PEDOT Silver Nanowires Printable Conductive Electrode

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Abstract

The number of touchscreen devices being produced in the world is exponentially increasing. 1.3 billion units of touchscreen panels were traded in 2012. This statistic is projected to increase to 3 billion by 2016. A majority of touchscreen devices are very dependent on the expensive, rare, and transparent conductive material, indium tin oxide (ITO), which has a very limited supply. A printable low cost alternative is necessary to sustain the production of high quality touchscreen products. A combination of printable conductive electrodes, Clevios HY-E & F-CE, are a promising solution to fabricate ITO free devices.

Overview

- There are increasing demands for touchscreen panels and these touchscreen devices are beginning to be used in new industries
- The conductive electrode is a fundamental component of these devices. The two main characteristics of the transparent conductive oxide (TCO) are optical transparency and electrical conductivity
- There are several different conductive electrodes including: PEDOT:PSS, ZnO, and CdO. But the problem with these materials is their limited conductivity. However, the most popularly used TCO in devices today is indium tin oxide

Goals
- Optimize and characterize new Clevios™ electrodes
- Test methodology of materials
- Use Clevios™ electrodes to replace ITO

Indium Tin Oxide

Pros:
- Widely considered the premium transparent conductive oxide
- Optically transparent
- Electrically conductive
- Stable

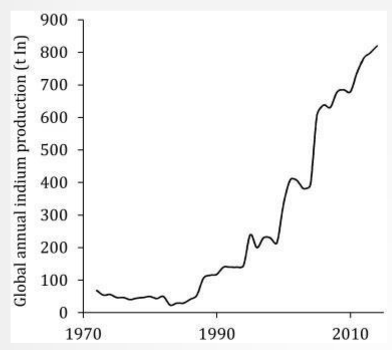


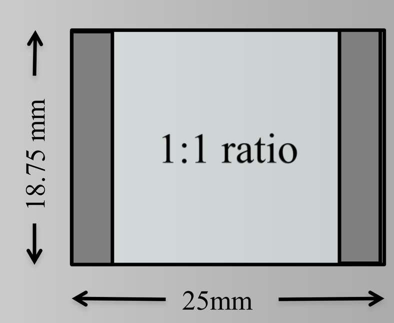
Fig 1. ITO production rate (1972-2014) [1]

Cons:
- Expensive
- Rare earth metal
- Limited supply
- Brittle
- Not flexible
- Complicated fabrication process
- Deposited though physical vapor deposition and magnetron sputtering which also impacts the cost

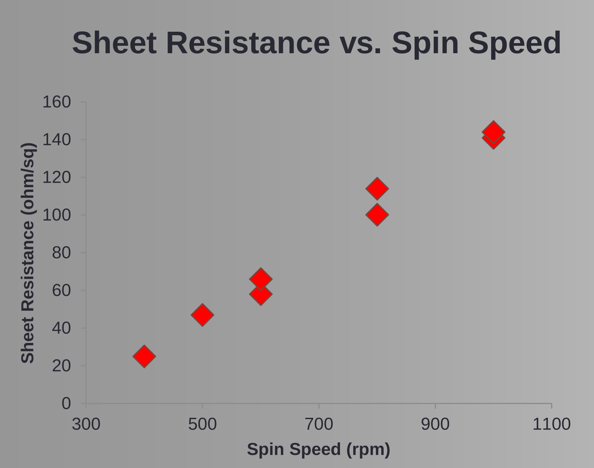
Methods

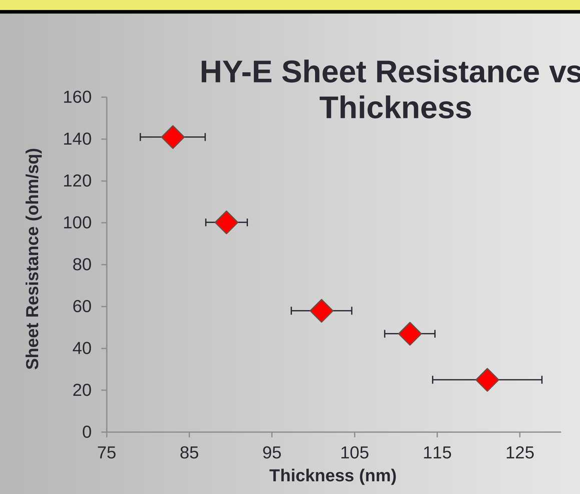
Characterization
- Thickness:
  - Profilometer: Scratch/swab techniques
- Sheet resistance:
  - 4 point probe machine
  - 2 point measurement w/silver contacts
- Transparency and Absorption:
  - Spectrometer

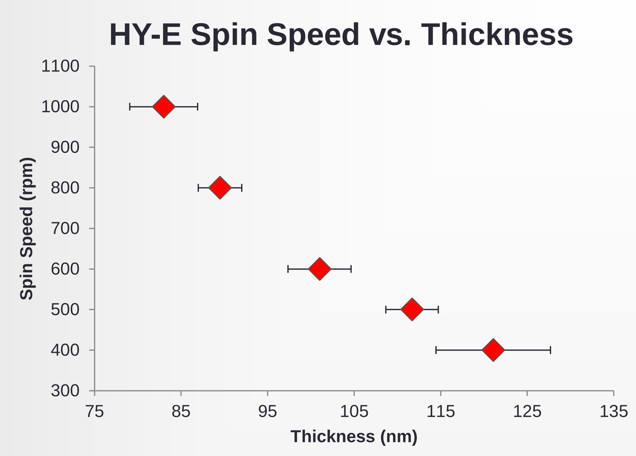
Fabrication Process
- Microscope slides (25 x 18.75mm)
- Substrate cleaning
- Deposition: Spin coating
- Annealing (Air/Glove box)
- Apply silver conductive paint
  - Planarization layer deposition:
  - Repeat steps 3-5 for second layer



Clevios™ HY-E: Ag-PEDOT:PSS





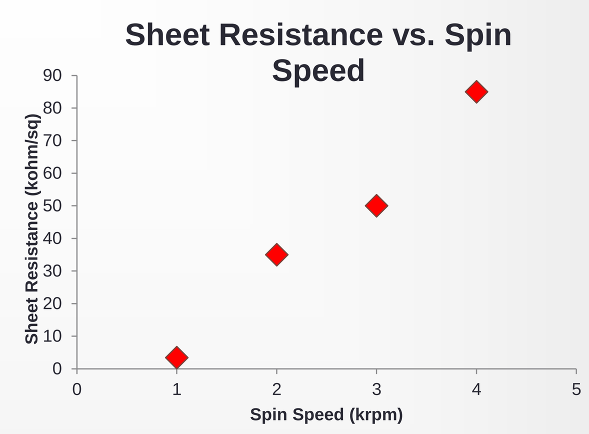


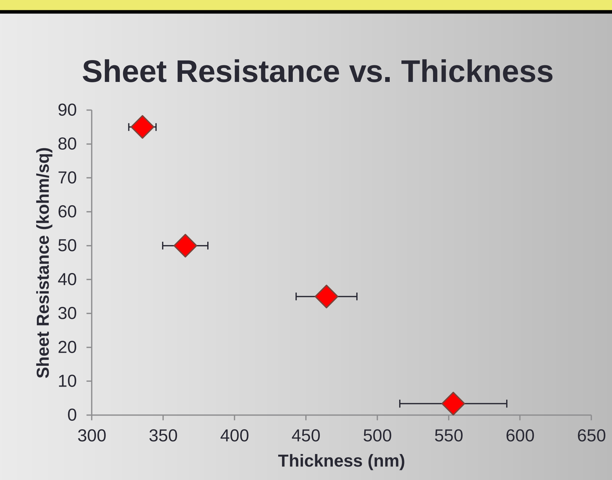
Clevios™ HY-E is an aqueous dispersion containing:
- PEDOT
- Silver nanowires
- Surfactant

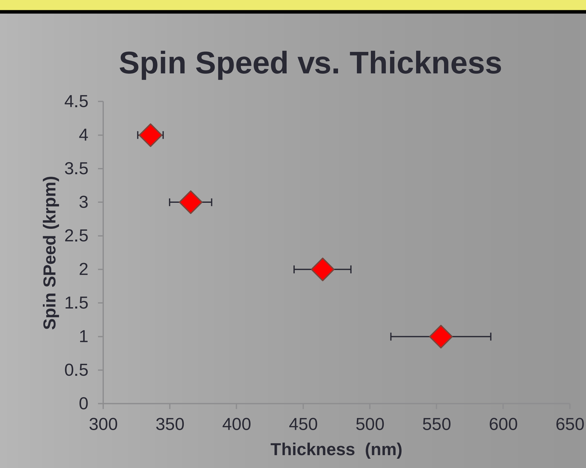
- The presence of the silver nanowires leads to greatly reduced sheet resistance and slightly increased haze compared to regular PEDOT dispersions
- R&D material that is still under development

- Sheet resistance comparable to ITO
- ITO Sheet resistance: 20 ohm/sq
- Clevios™ HY-E Sheet resistance: 25 ohm/sq
- Positive linear correlation between sheet resistance and thickness
- Control thickness by varying spin speed

Clevios™ F-CE: Planarization Layer



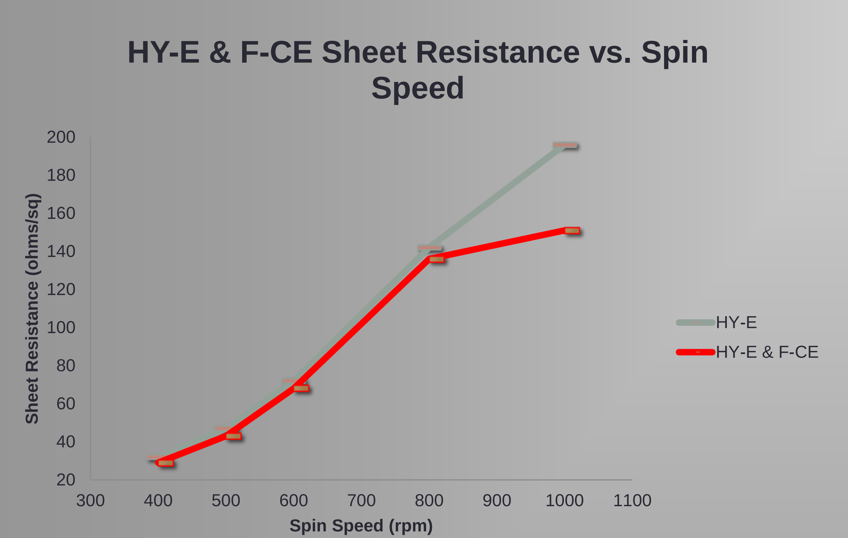




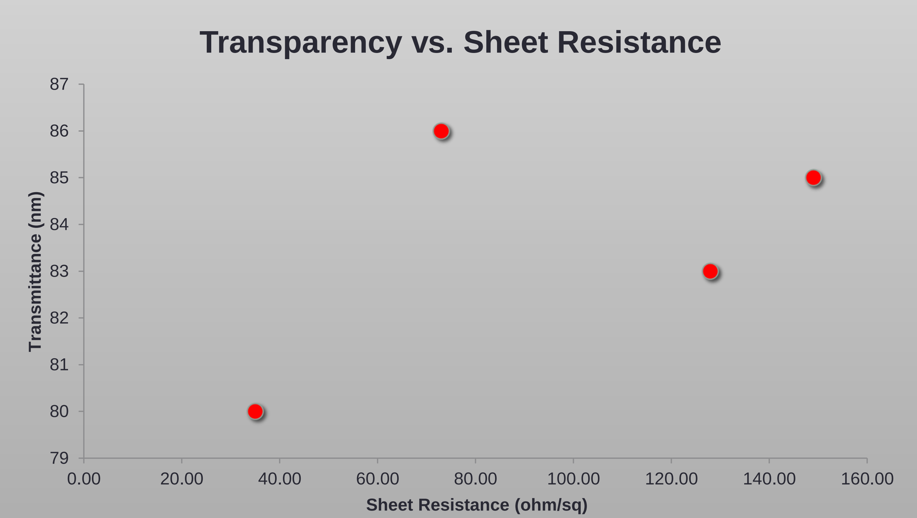
- Enhanced PEDOT from Heraeus
- Smoothens roughness from Ag nanowires

- Most important property of planarization layer is thickness
- Optimal thickness is ~400nm. Able to produce this thickness at 2000 rpm
- Conductivity 3 orders of magnitude lower than HY-E

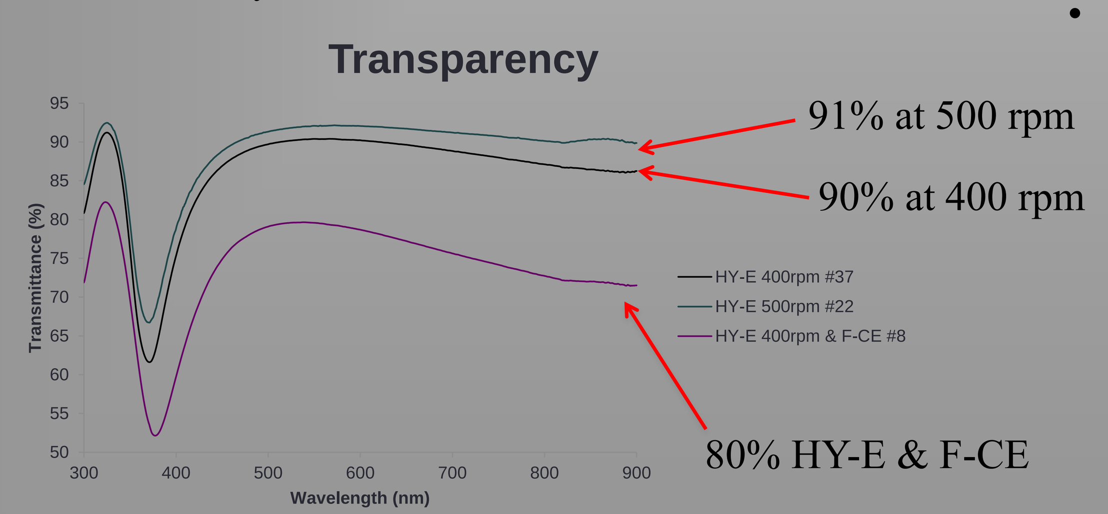
Clevios™ HY-E & F-CE

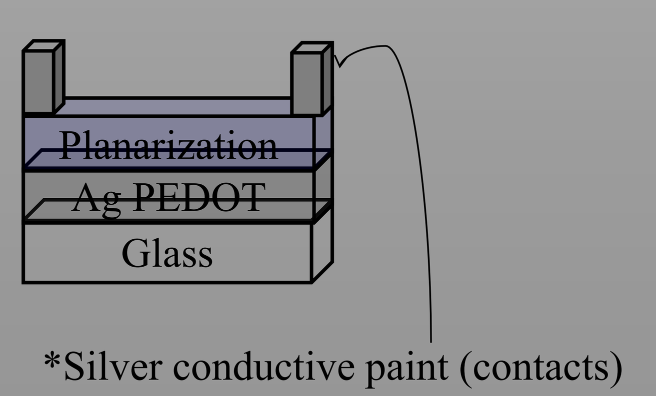


- Planarization layer slightly enhances conductivity



- Theoretical linear correlation between transparency and sheet resistance
- 2^{nd} point at 86% transmittance slight outlier in trend





*Silver conductive paint (contacts)

Summary

As a result of this project, the new Clevios™ electrodes HY-E & F-CE were successfully characterized and optimized. Sheet resistances of as low as 25 ohm/sq were obtained, which is relatively close to ITO's sheet resistance of 20 ohm/sq. Transparency of both Ag-PEDOT:PSS and planarization layers of 80% were achieved, which is in the same range as ITO's transparency of 85%. Given these properties, Ag-PEDOT:PSS is a comparable low cost alternative to replace ITO.

Acknowledgements

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