Fabrication of Transparent Large Area Conducting Electrodes for Flexible Electronics (OLEDs)

Nivedita [a], Monica Katiyar [a, b]
[a] Department of Materials Science & Engineering, Indian Institute of Technology, Kanpur, U.P. – 208016, India
[b] National Centre for Flexible Electronics, Indian Institute Technology, Kanpur, U.P. – 208016, India
[*] Correspondence: nivdita@iitk.ac.in

FlexE National Centre for Flexible Electronics

ABSTRACT

In this project, two approaches for realizing transparent large area conducting electrodes are proposed. The first approach is the crackle technique to create a homogeneous pattern of conducting wires. A film is made with an acrylic based ink/paste which cracks using a suitable steps and reagents. The cracks in the film are filled with a conducting metallic ink/ metal using vapour deposition and a continuous and connected network of wires is formed. The crackle material is then removed. This technique, in which metallic networks, such as metallic meshes and metallic nano/ micro wires are formed, can alleviate the restraint between transmissivity of light from OLED and conductivity as an electrode. It is a prospective way to create electrodes in flexible large area electronics at low cost. There are reports in the literature where such templating/ crackle methods have been employed for patterning over limited areas. For large area device applications using wire networks, it is important that the cracks in the template are of suitable dimensions, highly interconnected into a single network and reproducible in a roll to roll fabrication set up. In the second approach, we propose to create a continuous nanowire matrix using a novel adenine-silver based polymer. This CP (co-ordination polymer) is predicted to have high conductivity due to hybridization of unfilled orbitals of silver and adenine (ligand). In literature, the polymer is deposited on HOPG (Highly Oriented Pyrolytic Graphite) for alignment of the polymer. The nanowires align in the direction of the bonds of the graphene. But to use this as an electrode on large area devices independently (without HOPG), we have suggested to find ways of molecular alignment and nanowire fabrication and exploit the maximum conductivity on the surface in a continuous matrix.

INTRODUCTION

OLED (Organic Light Emitting Diodes) is an ultrathin light emitting technology, made by placing a series of thin films (usually the functional layers being carbon based) between two conductors (the electrodes).
When an electrical current is applied, light is emitted. OLEDs can be used to make displays and lighting, with possible applications that span TV sets, computer screens, mobile phones, decorative lighting and more.
Conventionally one of the electrode is indium tin oxide (ITO), for printed OLED technology a solution-processable alternative is required. Ag-nanowire and a metallic grid has been proposed by some researchers. Here, we are proposing two novel approaches to find a printable and flexible alternative to ITO.

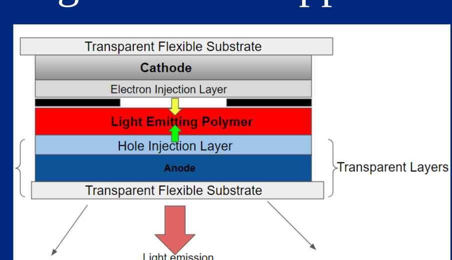

Figure 1: An OLED stack

APPROACH A-EXPERIMENTAL DETAILS

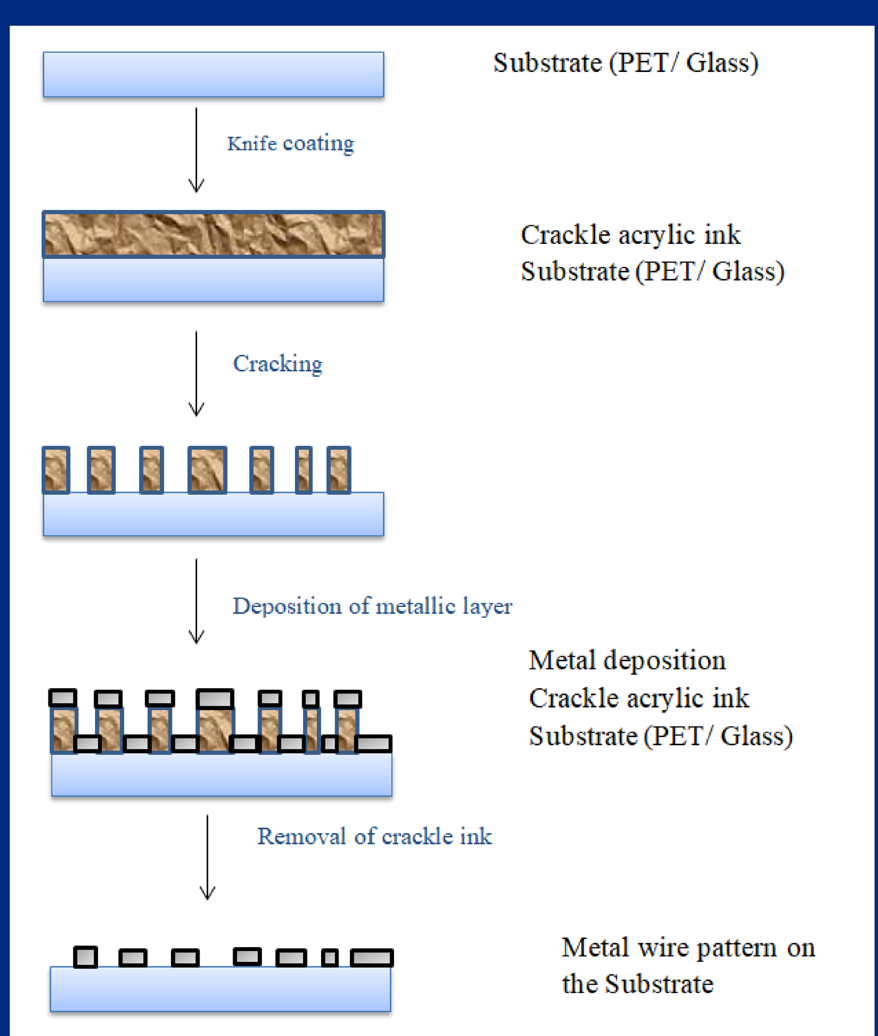

Figure 2: Process flow for metal network fabrication

Figure 3: Different steps involved in fabrication of electrode/ metal network

APPROACH A-CONCLUSIONS

- Network of Al metal, having line width in 200µm range was successfully formed using this technique.
- Further improvement in processing is required to reduce this metal line width to nanometre range.

FUTURE WORK

- Surface roughness, optical transmission and conductivity measurements will be done to evaluate this as electrodes in OLED
- Fabrication of OLED devices using this Al, Cu and Ag networks as electrode

APPROACH-A RESULTS AND DISCUSION

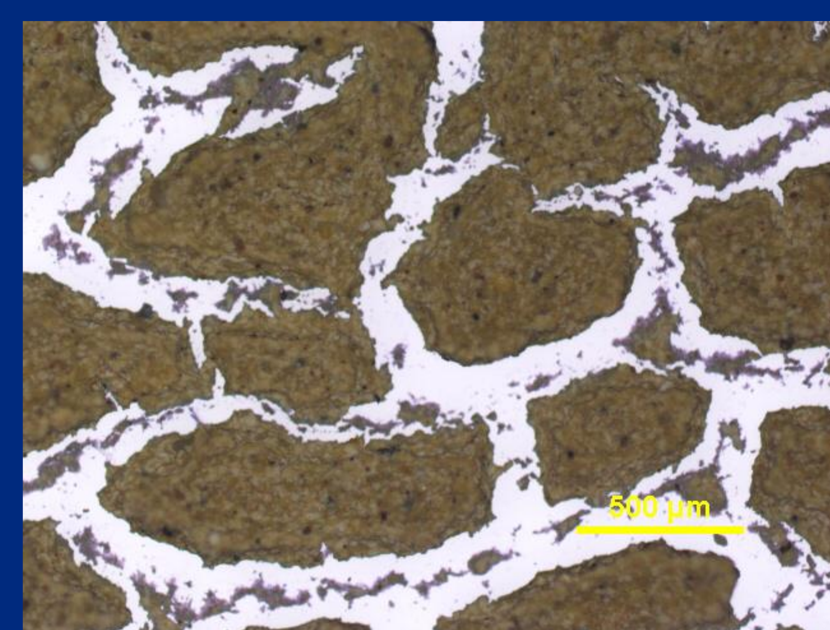

Figure 4: Optical micrograph of the cracks formed in the crackle ink after adding 2-ethoxy ethanol and annealing at 110°C for 2 minutes

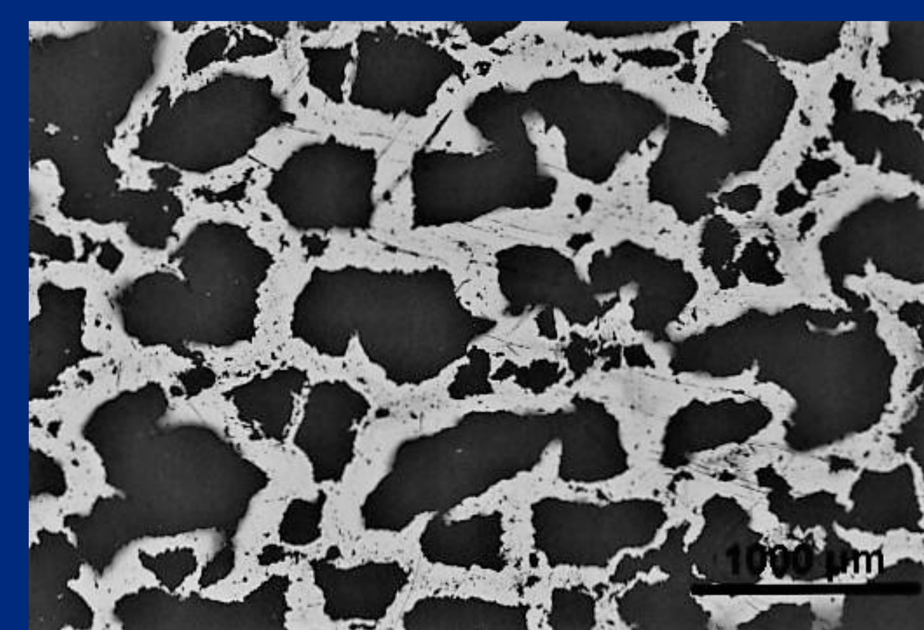

Figure 5: Optical micrograph of the Al metallic grid formed after removal of crackle ink. The thickness is 200 nm and average width is ~200µm

- The Al grid is found to be conducting. The mesh is interconnected and the junctions are seamless.
- The optical transmittance characterisations are yet to be done. Optical transmittance can be improved by reducing the crack width to sub micron levels.
- The metals Cu/ Ag can be used instead of Al to improve conduction and printing methods can employed instead of vapour deposition

APPROACH B - ONE DIMENTIONAL COORDINATION POLYMER BASED NANO-WIRES

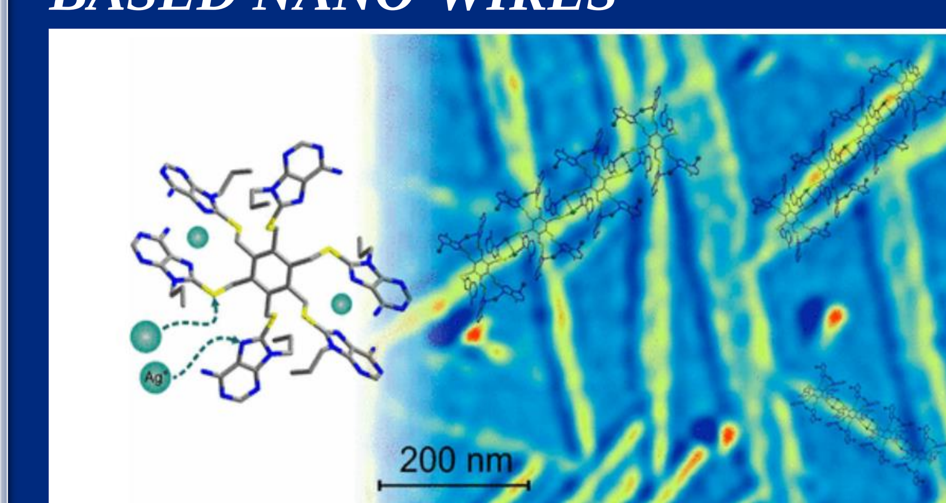

Figure 6: Hexapodal Adenine-Ag 1D polymer [2]

This novel polymer can be used as an electrode as well as a hole injection system.

The challenge is to use it in large area devices. Its assembly and alignment can be motivated knowing its chemical nature more in depth.

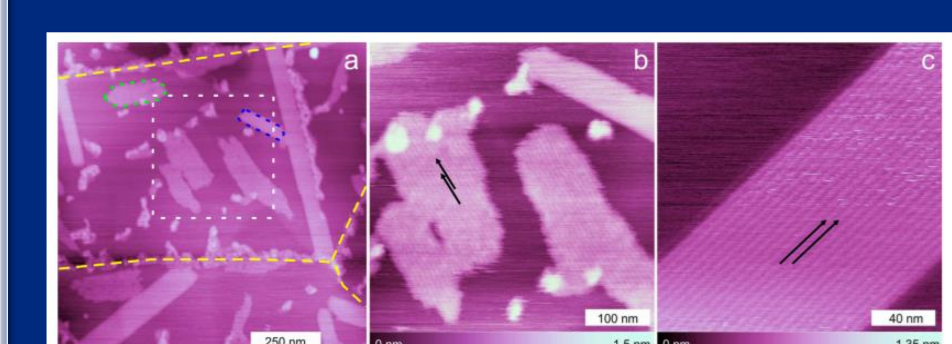

Figure 7: AFM topography of ultrathin film of Ligand-Ag on an HOPG showing directionality [2].

- Thickness is less in nm range, we need at least few tens of nm for robust devices
- We need to make films over large area extending up to a few meters range

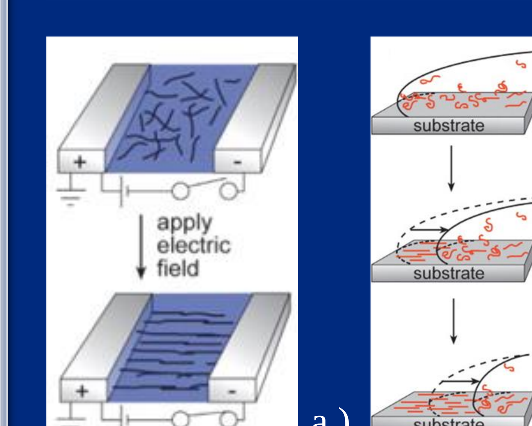

Figure 8: (a) Techniques for nanowire alignment Dielectrophoresis (DEP) & (b) Shear forces due to dewetting/ removal of solvent . [3]

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