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OVERVIEW OF PLASTIC SUBSTRATES FOR PRINTED ELECTRONICS

Robert Rustin
Sr. Application Development Manager

Special thanks to:
Karl Rakos
Bill MacDonald

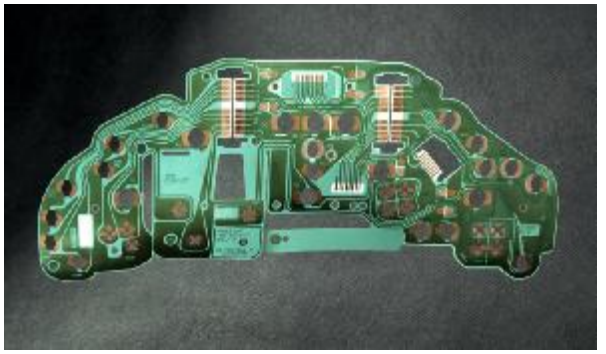
Market Knowledge Customer Success Technical Capability

Overview

- Flexible Electronics Today
- Development Highlights
- Industry Challenges
- Conclusion

Printed Electronics Exist Today

- Membrane Touch Switch
  - Automotive MTS, eg seat sensors
  - PEN allows higher temperature specifications
- Flexible Printed Circuits / Flat Flexible Cable
  - Automotive wiring harness replacement with flat cables
  - LED rear light clusters and daylight running lights
- Optical Displays
  - Electroluminescent lamps and next generation displays



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Printed Electronics Today

- Security, ID, health cards
- Passports
- Protective Labels
- Medical Test strips

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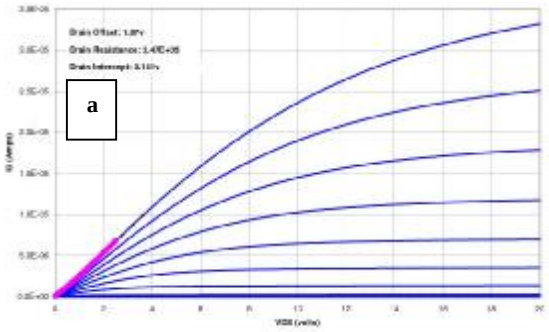
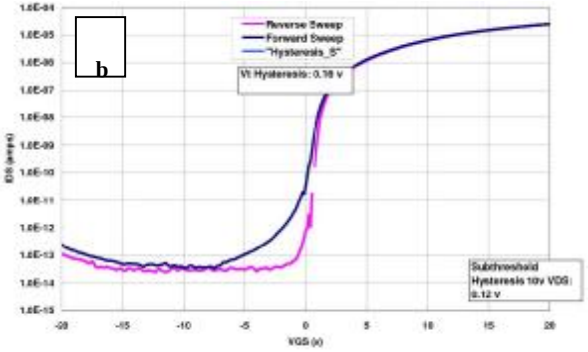
FDC Technology on PEN

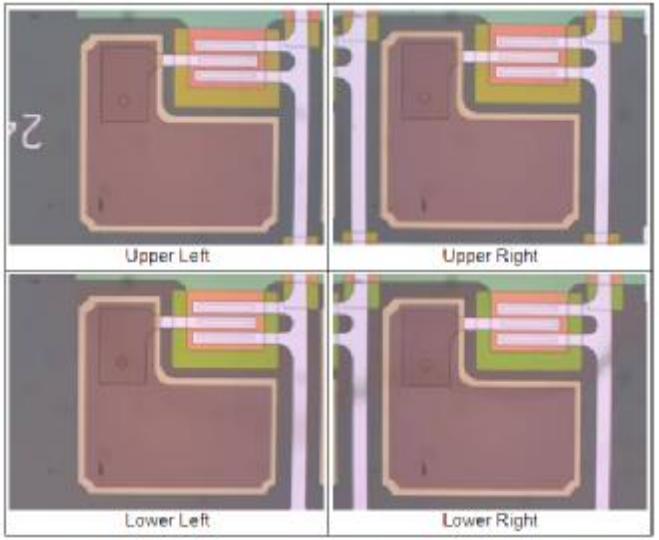
Parameter	FDC
Max. Process Temperature	180 °C (flex)
Saturation Mobility (cm^2/V-s)	0.7
ON/OFF Ratio	2 x 10^9
Drive Current (μA)	30
Threshold Voltage (V)	1.0





Typical output (a) and transfer (b) characteristics of a-Si TFTs fabricated on PEN

3.8-in QVGA E-Ink Display on PEN



TFT pixels at 4 corners of 3.8-in QVGA

Developments

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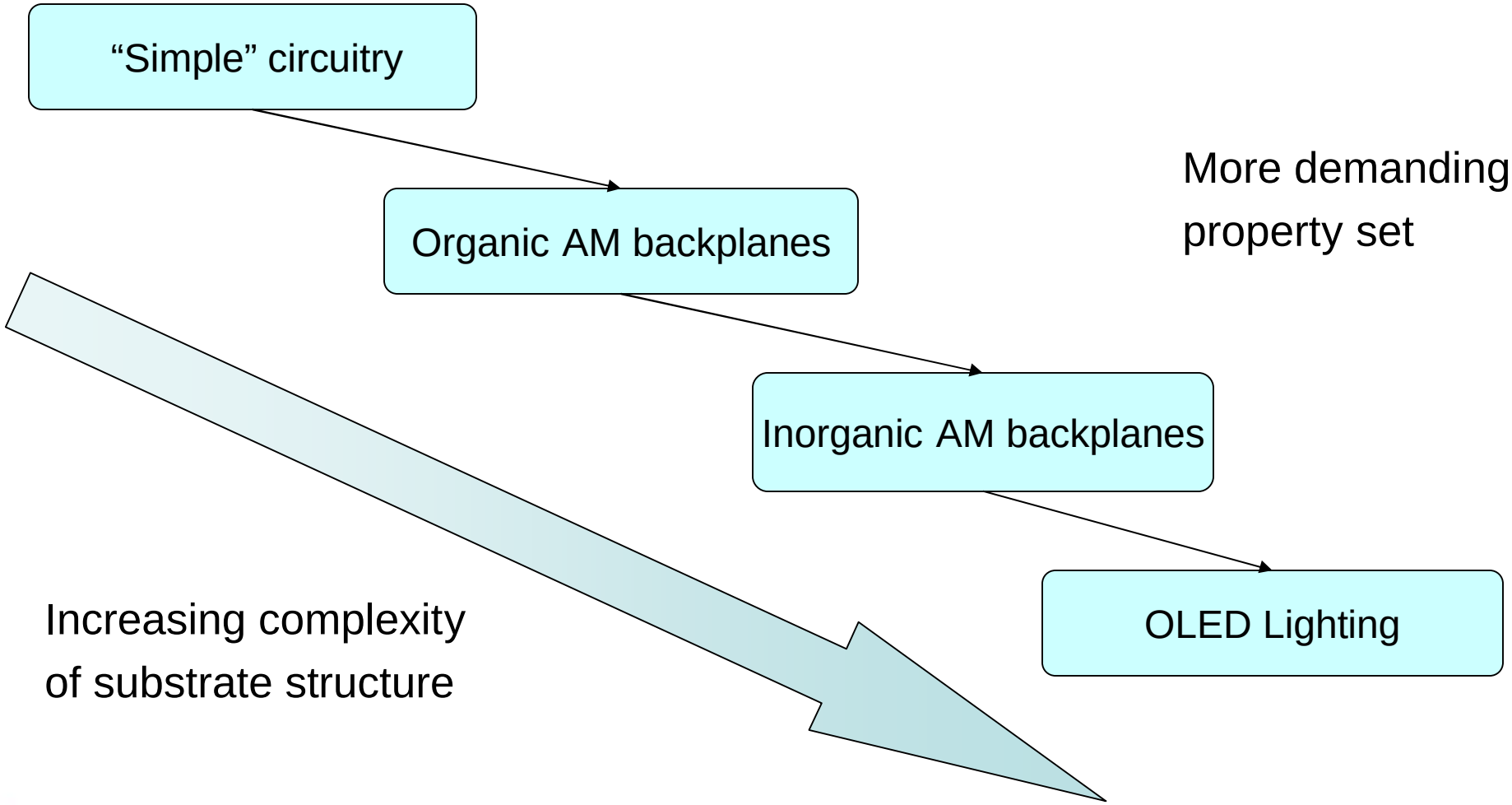
Factors Influencing Substrate Choice-Property Set



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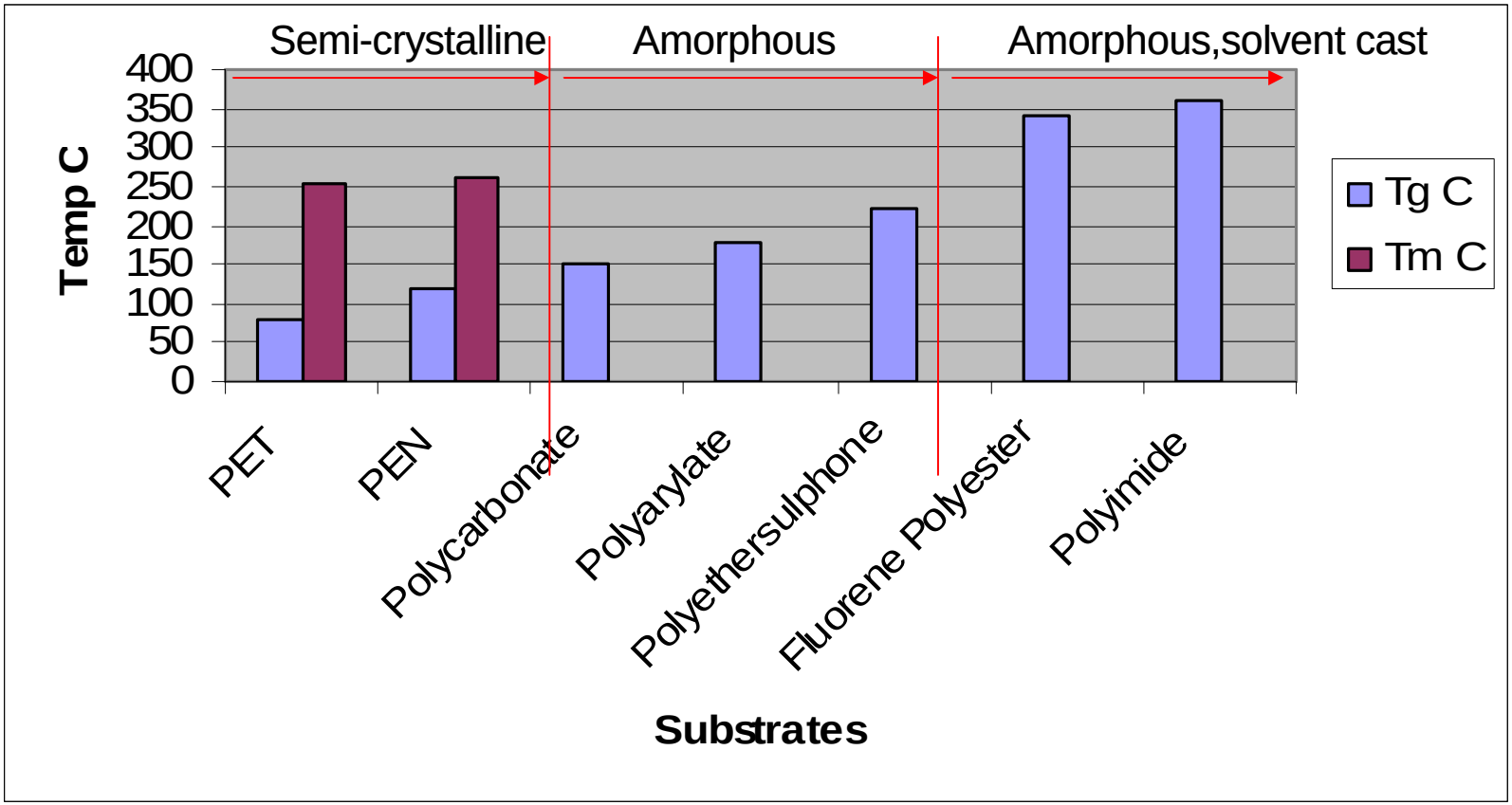
Key Challenges for Engineered Substrates into Flexible Electronics Applications

- Low Coefficient of Thermal Expansion
- Low Shrinkage
- Upper Temperature for Processing
- Surface smoothness
- Barrier
- Solvent Resistance
- Moisture Resistance
- Clarity
- Rigidity
- Conductive layers
- Commercial availability
  - Development started in late “90’s” primarily for OLED and LCD applications
- Substrates for the more demanding applications are likely to be multilayer structures containing both organic and inorganic layers

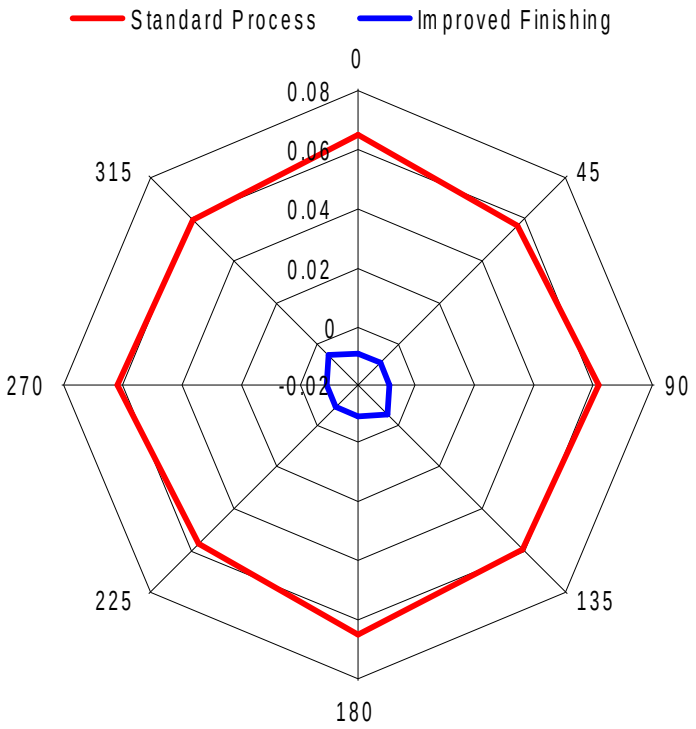
Factors Influencing Film Choice-Substrate Properties

Films grouped by thermal properties

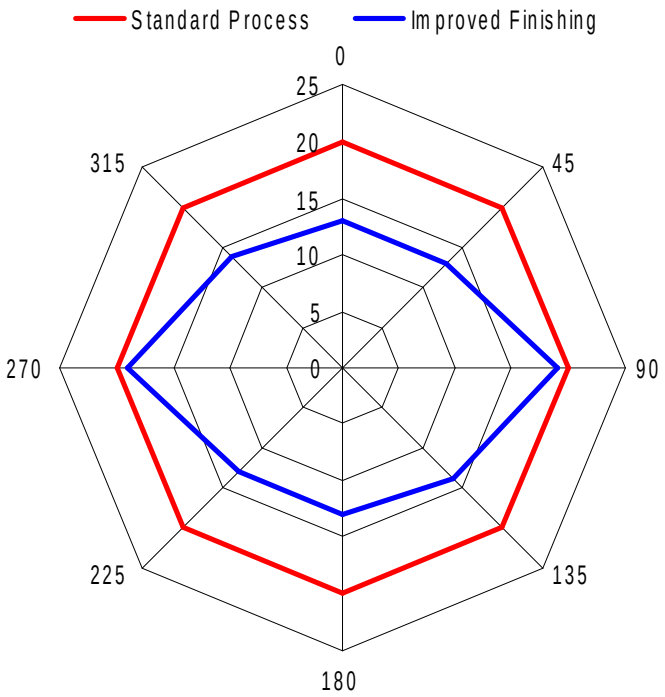


Improved Process for Heat Treating

- Thermal finishing cycle virtually remove shrinkage:–0.01% at 180C, 30’ (left graph)
- CLTE is reduced by 25%: 20ppm/K **à** 15ppm/K (right graph)



Shrinkage % (180°C, 30min) vs. direction in plane of Teonex® PEN film (0°=MD)



CLTE (ppm/K) vs. direction in plane of Teonex® PEN film (0°=MD)

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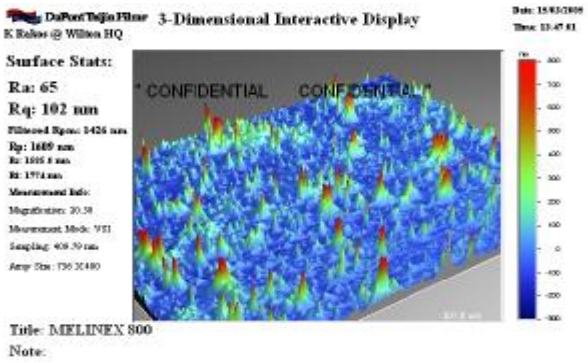
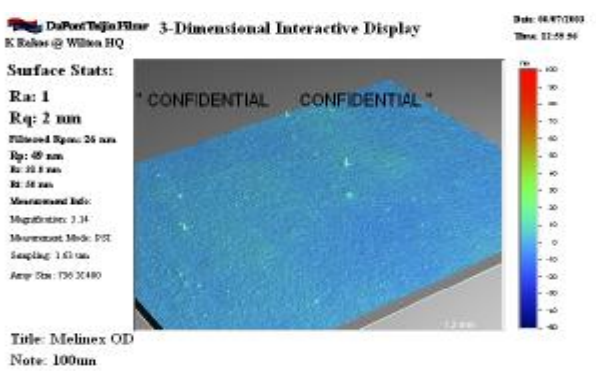
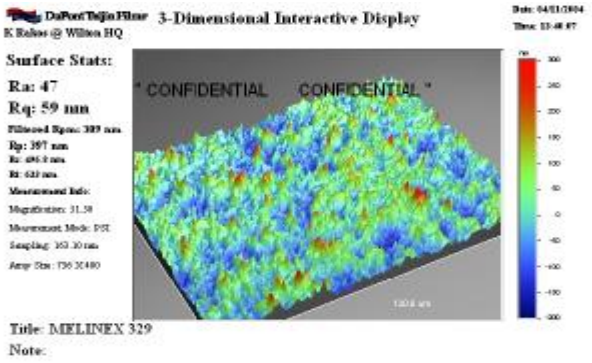
Surface Roughness from Additive Packages



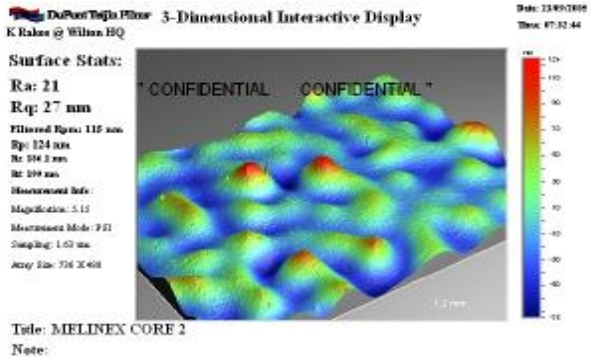
Standard Packaging Film



"Electronics" Grade Film



White Opaque Film



Laminating Film

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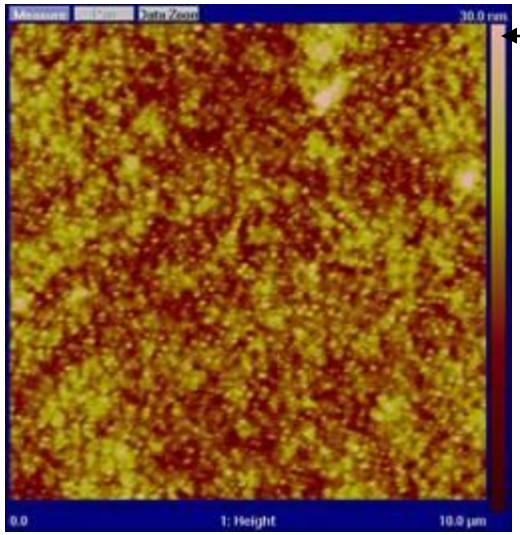
Optimized Surface for Fine Features



30nm

AFM - 10 micron square
ST506 surface

Amplitudes +/- 30nm

20nm

AFM - 10 micron square
Planarised ST506 surface

Very smooth - within the noise floor

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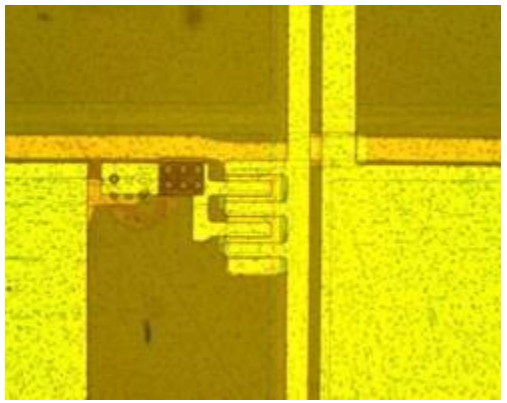
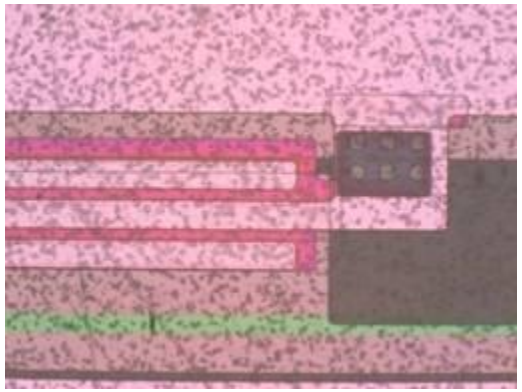
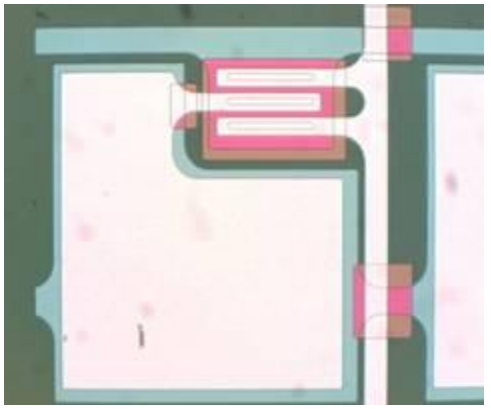
Does Rougness Impact Circuitry?

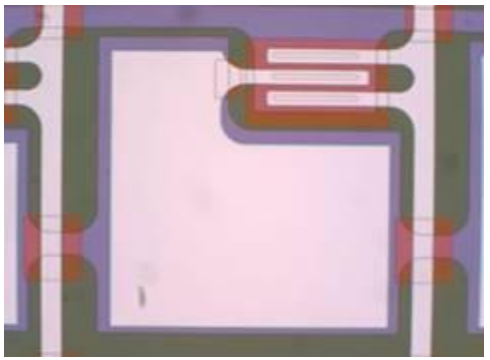
QVGA aSi TFT array built on PEN





Planariser





Uncoated Heat stabilised PEN

Planarised Heat stabilised PEN

Slide shown courtesy of Flexible Display Centre, ASU

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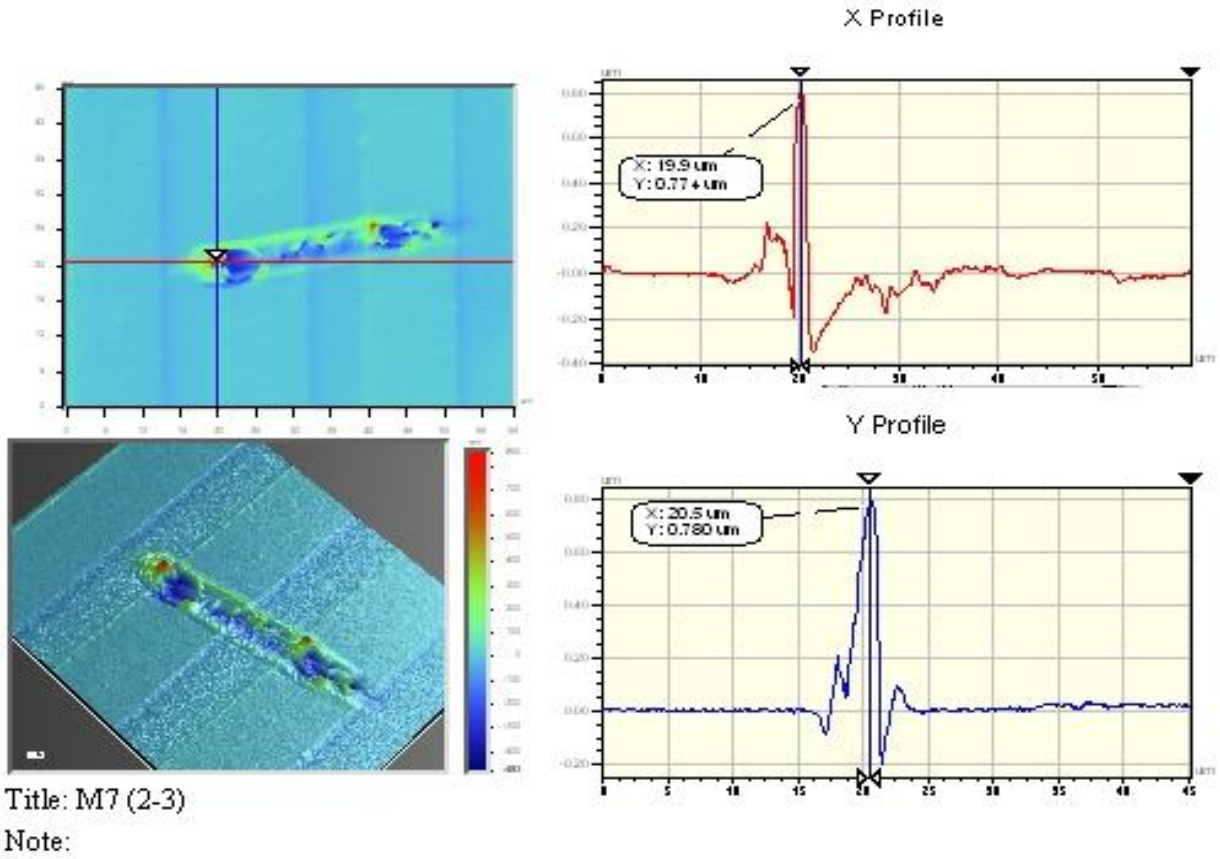
Challenge from Scratches



Scratches and Surface Debris can easily cause trace breaks.

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Industry Challenges

- For economics, machine scale is large, producing millions of square meters an hour.
  - Need large scale opportunities
  - Today, must leverage products for other markets to meet small scale demands
- Measurement
  - Size of defects and density becoming tighter
  - Measurement systems do not exist for volume QC, must rely on spot measurement
- Global Supply Chains
  - US producers must design for “best in class” global standards.
  - Aggressive investment in Asia for the LCD industry

Summary

- Development of Films for Printed Electronics have been ongoing for many years, leveraged from other industries.
- Choice of film type and thickness is crucial.
  - Important to pick the right film for the application.
- Control of surface quality is critical.
  - Critical to understand the type of surface defects which impact device manufacture and performance.
- Global supply chains are a given
  - “Best in class” assets need investment and on-going re-investment

Thank You

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Melinex® polyester film **Mylar**® polyester film
Teijin®**Tetoron**® polyester film **Teonex**® PEN polyester film

How many times a day do you rely on PET and PEN polyester films from DuPont Teijin Films?