Nature Inspired Manufacturing

Spinach-based photo-catalyst for selective plating on polyimide-based substrates for micro-patterning circuitry

Presenter: Dr. Tom Jones,
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https://doi.org/10.1016/j.cherd.2019.10.044

The demand…

1. **Reduce** toxicity of electronic fabrication processes
2. Adopt a **rapid, selective** micropatterning technique

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Jose Marques-Hueso[a,], Thomas D.A. Jones[a,c], David E. Watson[a], Assel Ryspayeva[a], Mohammadreza N. Esfahani[b], Matthew P. Shuttleworth[b], Russell A. Harris[b], Robert W. Kay[b], Marc P.Y. Desmulliez[a]*

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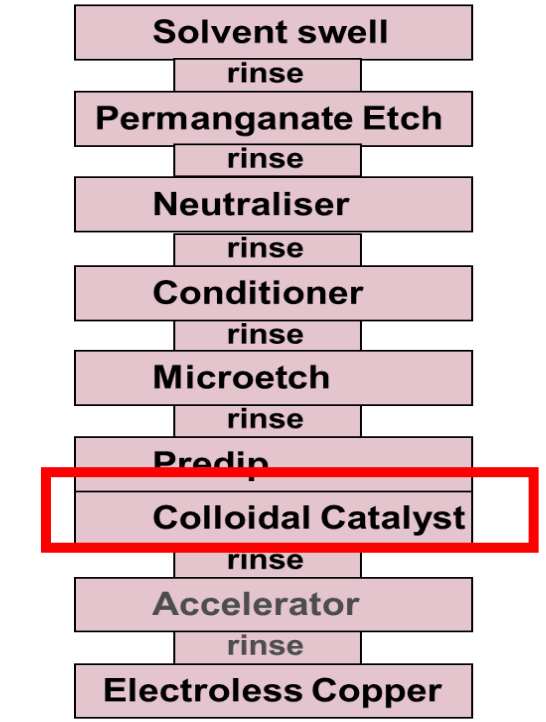
Background

- The formation of an **economic, rapid catalyst** to receive copper circuitry (electroless)
- **Ag** is economic (compared to Pd activator used in electroless Cu)

Pd: $ 77 per gram
Ag: $ 19 per gram

E'less Cu process



Pd/tin complex

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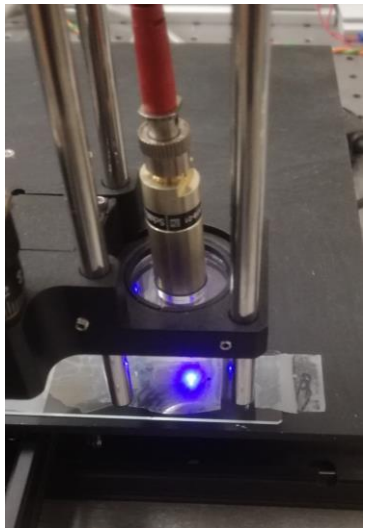
Background

- **Photoreduction** (rather than chemical reduction, fomaldehyde) – a selective reduction process
- Negates the need for high volume solution baths



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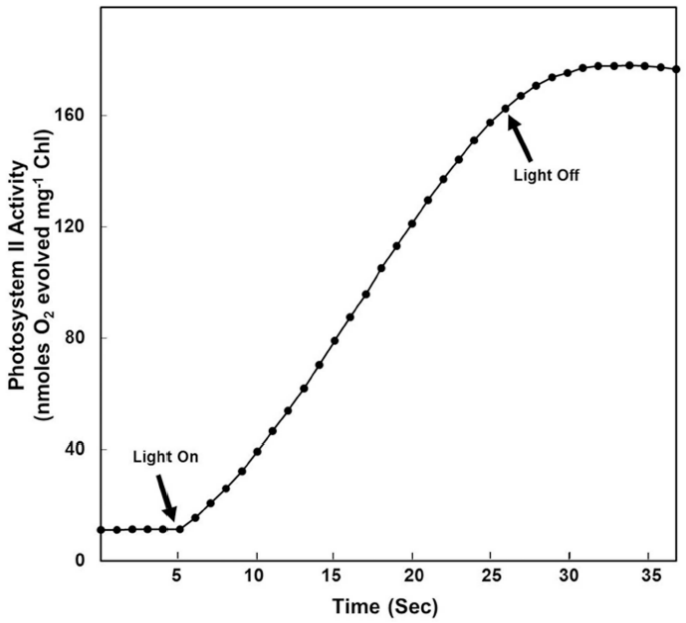
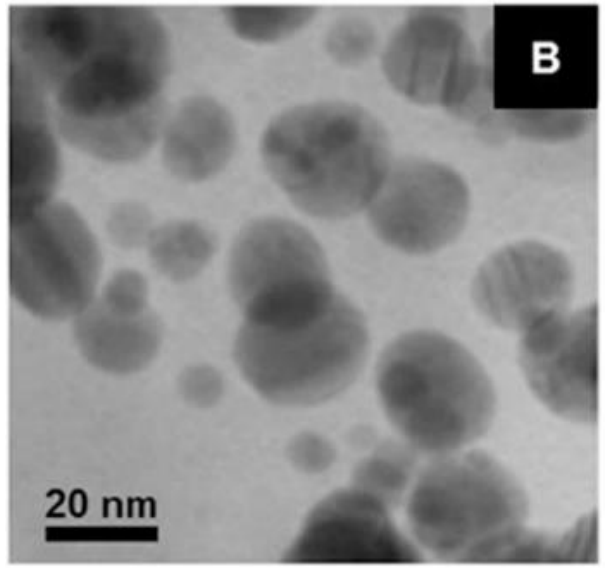
Background

- Ag photoreduction – to form catalyst for e'less plating
- **Improve Ag photoreduction** by the use of an accelerator (photosensitiser)
- **Spinach acts as photosensitiser**

Oxygen production (photosensiter indicator)



Photoreduced Ag Nanoparticles



N. Shabnam, P. Sharmila, H. Kim, P. Pardha-Saradhi, Light Mediated Generation of Silver Nanoparticles by Spinach Thylakoids/Chloroplasts, PLoS One. 11 (2016) e0167937. https://doi.org/10.1371/journal.pone.0167937.

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Background

- Theory: photosensitivity related to chloroplasts within spinach…

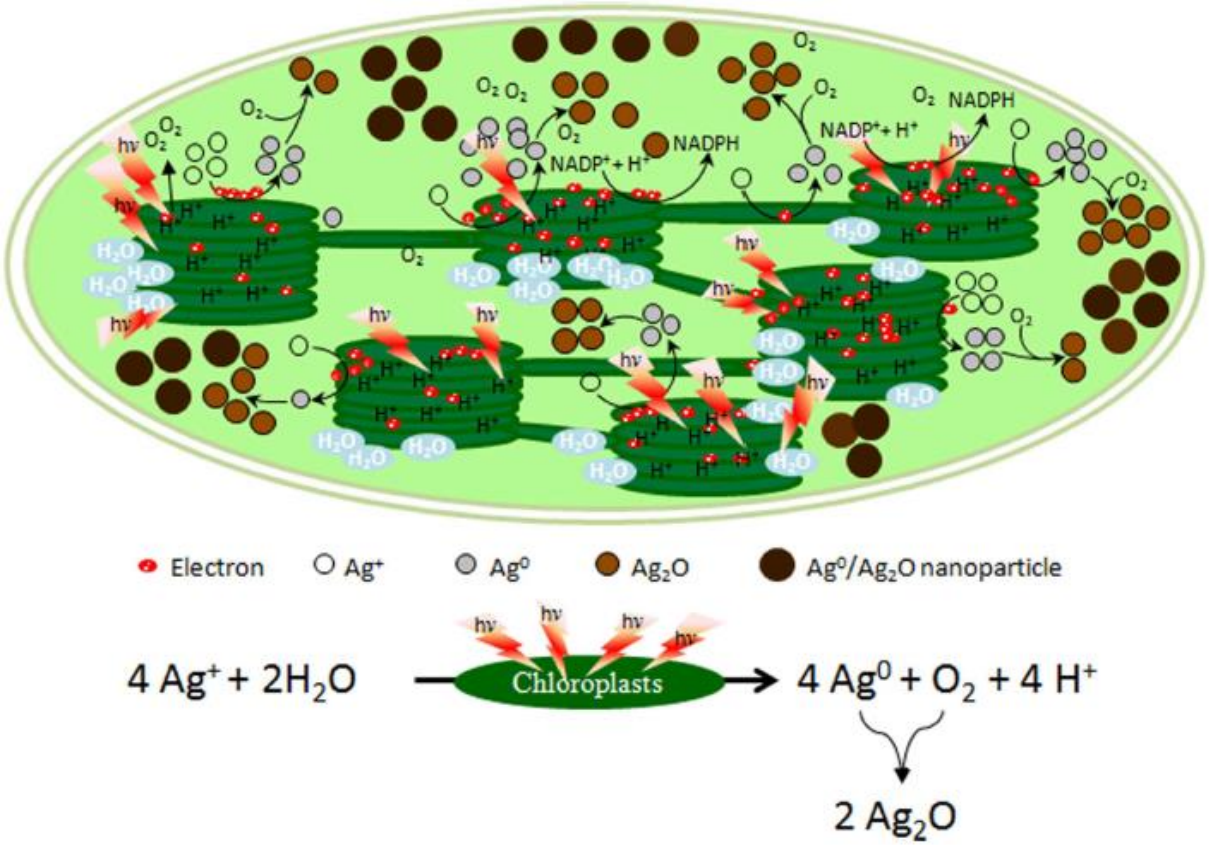
$$4Ag^{+} + 2H_2O \xrightarrow[\text{Thylakoids}]{h\nu} 4Ag^{0} + O_2 + 4H^{+} \quad (1)$$

$$nAg^{0} \longrightarrow Ag^{0}\text{-NPs} \quad (2)$$

$$4Ag^{0} + O_2 \longrightarrow 2Ag_2O \quad (3)$$

$$nAg_2O \longrightarrow Ag_2O\text{-NPs} \quad (4)$$

$$Ag^{0}\text{-NPs} + O_2 \longrightarrow Ag_2O\text{-NPs} \quad (5)$$



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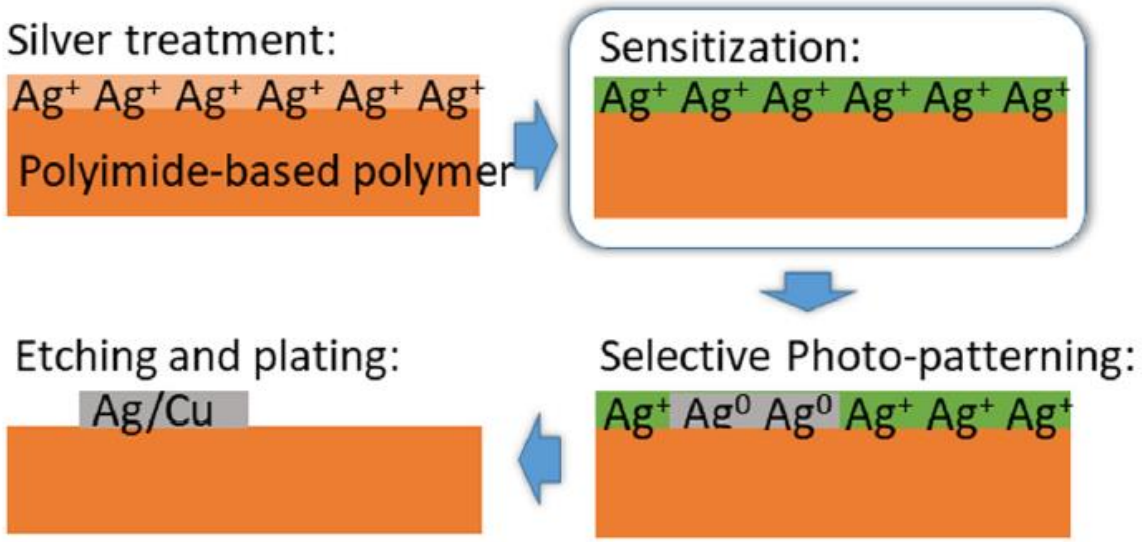
Our work

- Processed in polyimide based materaials
- Cheap and used in high value 3-D printers



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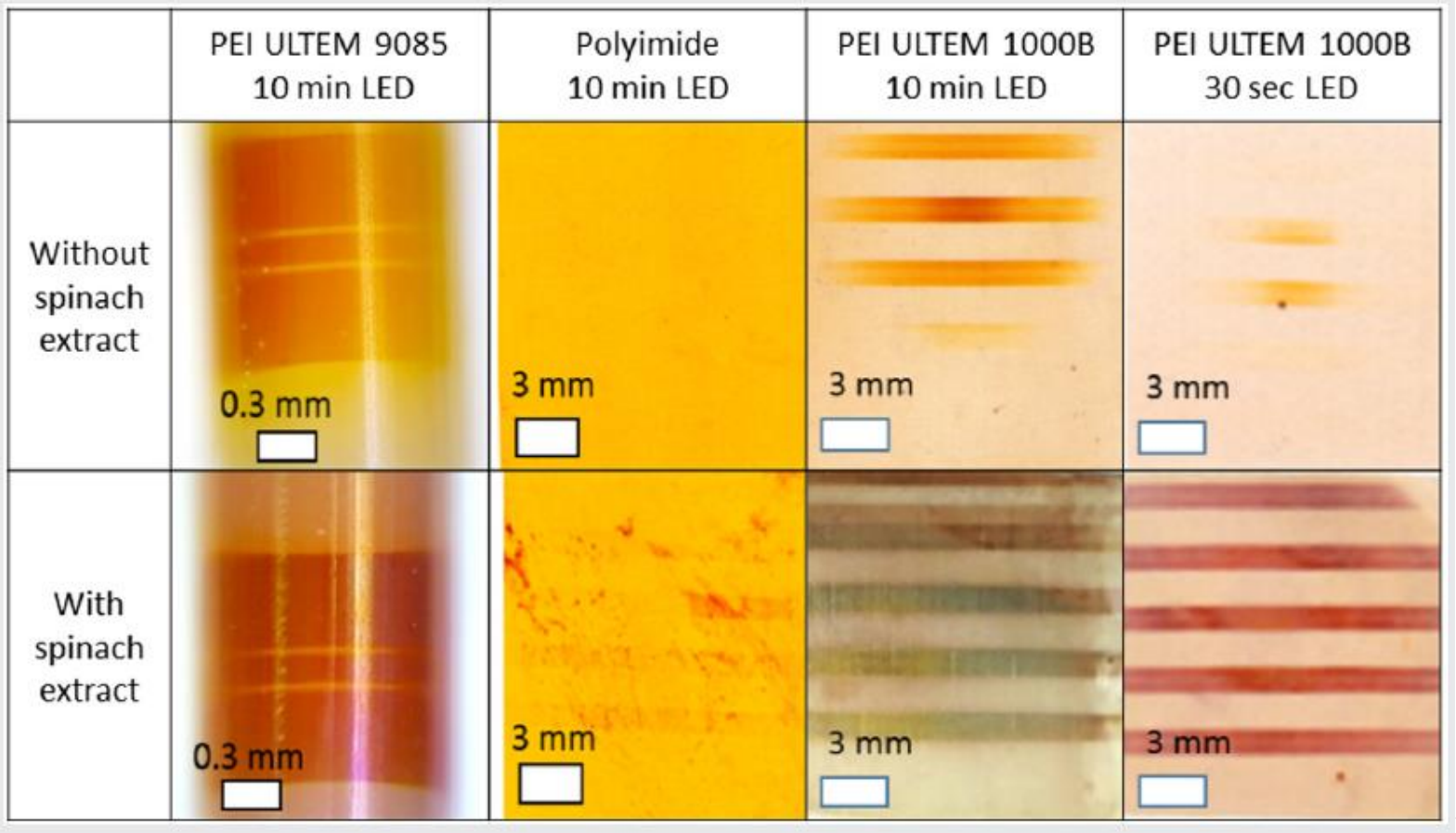
Photoreduced Ag nanoparticle / nanofilms



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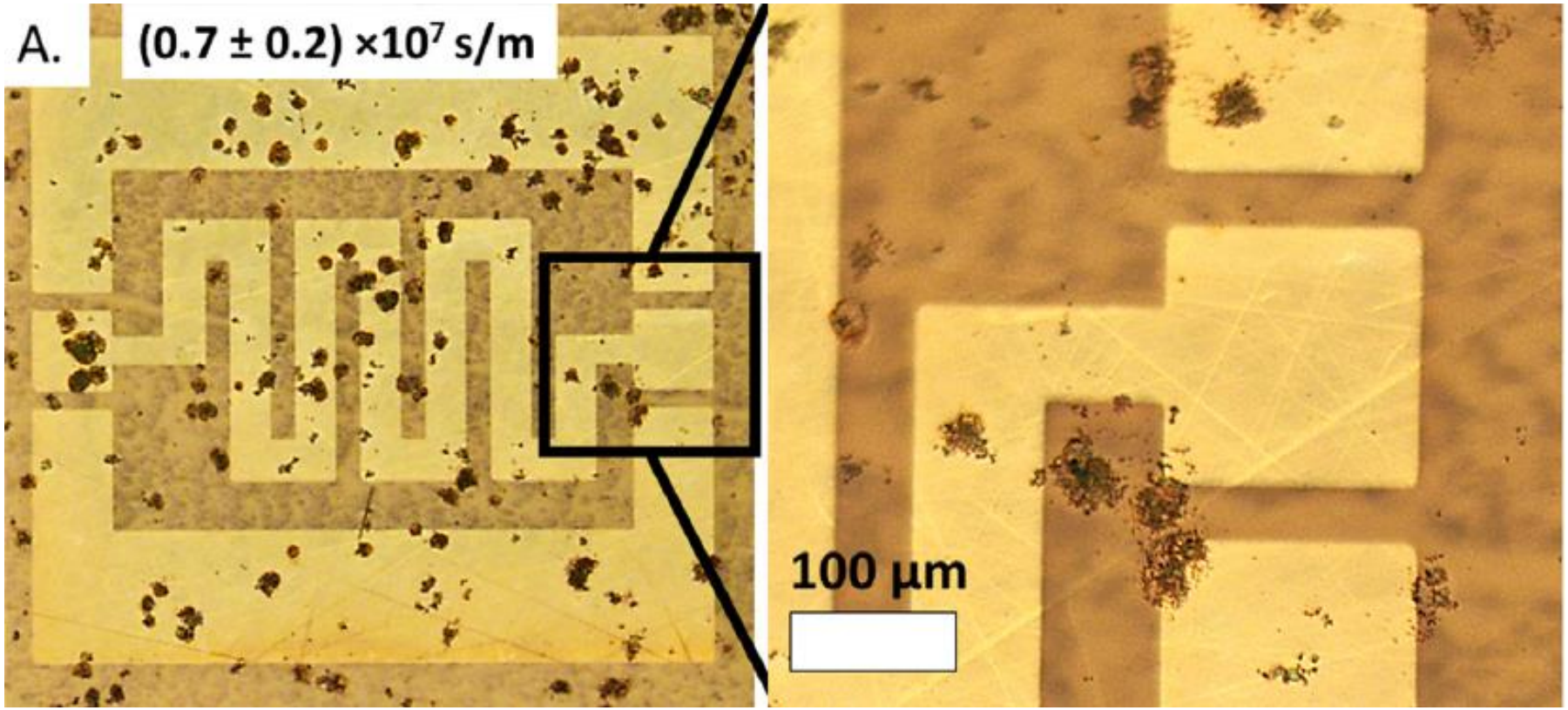
Our work

Bulk conductivity of Cu: 5.96×10^7 s/m

Electroless Cu onto Ag nanoparticles



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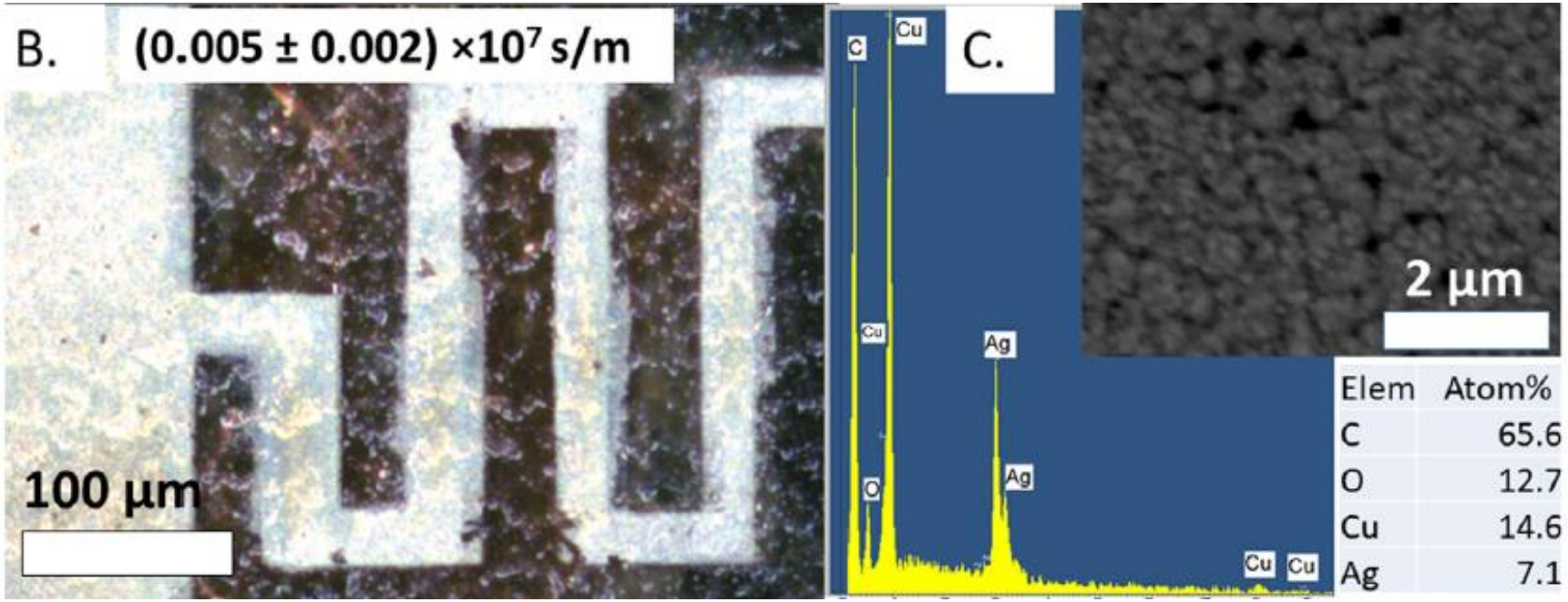
Ionic liquid Immersion Ag

Bulk conductivity of Cu: 5.96×10^7 s/m



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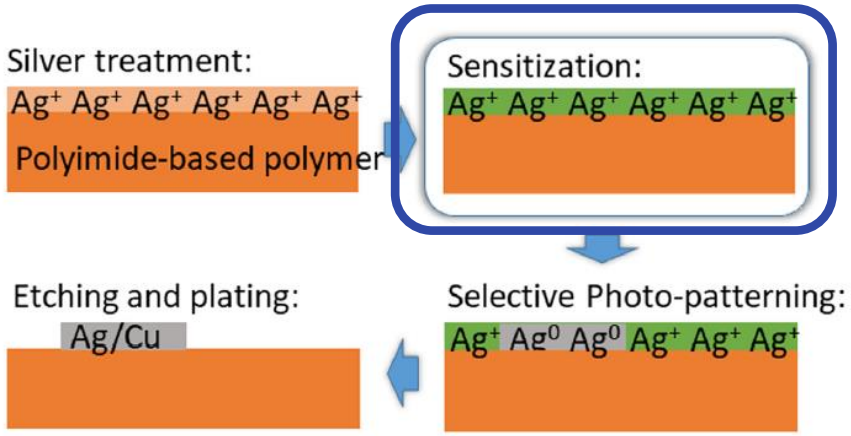
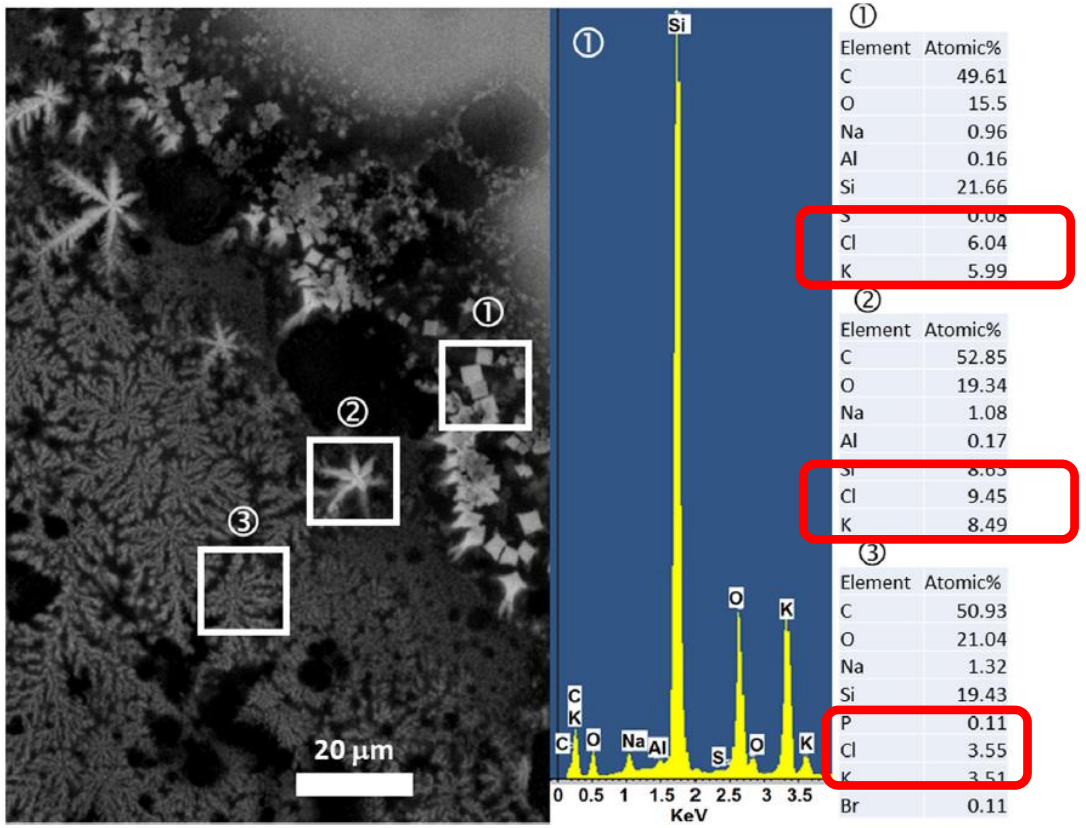


Dried spinach extract



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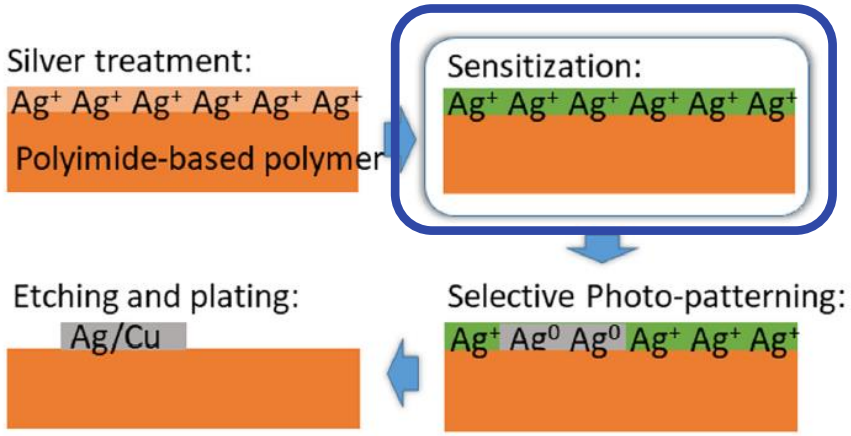
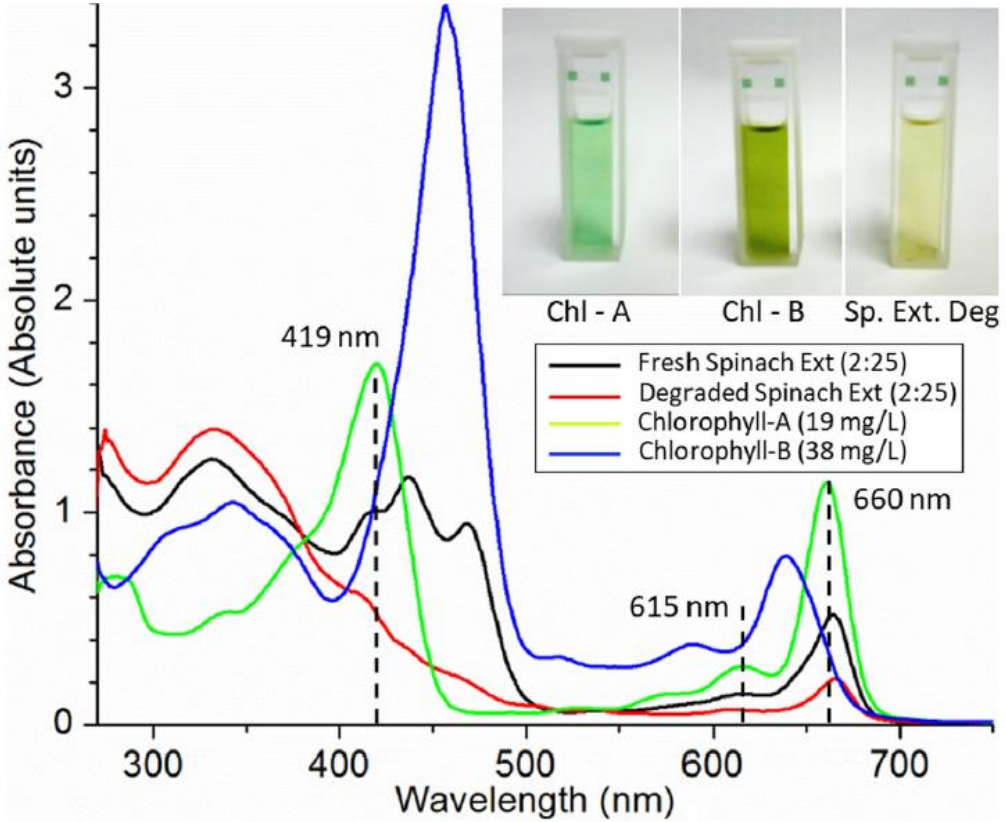


The peaks for chlorophyll don't match



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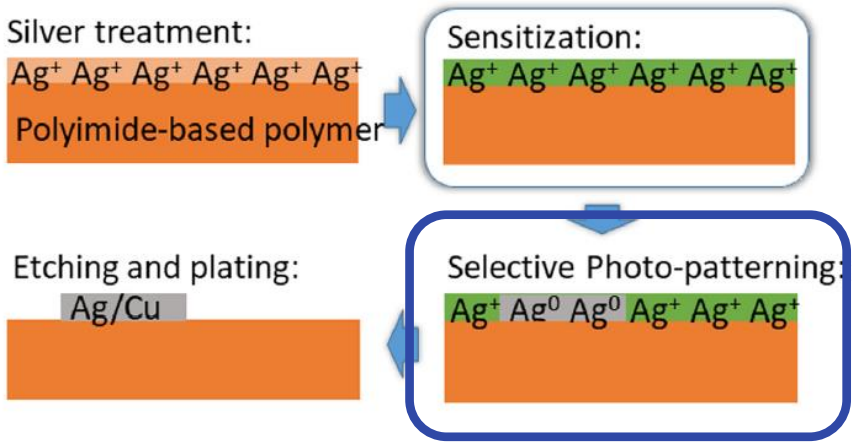

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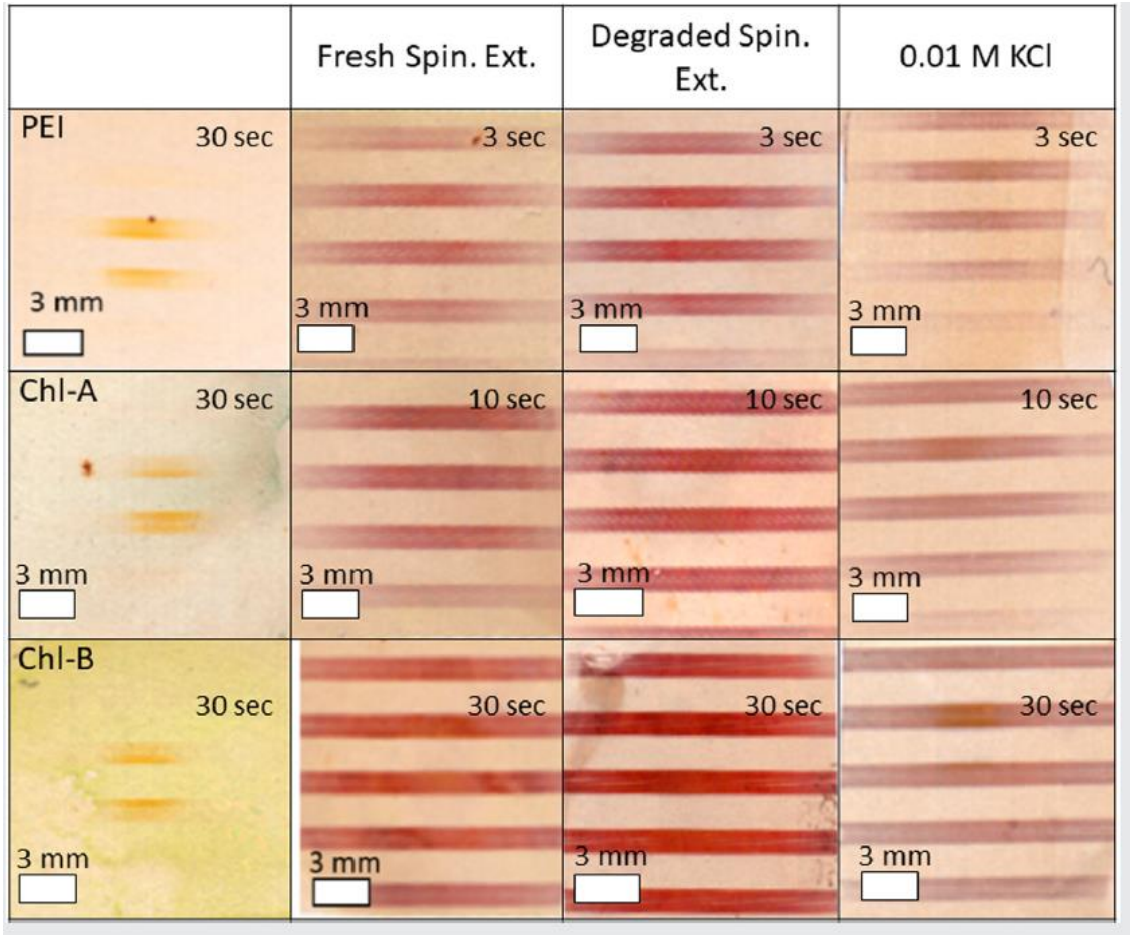

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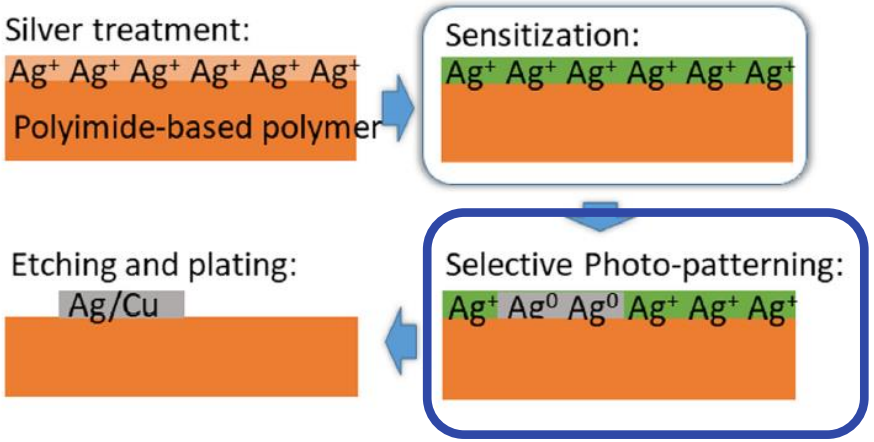

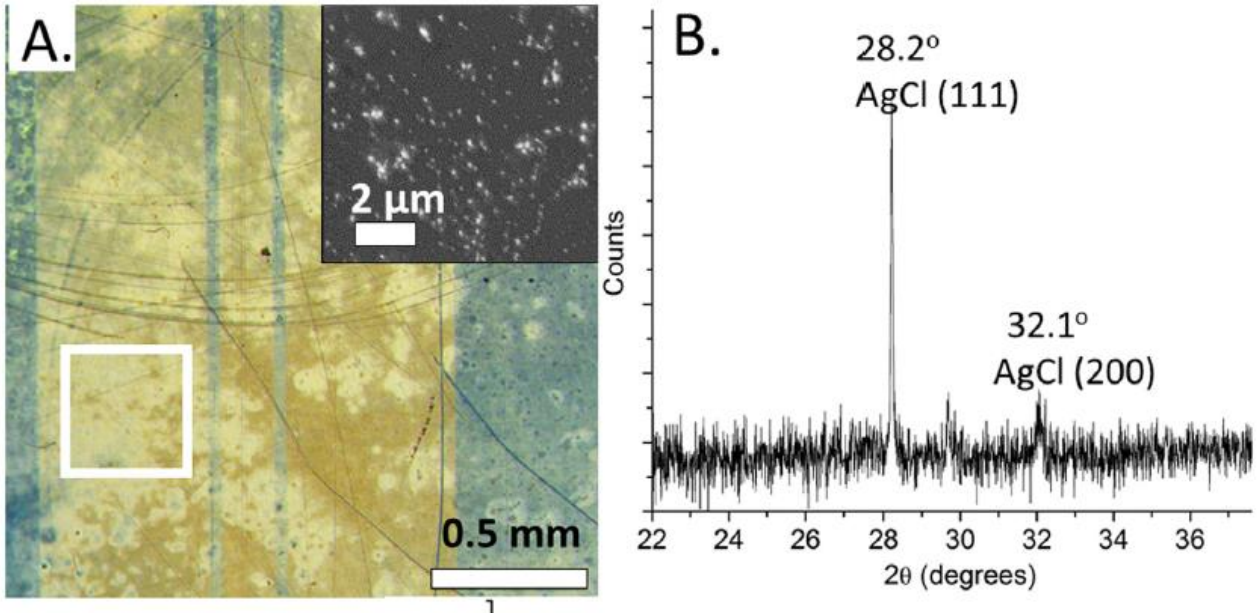

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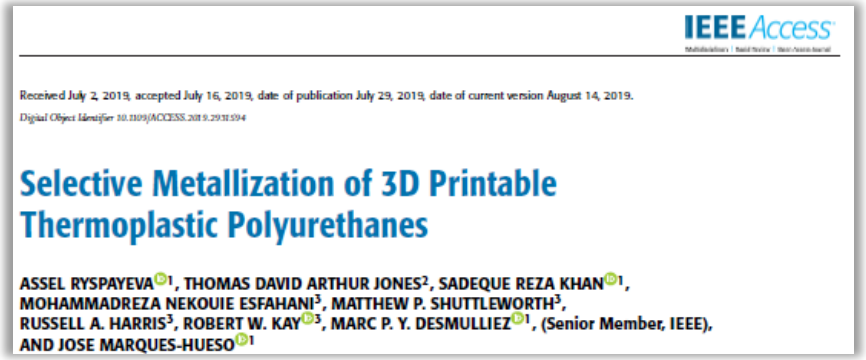
Follow up work



IEEE Access

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Selective Metallization of 3D Printable Thermoplastic Polyurethanes

ASSEL RYSPAYEVA[1], THOMAS DAVID ARTHUR JONES[2], SADEQUE REZA KHAN[1], MOHAMMADREZA NEKOUIE ESFAHANI[3], MATTHEW P. SHUTTLEWORTH[3], RUSSELL A. HARRIS[3], ROBERT W. KAY[3], MARC P. Y. DESMULLIEZ[1], (Senior Member, IEEE), AND JOSE MARQUES-HUESO[1]

Microelectronic Engineering 209 (2019) 35–40

Contents lists available at ScienceDirect

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Research paper

A rapid technique for the direct metallization of PDMS substrates for flexible and stretchable electronics applications

Assel Ryspayeva[a,*], Thomas D.A. Jones[a], Mohammadreza Nekouie Esfahani[b], Matthew P. Shuttleworth[b], Russell A. Harris[b], Robert W. Kay[b], Marc P.Y. Desmulliez[a], Jose Marques-Hueso[a]

FULL PAPER

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A Rapid Photopatterning Method for Selective Plating of 2D and 3D Microcircuitry on Polyetherimide

Jose Marques-Hueso, Thomas D. A. Jones, David E. Watson, Assel Ryspayeva, Mohammadreza Nekouie Esfahani, Matthew P. Shuttleworth, Russell A. Harris, Robert W. Kay, and Marc P. Y. Desmulliez*

Surface & Coatings Technology 360 (2019) 285–296

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Surface & Coatings Technology

journal homepage: www.elsevier.com/locate/surfcoat

Direct metallisation of polyetherimide substrates by activation with different metals

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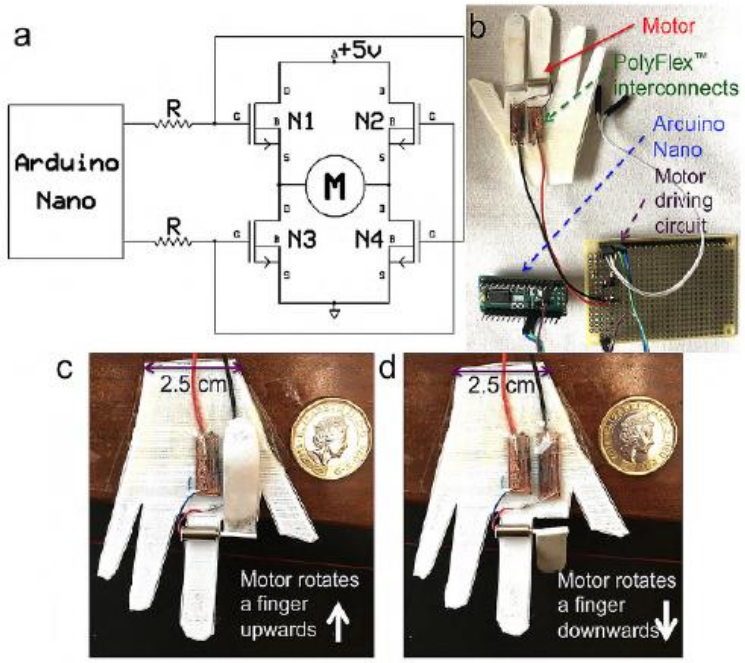

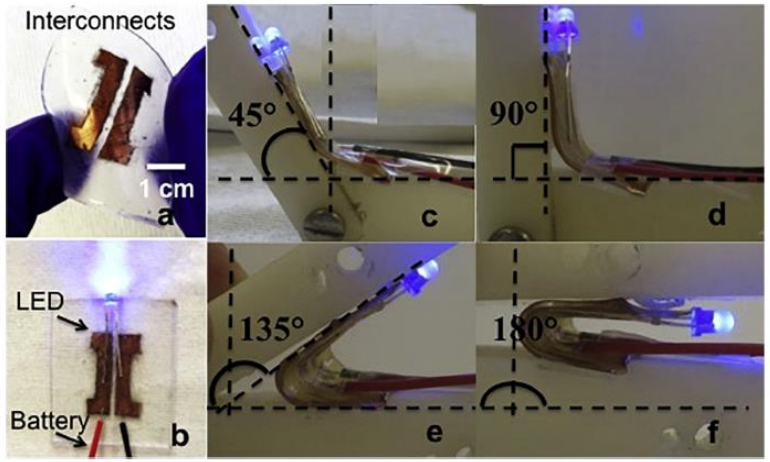

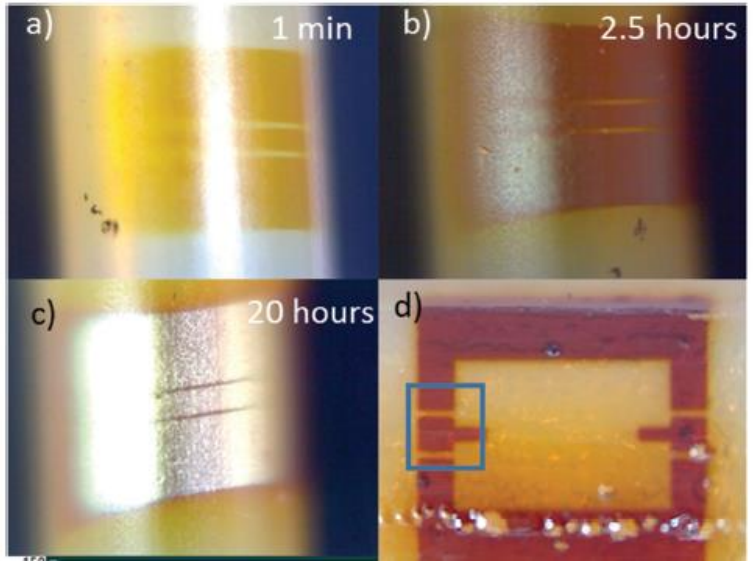

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Thank you for your time

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