Why Strained Semiconductors are like Crinkle - Cut Crisps

Paving the way for the next generation of synthetic skin

1 MILLION
nerve fibres in skin, working to detect temperature, pressure, and pain [1]

35 - 40 MILLION
people needing prosthetics, the number only *increasing* with the aging population [2]

WHY are we interested?

98%
of upper limb prostheses users wish they could feel pressure in their prosthetic limbs [3]


[4]

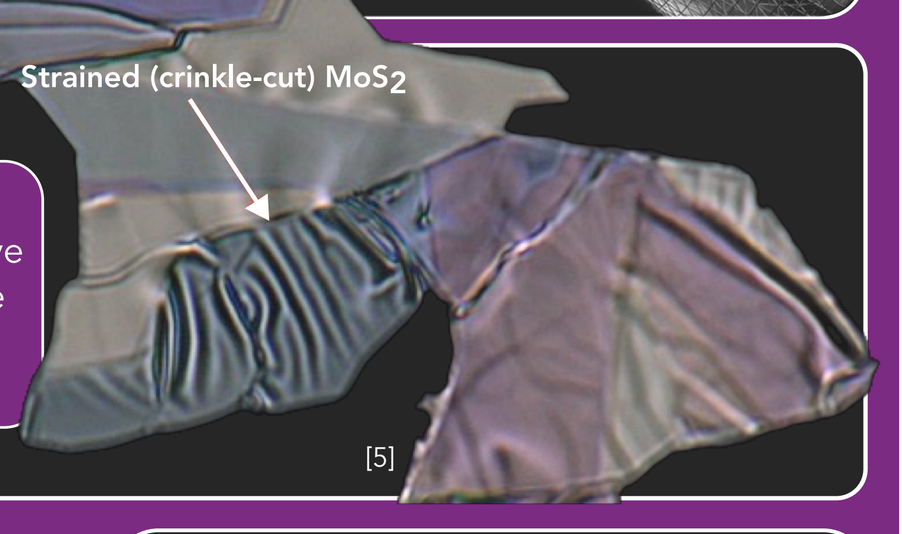
WHAT are strained semiconductors?

Insulators – where the electrons stay with their own nuclei and cannot move around the material.

Semiconductors – the materials in the middle. Under certain conditions, semiconductors act like insulators and under others the electrons can move freely, like in conductors.

Conductors – where the electrons can leave their atoms and move freely through the material.

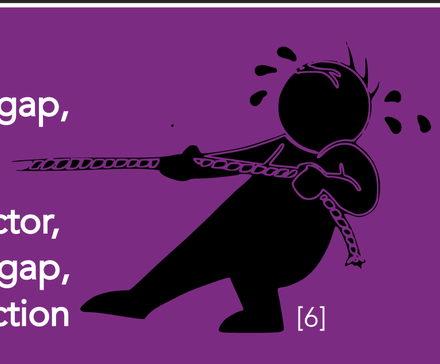
larger bandgap ← → smaller bandgap



[5]

If you squash a semiconductor,
a.k.a. "apply **compressive** strain", you **increase** the bandgap,
requiring **more energy** to begin conduction

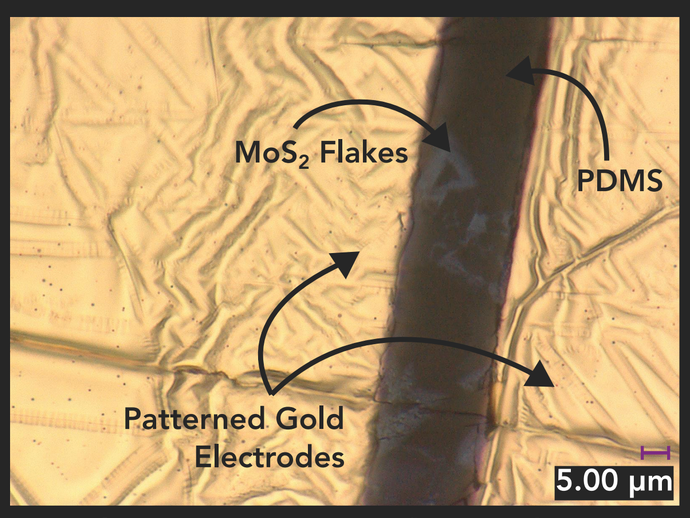
If you s t r e t c h a semiconductor,
a.k.a. "apply **tensile** strain", you **decrease** the bandgap,
requiring **less energy** to begin conduction


[6]

Bandgap: the energy difference between the furthest energy level bound to the atom (valence band) and the sea of delocalised (free) electrons in a material (conduction band). *I.e., the energy needed to make a semiconductor conduct.*

Sections of semiconductor can be made to act more like an insulator or conductor by applying mechanical strain

HOW do we make them?



Optical microscope image of strained MoS_2 on a PDMS substrate with gold electrodes

1 [7]
Grow 2-dimensional molybdenum disulfide (MoS_2) film either using chemical vapour deposition or sputter coating

2
Transfer onto a flexible substrate, for example polydimethylsiloxane (PDMS) using novel method

3
Deposit metal electrodes onto the flexible substrate to allow the sensor to measure the change in current. Gold is best, due to its high malleability

4
Measure the change in current, or the change in flow of freed electrons, during multiple strain cycles

By measuring how tensile strain alters the current, the system can triangulate the location of applied pressure and relay this information to the user. This enables a highly scalable yet structurally simple touch sensor

Crinkle cut crisps **taste** better because they hold more **salt**.
Crinkle cut semiconductors **insulate** better because they hold more **electrons**.

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[1] Website: https://shorturl.at/U6cPl 25/11/19
[2] Mduzana L, et al. Exploring national human resource profile and trends of Prosthetists/Orthotists in South Africa from 2002 to 2018.
[3] Jabban L, et al. Pressure Sensitive Skin for Prosthetic Hands: 2D Contact Location Determination Using Output Connections from a Single Side.
[4] Website: https://shorturl.at/7HVOr 13/07/2021, Sheedy C
[5] Y. Jahn, Ben Gurion, University of the Negev
[6] https://shorturl.at/i1QUU
[7] https://www.europesnacks.com/crinkled-crisps/

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