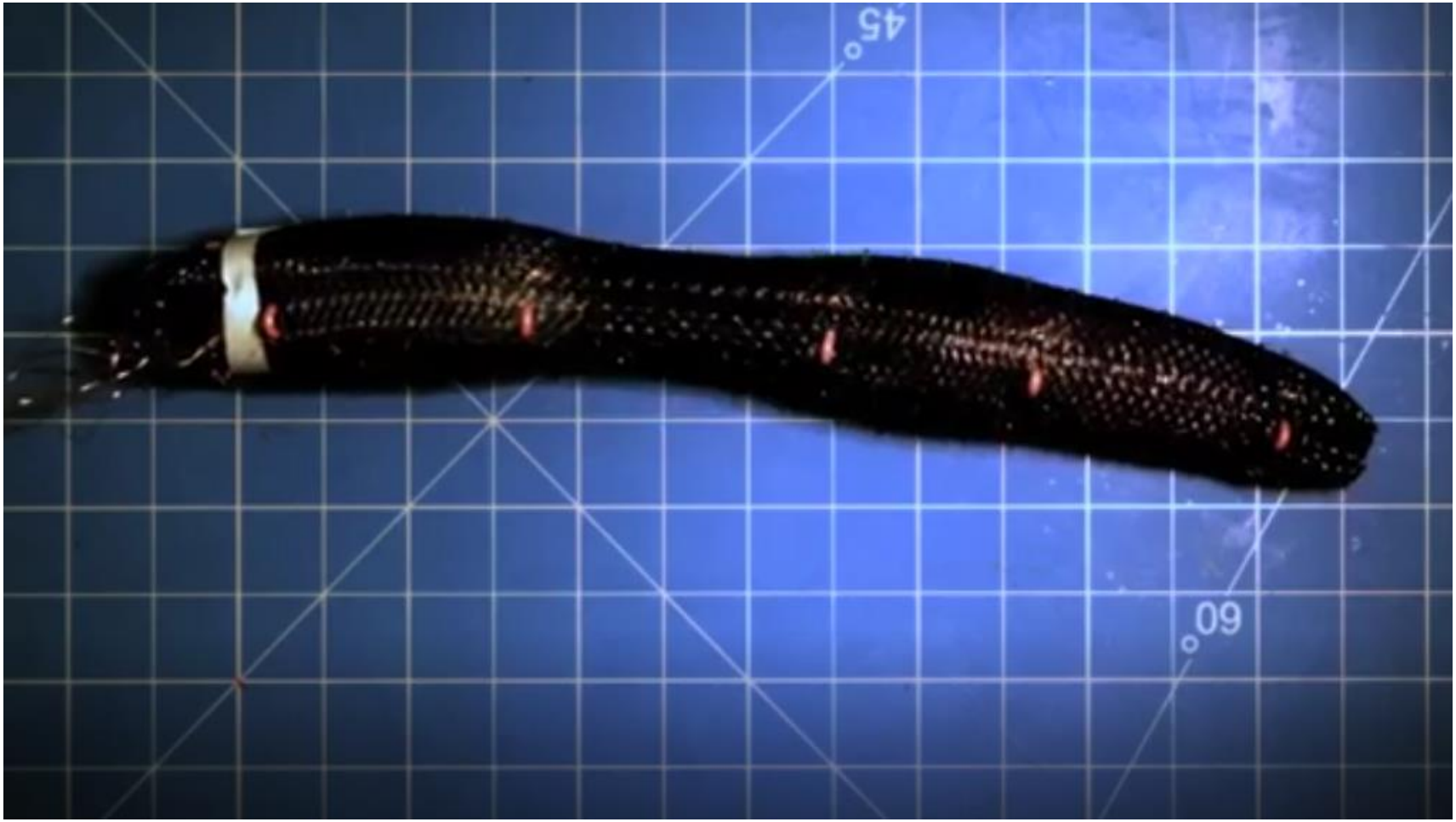
- Energy & Environment



Georgia Tech : https://www.youtube.com/watch?v=7jsOerwz4Z8&t=47s

Soft robotics – earthworm robot

- Soft Robotics



MIT News : https://www.youtube.com/watch?v=P4EC4u4neIo

Kinetic technologies

- Kinetic Art / Architecture

MIT : https://www.youtube.com/watch?v=lvtfD_rJ2hE&t=2s

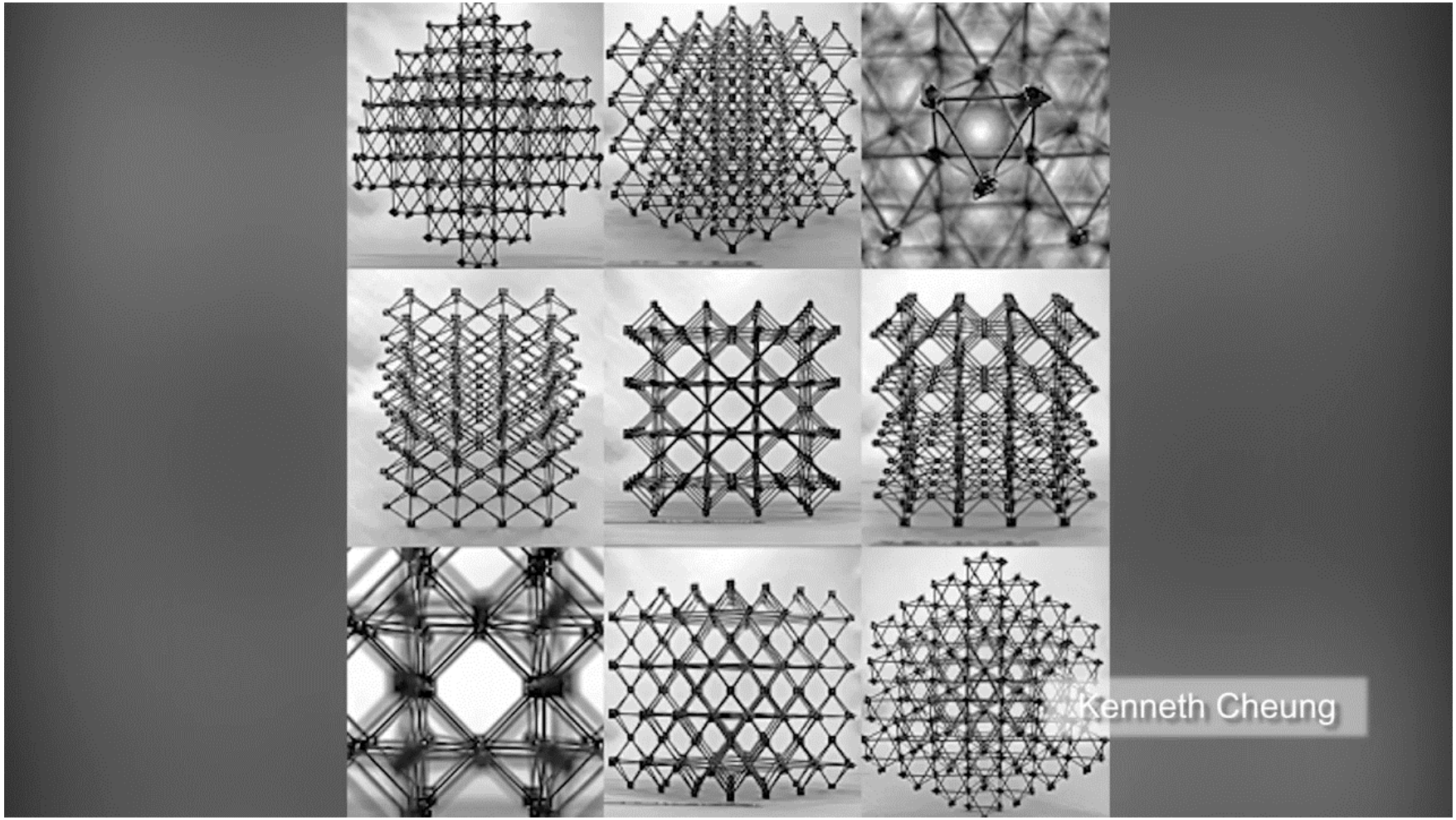
4D printing cube

- 3D / 4D Printing

https://www.youtube.com/watch?v=qMJXzPiJkH8

Ultralight Lego like material

- Light weight structure



MIT : https://www.youtube.com/watch?v=TbDDWGQHsHQ

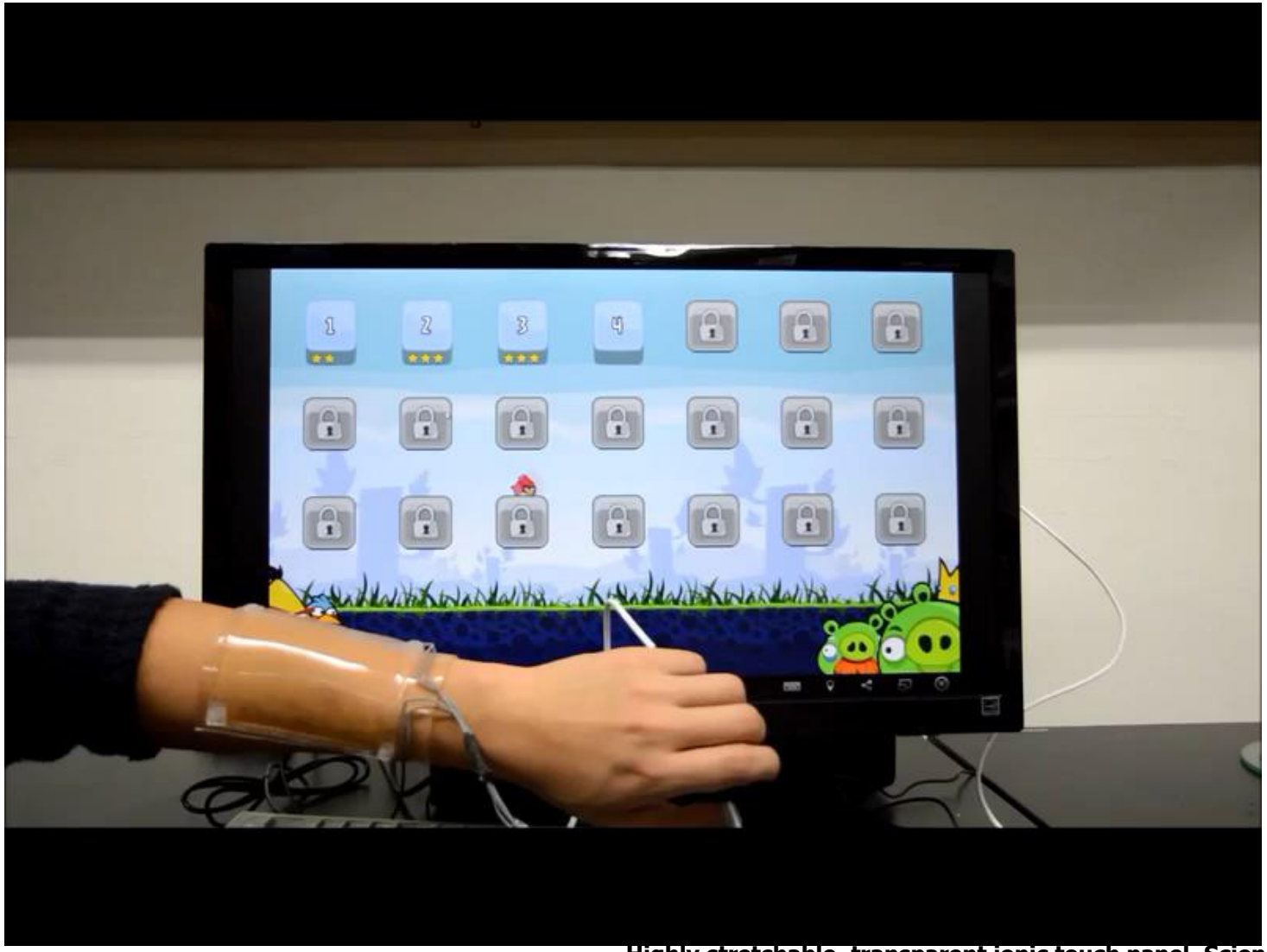
Boeing : Lightest. Metal. Ever.

- Light weight structure

Boeing : https://www.youtube.com/watch?v=k6N_4jGJADY

Touch panel using hydrogel

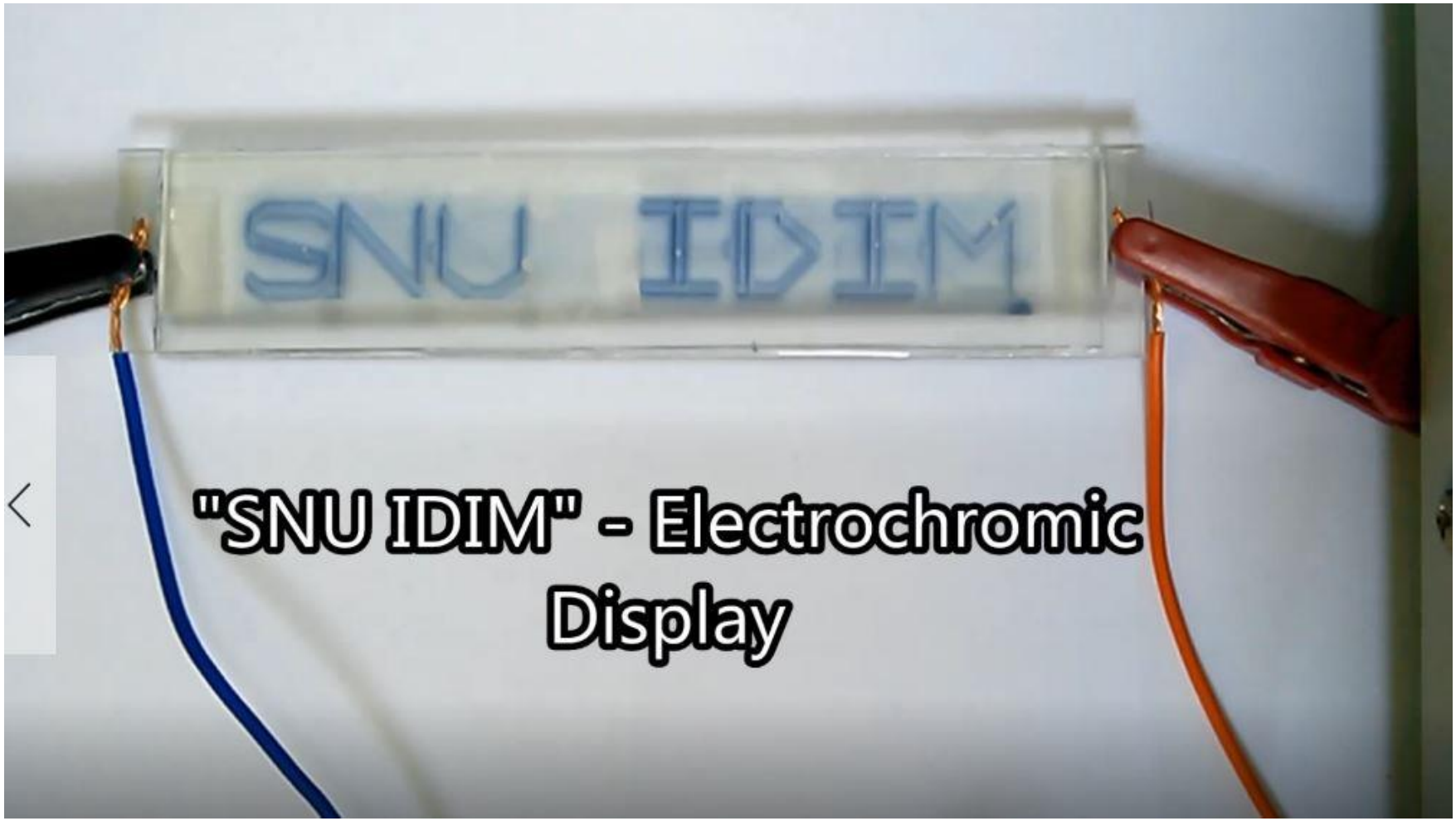
- Hydrogel application



Highly stretchable, transparent ionic touch panel, Science, 2016

Electro chromic windows

- Electro chromic windows



Smart tennis sensor

- Sports

https://www.youtube.com/watch?v=upHOTFAhF50

miCoach smart ball

- Sports

https://www.youtube.com/watch?v=yIWhjLO-2lk

Team project information

- Presentation
  - 1st, 2nd, 3rd and 4th (totally 4 times presentation)

- Final presentation
  - PPT Presentation + A0 poster + Product demo
  - If the demo is unavailable in the classroom, you can record **video** and show it through PPT

- Individual contribution will be considered
  - The score of each team member will be graded according to the individual contribution during the team project