Thin Films of Liquid Metal by Electrophoretic Deposition of Particles

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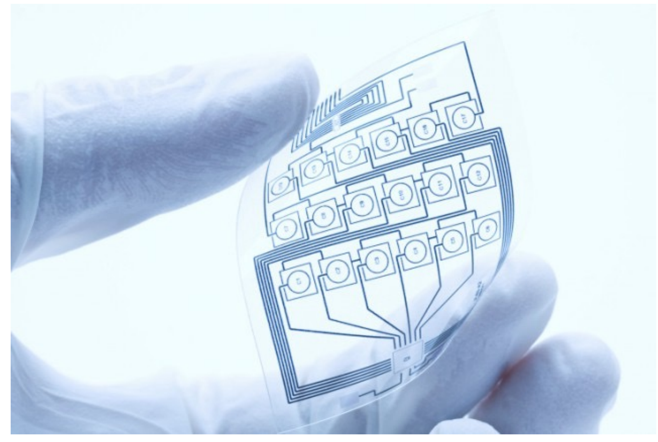
Introduction

Flexible Electronics

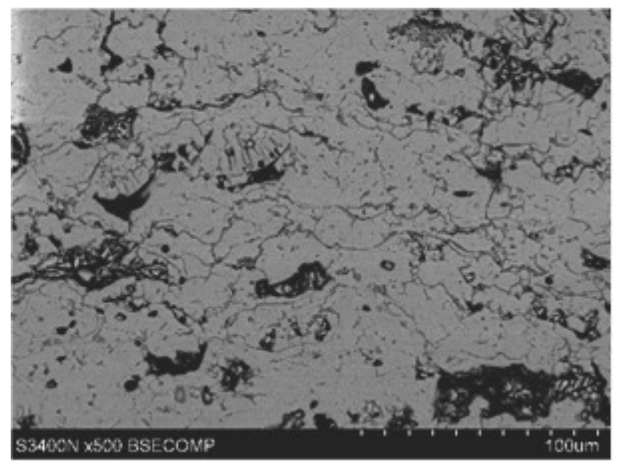
www.mddionline.com/how-make-flexible-electronics-stick.



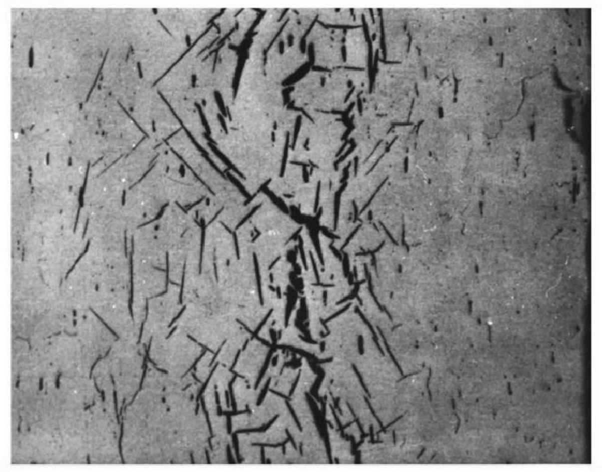
arstechnica.com/science/2012/06/bend-me-shape-me-flexible-electronics-perform-under-punishing-conditions/.

- With time and use flexible electronics begin to degrade forming microcracks

Microcracks



Glema et al, *International Journal of Damage Mechanics (2010)*



Moskal et al, *Defect and Diffusion Forum* (2011)

- Microcracks reduce conductivity and efficiency eventually deteriorating the entire device itself

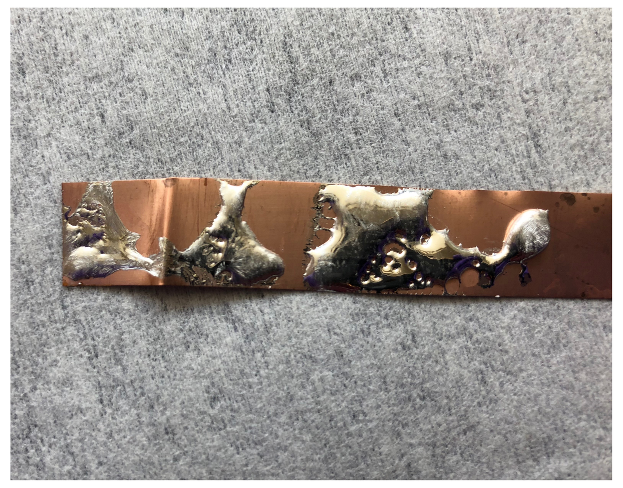
EGaIn

Ladd et al, *Advanced Materials, (2013)*

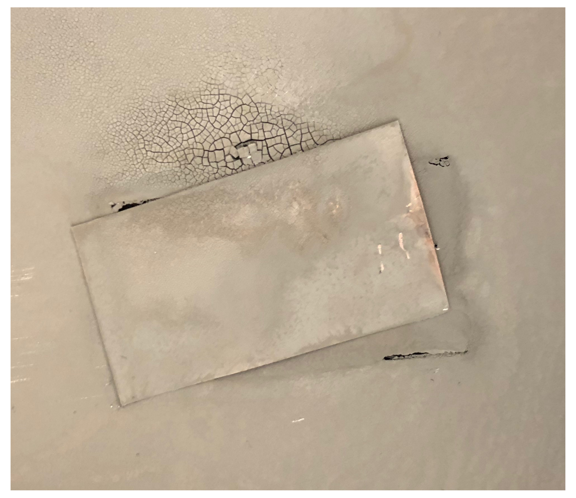
Chiechi et a;, *Chem. Int. Ed.* (2008)

- Melting point near 16 C
- Thin oxide layer
- Removed by electrochemical reduction or Acid-Base reaction

Alternative Deposition Methods



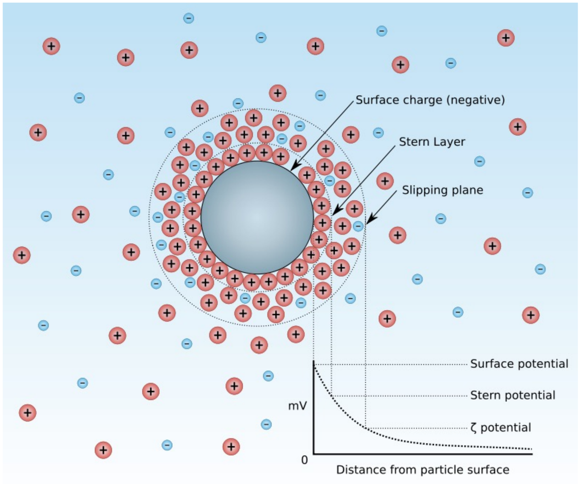
Physical Placement



Dry Deposition

Nanoparticle Solution Synthesis

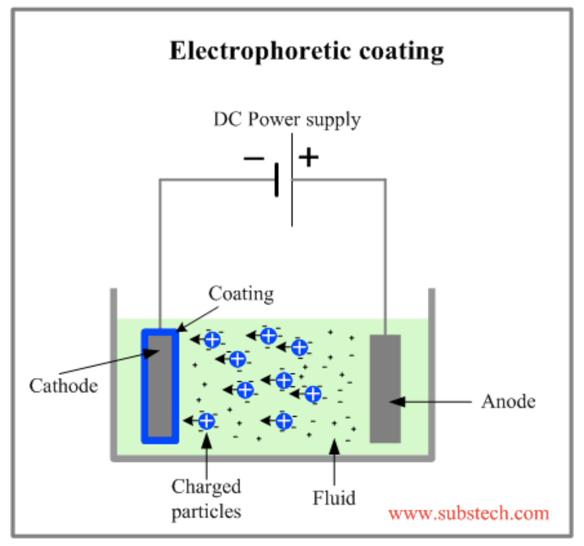
EGaIn nanoparticle solution



en.wikipedia.org/wiki/Zeta_potential

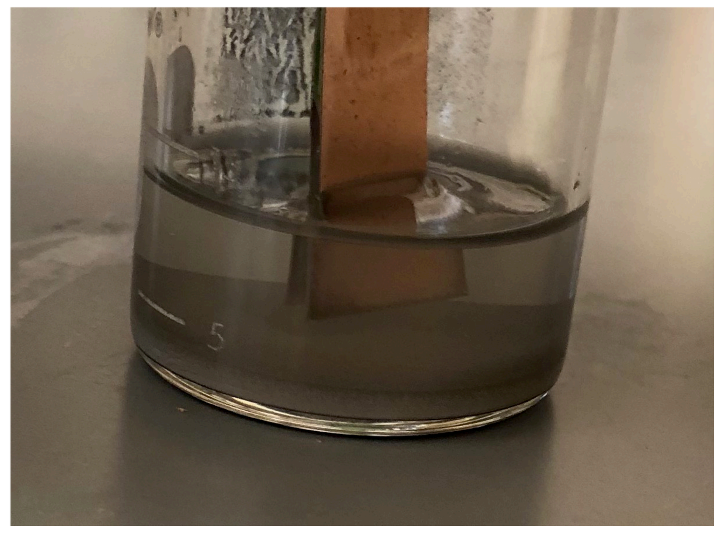
Surface Charge

Electrophoretic Deposition



www.substech.com/dokuwiki/doku.php?id=electrophoretic_deposition.

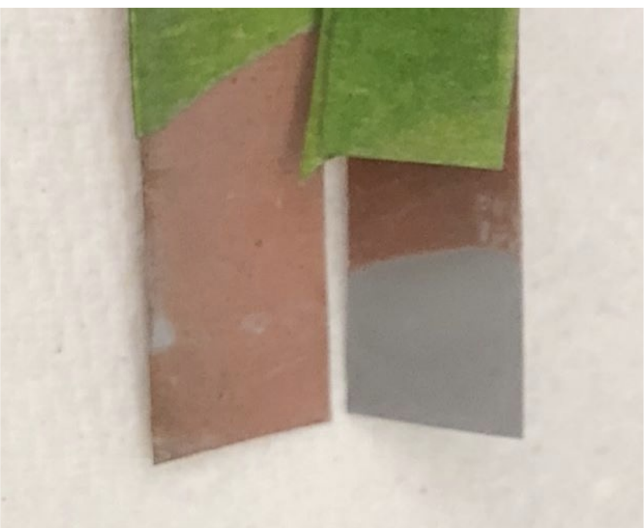
EPD Setup



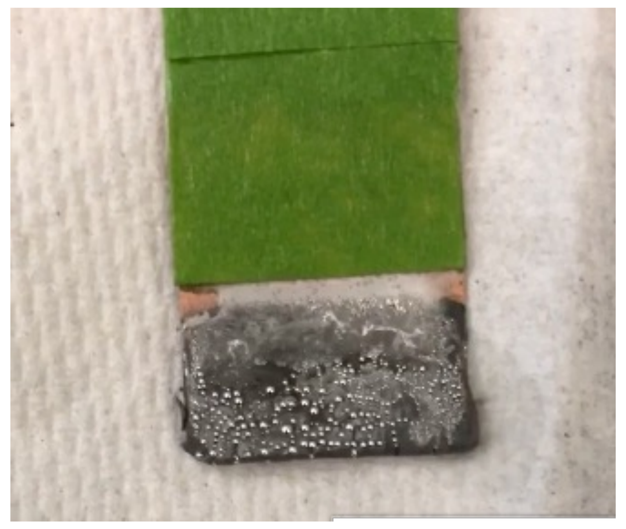
EGaIn EPD

EGaIn Electrophoretic Deposition

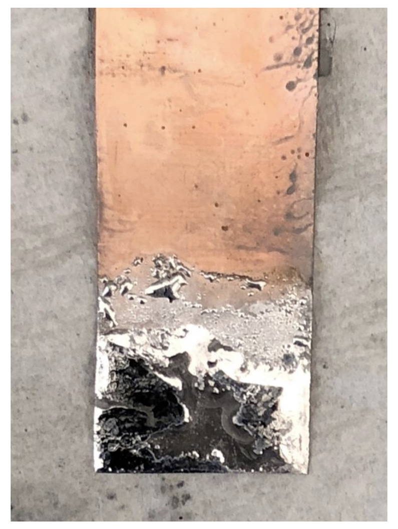
Wet EGaIn EPD



Dry EGaIn EPD

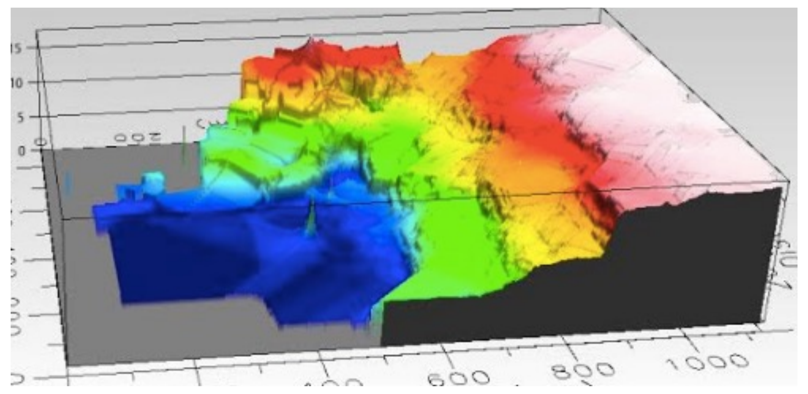


Acid Wash

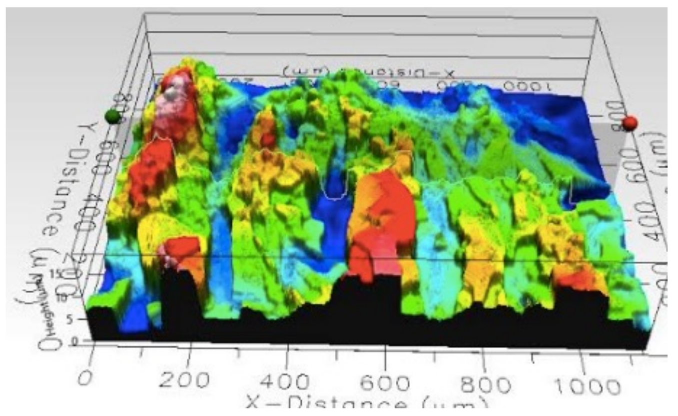


Liquid Metal Thin Film

Surface Morphology Characterization



Step Height



Surface Morphology

Measurements

Average Height: 11.46 µm
Maximum Height: 17.51 µm
Minimum Height: 0.9695 µm
Step Height: 10-20 µm

Conclusion

- EPD is a viable method for EGaIn nanoparticle deposition
- EPD is optimized with an electric field 200-250 V/cm, charging salt concentration near 0.108M, and 0.03g/L EGaIn in IPA
- Charging salt is not necessary for deposition to occur, but is necessary for deposition to adhere strongly
- Thin Film thickness is directly correlated to EGaIn concentration charging salt concentration and duration of EPD
- HCl Acid wash is necessary for liquid thin film creation
- Ice Bath is not necessary for EGaIn deposition but does increase efficiency
- EPD efficiency decreases at temperatures that are too cold

Future Work

- Reduce film thickness
- Further Surface morphology characterization
- Decrease thin film surface roughness
- Find Ideal temperature for EPD
- Apply EGaIn EPD to circuits
- Maximize EPD Rate