Michael Spaid

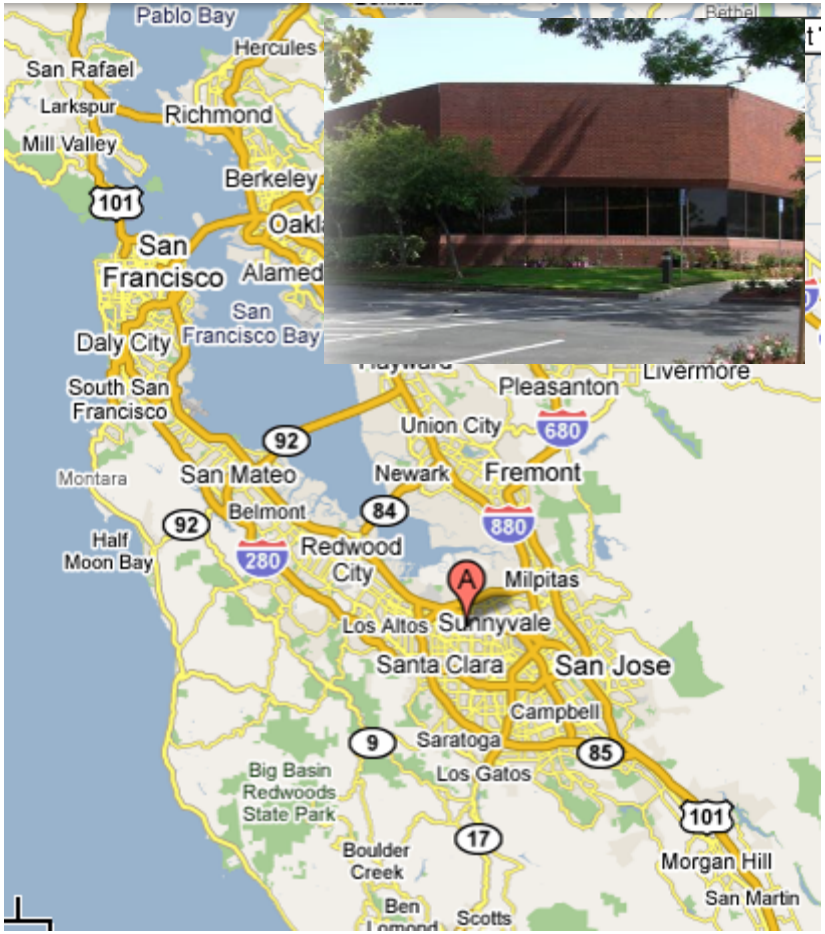
Cambrios Technologies Corporation

September 21, 2011

Cambrios Introduction

- Venture funded company located in Sunnyvale
- 40 people, mostly scientists/engineers
- Focused on one innovative material for more than 5 years
- 2 product families for 1st market (touch):
  - ClearOhm™ Coated Film
  - ClearOhm™ Ink
- Commercial products in the market

Cambrios Technologies Corporation

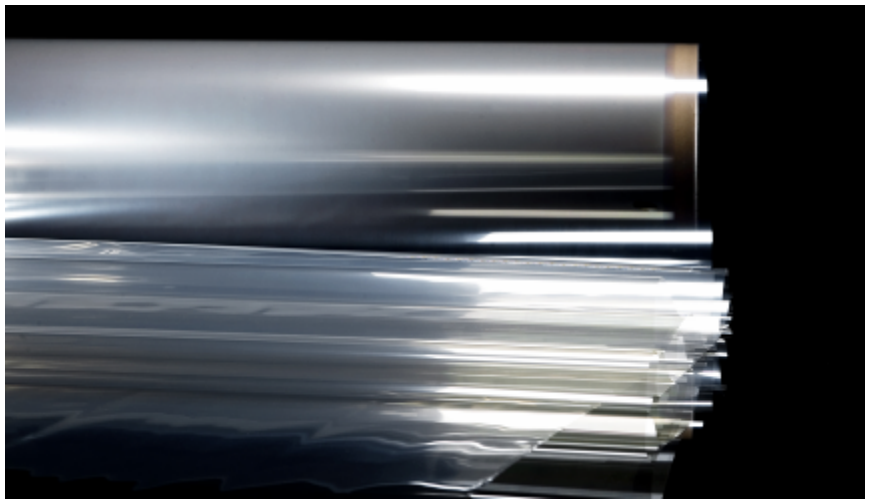


Cambrios Technologies Corp.
Sunnyvale CA

Cambrios Technologies K.K.
Tokyo Japan

Cambrios' Products

- ClearOhm™ Coating Materials
  - Manufactured in Sunnyvale
- ClearOhm™ Conductive Film
  - Coated in Japan



ClearOhm™ Coating Material

- Wet coatable dispersion of high aspect ratio metallic nanostructures
- Competitive optical & electrical properties as compared to commercial sputtered conductive oxides
  - From <10 ohms/square to 300 ohm/square
- Low processing temperature
  - Compatible with most substrates
    - PET, Polycarbonate, PEN, glass, others
- Suitable for use on existing production equipment
  - Roll-to-roll coating or sheet coating

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Transparent Conductors are Everywhere Today



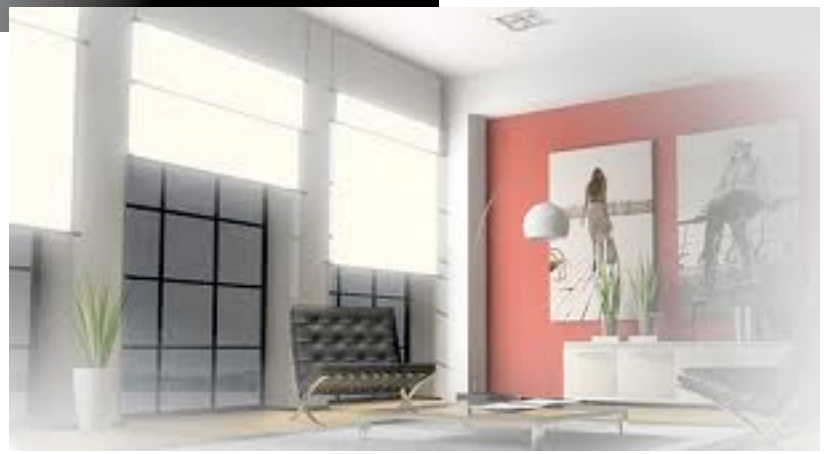




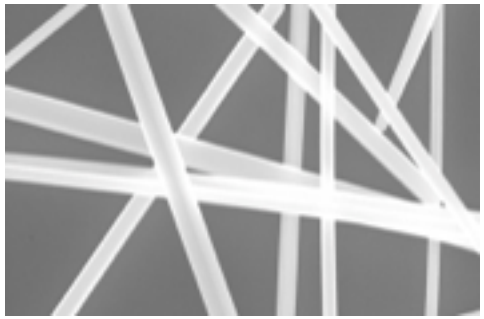


CAMBRIOS

Large New Markets for Transparent Electrodes



Cambrios Opportunity

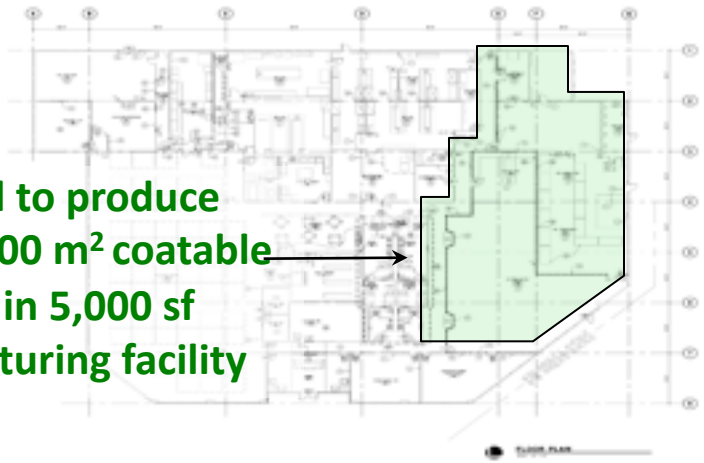


A NEW TYPE OF TRANSPARENT CONDUCTIVE MATERIAL

A HUGE, EXISTING MARKET FOR A SINGLE MATERIAL TYPE

LARGE EMERGING APPLICATIONS

Potential to produce 30,000,000 m² coatable material in 5,000 sf manufacturing facility



CURRENT FACILITY CAN SERVE WHOLE CONSUMER ELECTRONICS CATEGORIES

Commercial Priorities

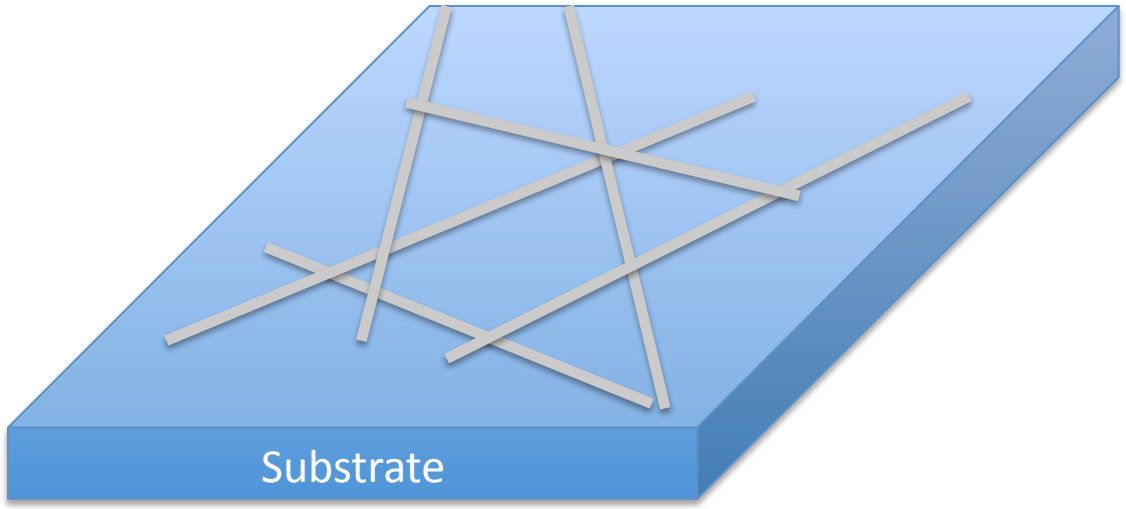
- Consumer Electronics
  - Touch Panel
  - LCD
  - OLED Display

- Cleantech
  - OLED Lighting
  - Thin Film Photovoltaics

Technology

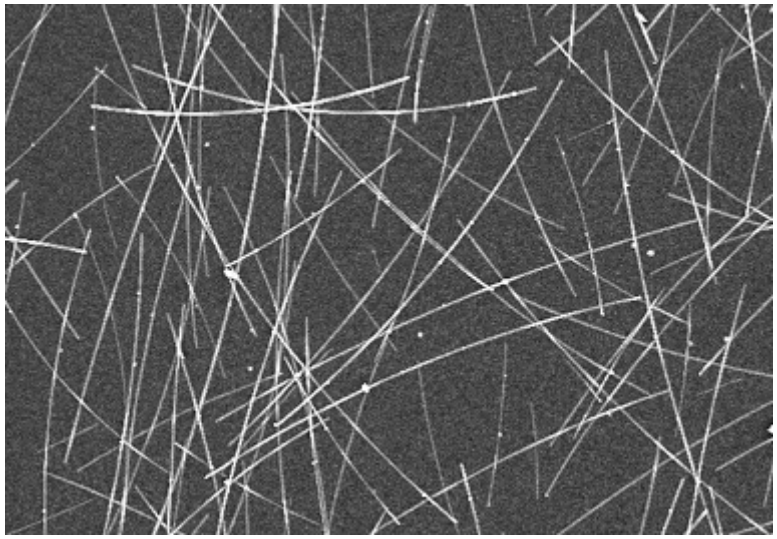
ClearOhm™ Layer Structure

1. Coat nanowire layer
2. Coat overcoat (optional, application dependent)

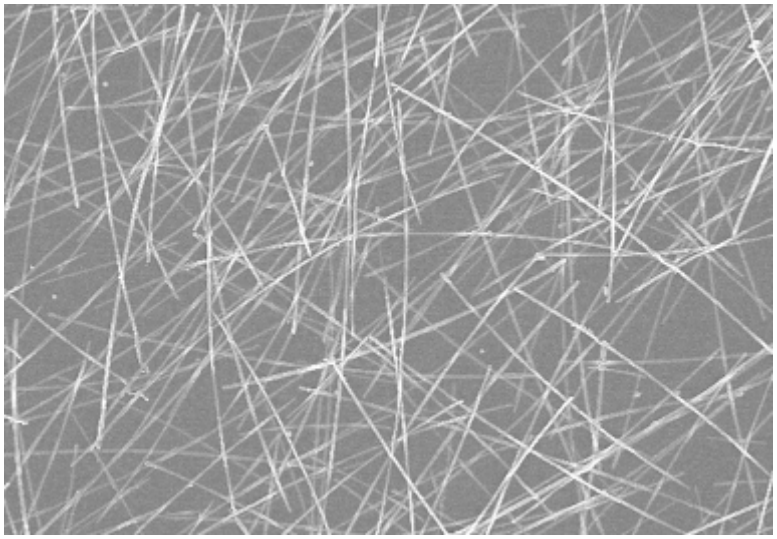


Nanowire Surface Concentration Determines Sheet Resistance

50 Ohms / sq.



15 Ohms/sq.

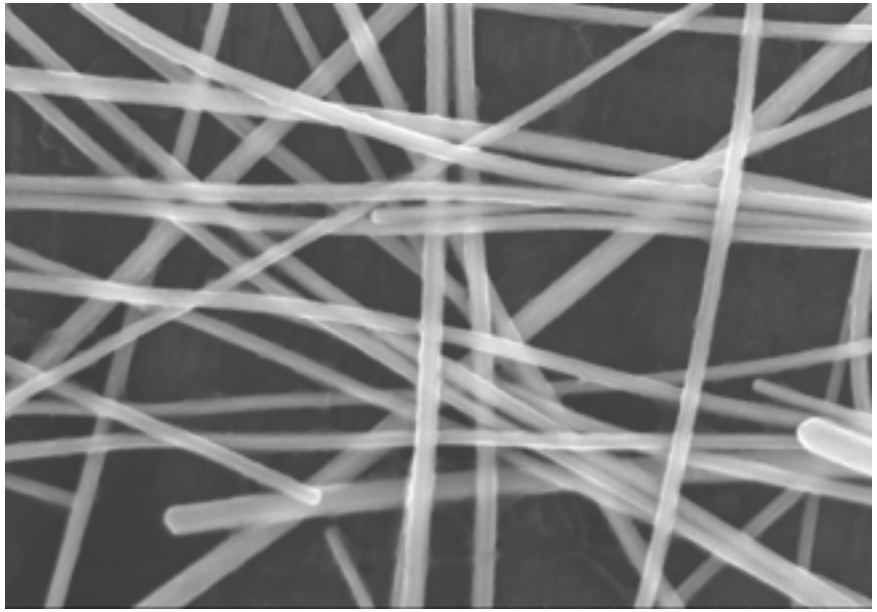


Higher Nanowires Surface Concentration = Lower Sheet Resistance

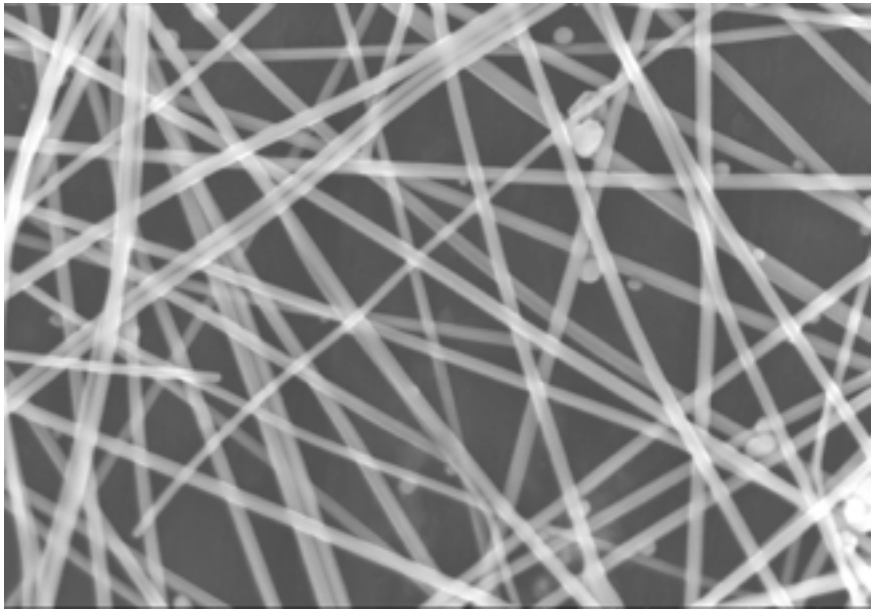
* % Total forward transmission, glass as reference

Engineered Nanostructures: Control over Material Properties

Higher haze



Lower haze



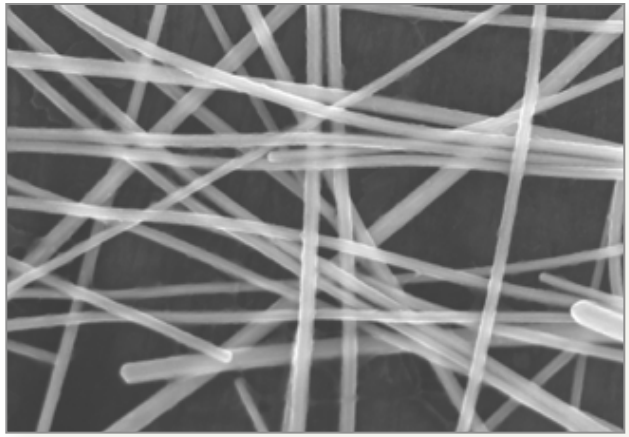
Independent process control of nanowire length and diameter

ClearOhm™ Film: A Better Transparent Electrode

ITO

- Volatile commodity
- Brittle, cracking problems
- Weakly conductive
- Expensive material
- Requires Index matching
- Requires High Temperature to crystallize
- Expensive to pattern

ClearOhm™ Film



- Silver: common electronic material
- Completely bend-able film, , no cracking, high manufacturing yield
- Most conductive metal; crystalline
- 1% surface coverage
- Deposited by wet coating
- Etch, Transfer, or Print

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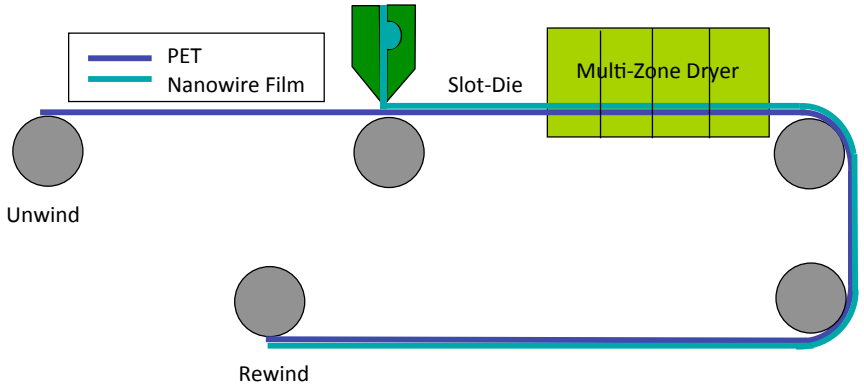
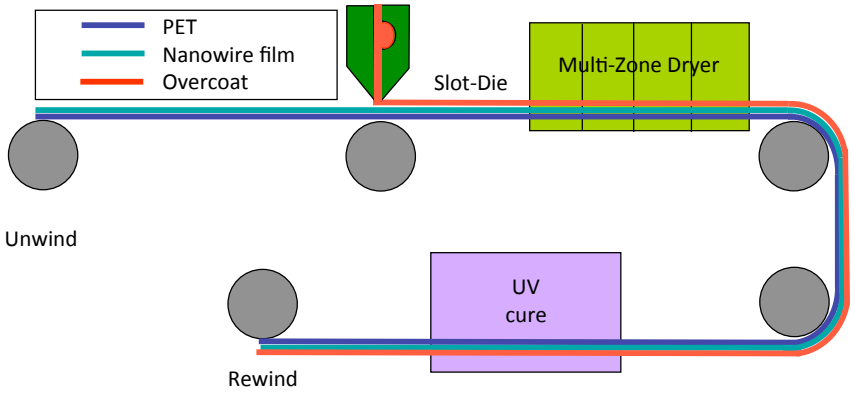
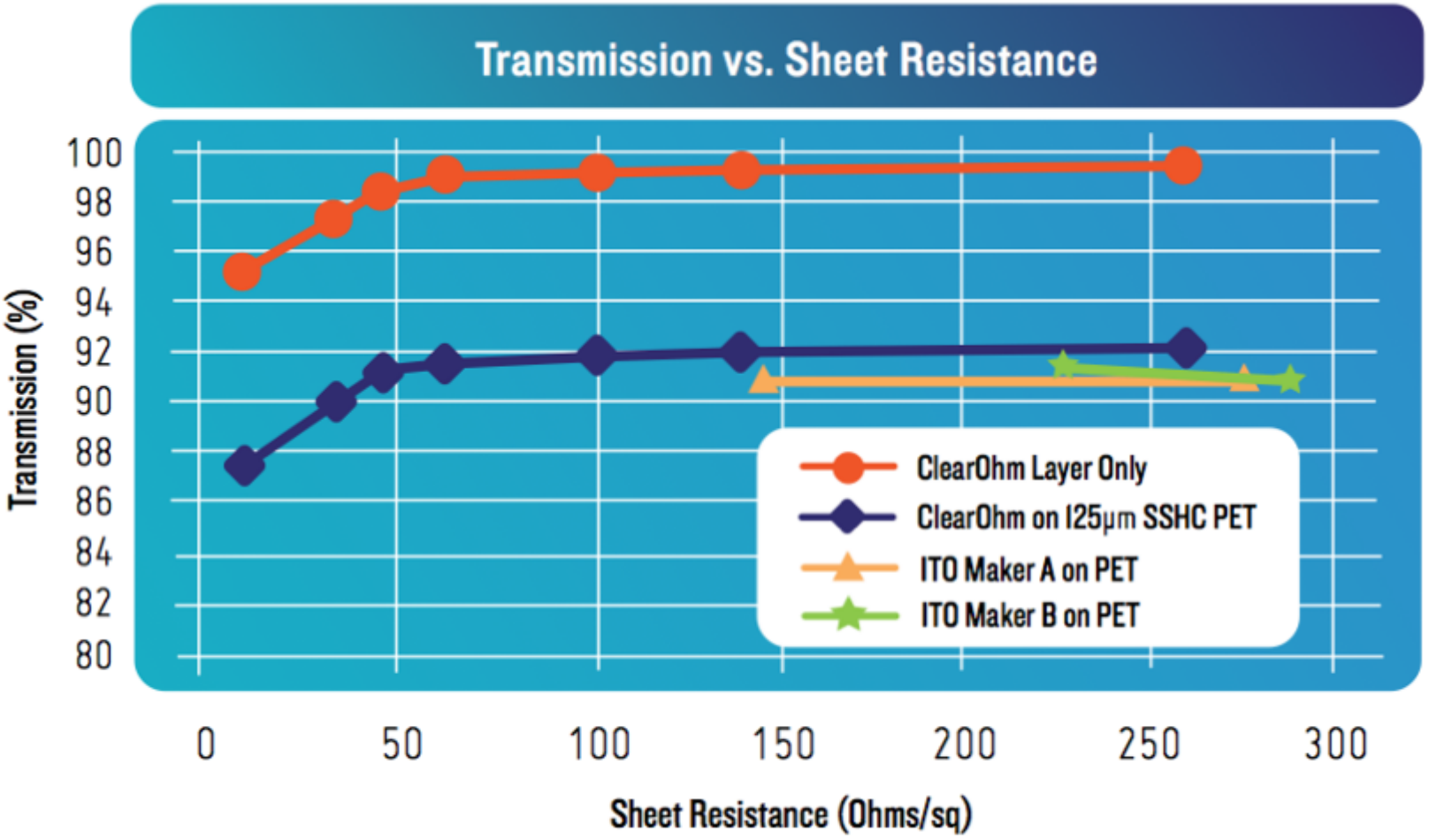
ClearOhm™ Film Manufacturing Process



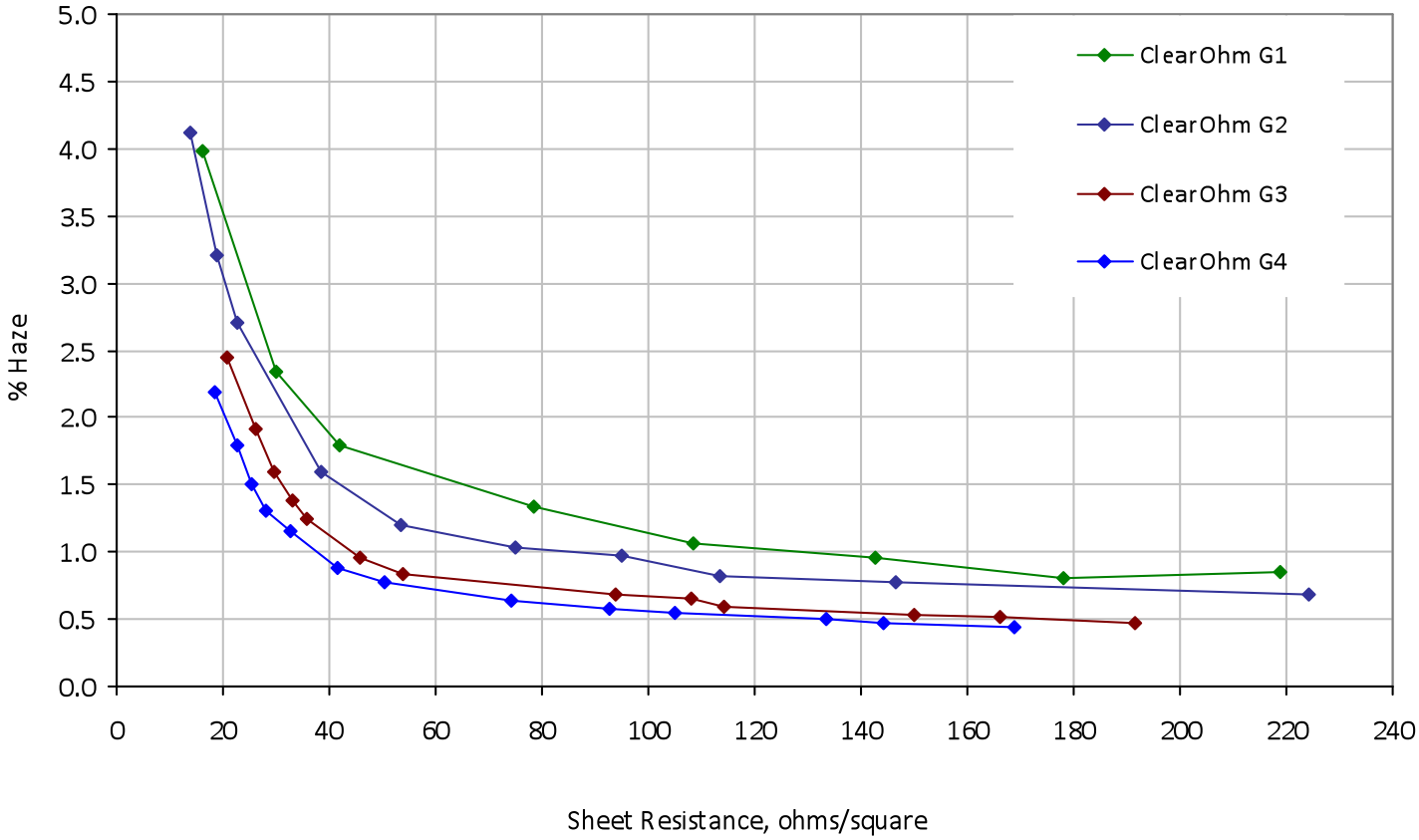


- ClearOhm™ film is created by a roll-to-roll wet coating process
- Process temperatures are < 120C

Optical Performance: Transmission

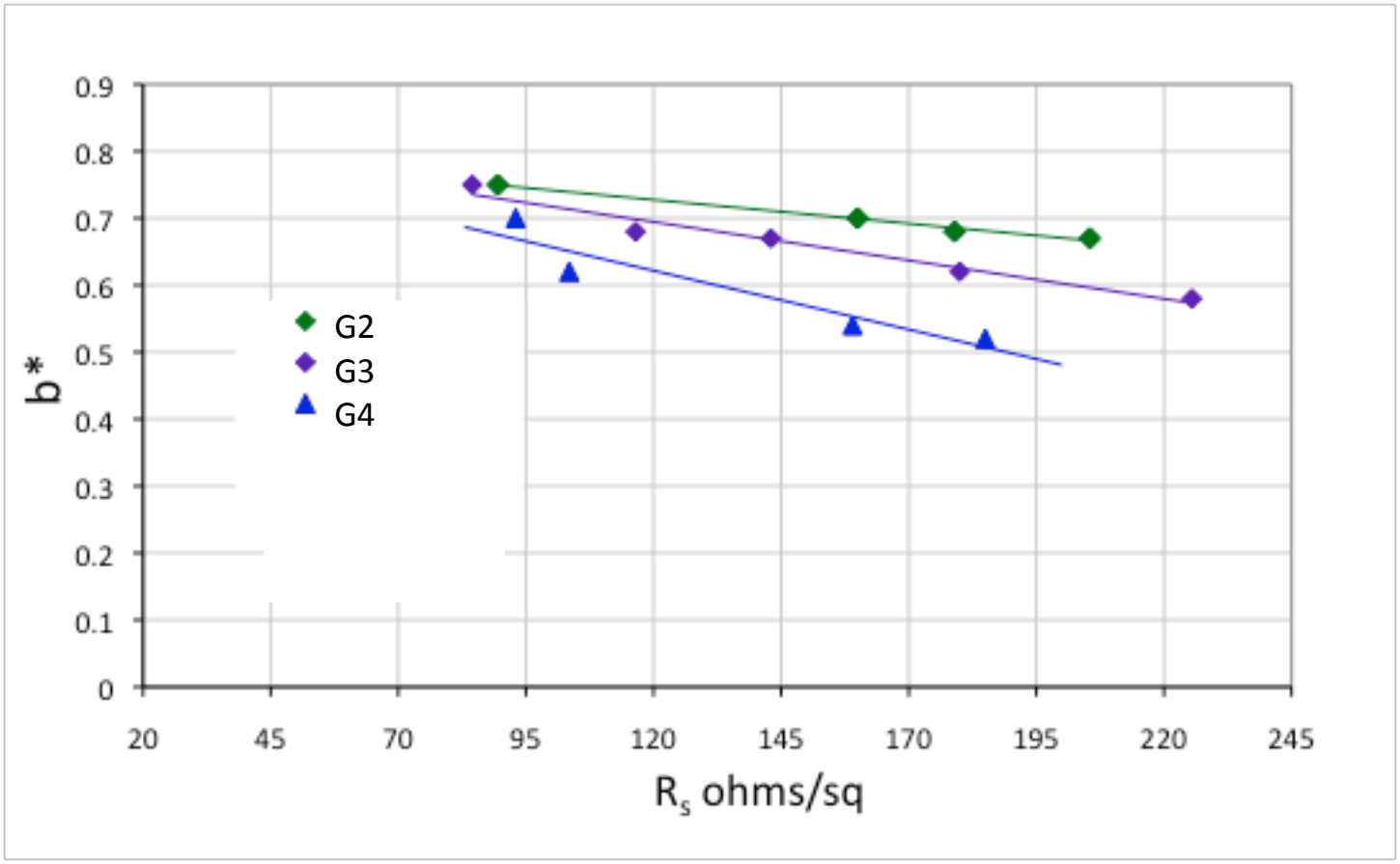


Optical – Electrical Performance: Haze



G4 is Cambrios' most optical clear material

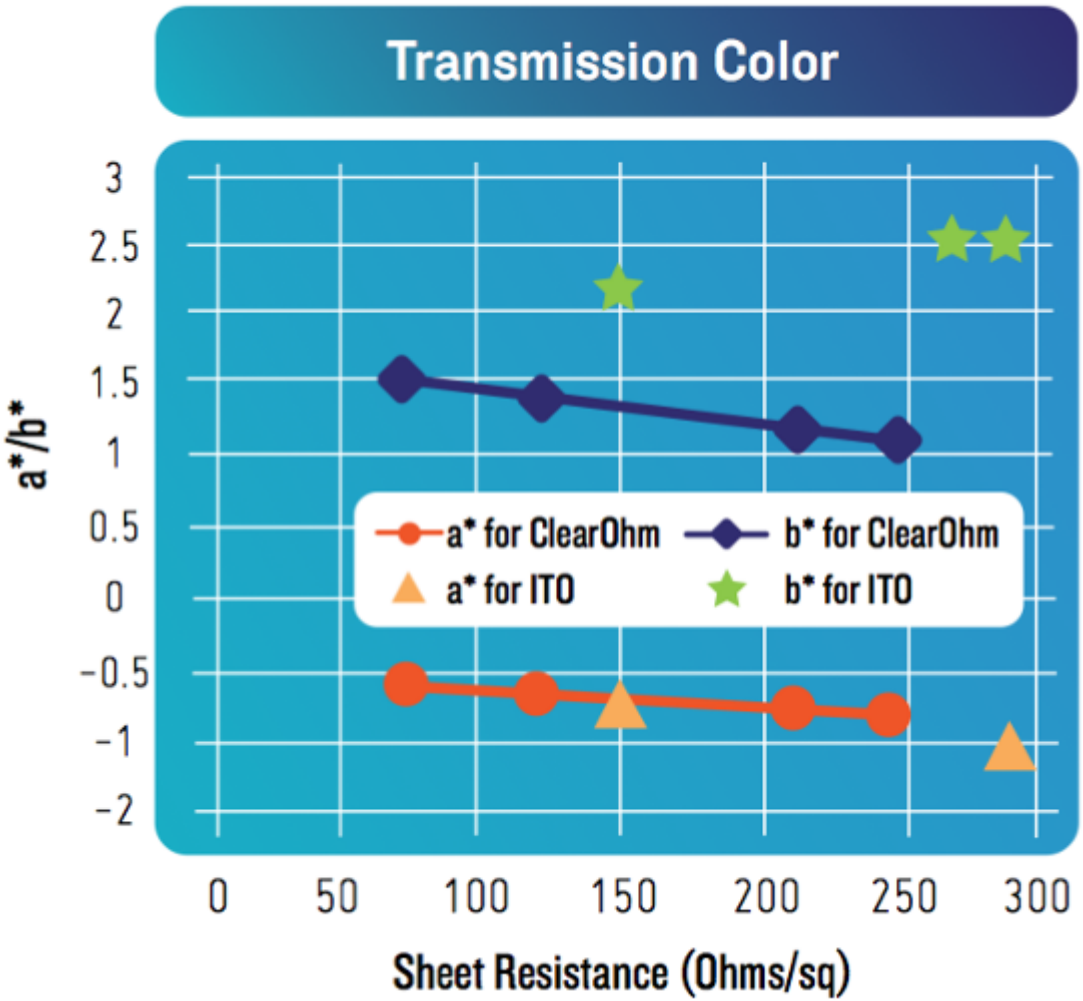
Optical-Electrical Performance: Color



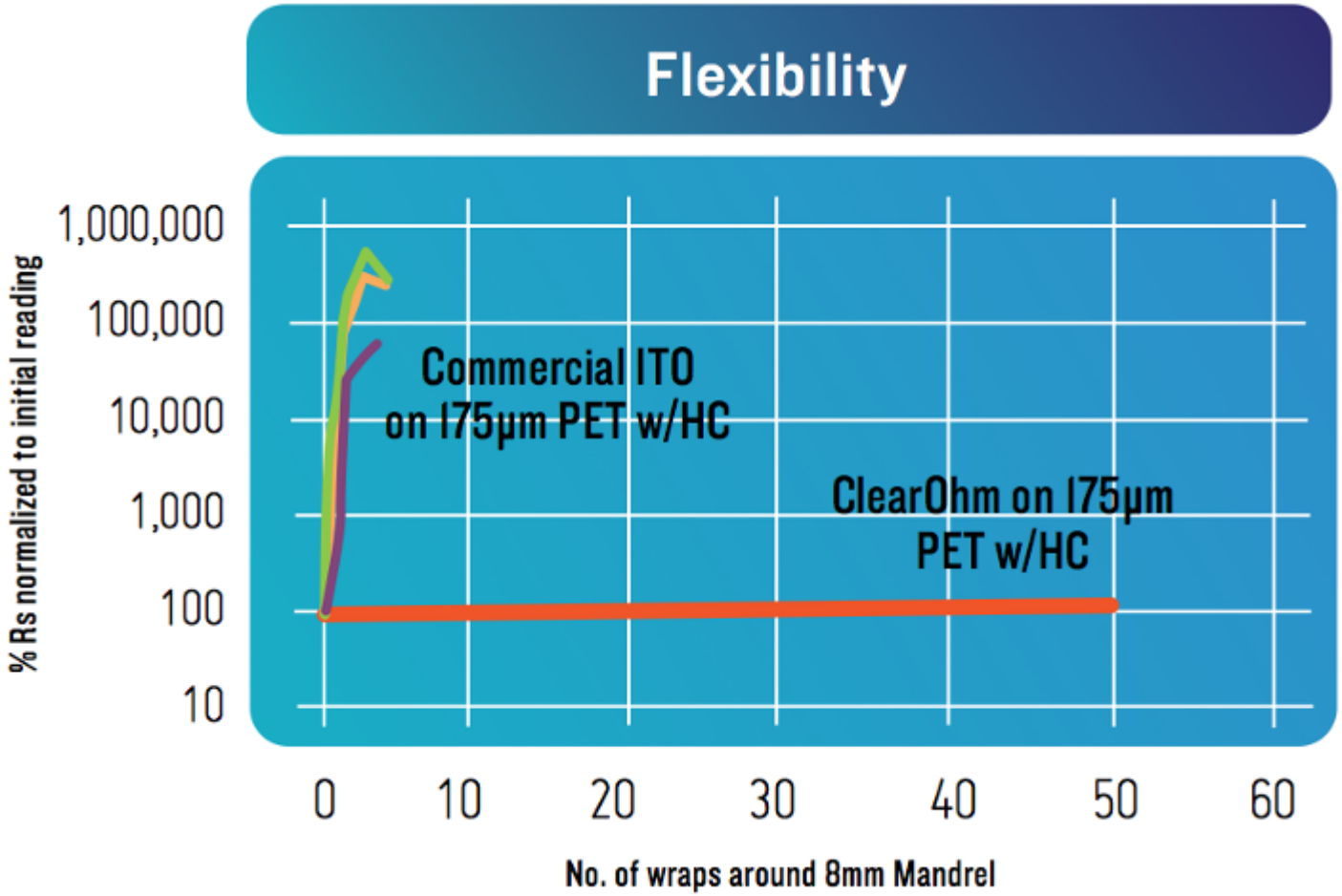
G4 ClearOhm™ Ink has a more neutral color relative to G2 & G3

Results on Eagle 2000 glass, reference b* = 0.34

Optical Properties: Color



ClearOhm™ Film Greatly Reduces Cracking



ClearOhm™ Film Specification vs. ITO

	ClearOhm	ITO	ClearOhm	ITO	ClearOhm	ITO
Resistance (Ω/sq.)	250	270	130	150	80	NA
% Transmission	92.4	90.8	92.3	90.8	92.1	
% Haze	0.6	0.7	0.7	0.7	0.9	
yellowness (b*)	0.9	2.5	1.2	2.2	1.5	
Cracking	Pass	Fail	Pass	Fail	Pass	
Reliability	Pass	Pass	Pass	Pass	Pass	

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Commercial Progress

Smart Phones on the Market with ClearOhm™ Material

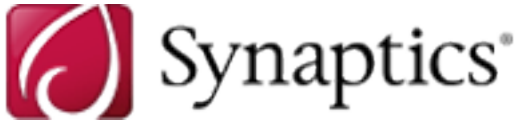
Sensor Makers & Chip/Module Makers: Early Adopters

NISSHA

Nissha Started Mass Production of Touch Sensor Films Using Metal Nanowires

March 30, 2011
Nissha Printing Co., Ltd.

Nissha Printing Co., Ltd. (hereafter "Nissha") has started mass production of the world's first touch sensor films using metal nanowires (ClearOhmTM coating materials and coated films) as a transparent conductive film material. Synaptics, Inc. integrates these sensors into touch sensing systems for major smartphone manufacturers.



Cambrios ClearOhm™ Film Used in Smart Phone

Sunnyvale, CA — April 6, 2011 — Cambrios Technologies Corporation announced today that its ClearOhm™ transparent conductive film has been incorporated into the touch sensor of a leading smart phone. The touch sensor and touch module solution were developed by Nissha Printing Co., Ltd. of Japan and Synaptics Incorporated (NASDAQ: SYNA), respectively, and mark the first commercial implementation of Cambrios ClearOhm in place of indium tin oxide (ITO).

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ClearOhm™ Enabled Functional Films

Hitachi Chemical
Working On Wonders

FOR IMMEDIATE RELEASE

Cambrios and Hitachi Chemical Collaborate on Development and Production of Patternable, Transferable Transparent Conductive Film

Sunnyvale, CA - July 25, 2011 - Cambrios Technologies Corporation announced today that the company's ClearOhm™ silver nanowire coating materials have been combined with Hitachi Chemical¹s photosensitive film technology to develop an innovative, very highly transparent conductive film that can be transferred to various substrates such as glass, polycarbonate and PET film. Hitachi Chemical plans to begin production of the film later this year with the aim of producing significant volumes by mid 2012 to meet the increasing demand for transparent conductive films for touch panels for smart phones and tablet PCs.

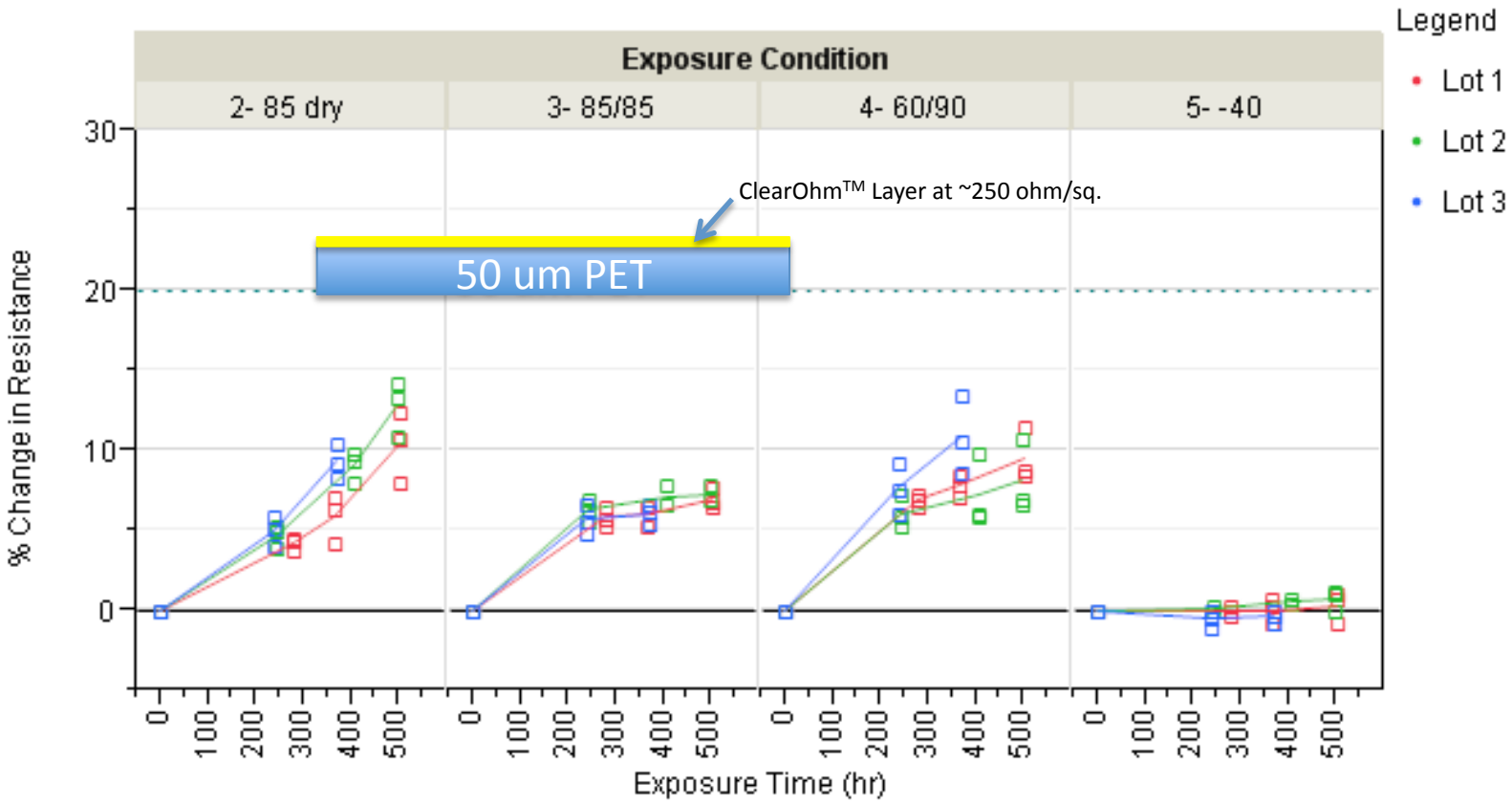
'TORAY'
Innovation by Chemistry

Toray Advanced Film Developed New Transparent Conductive Material Using Silver Nanowire Ink

- Best in the world in transparency and conductivity, superior flexibility, natural color, durability and workability; to be mass-produced for use in touch panels -

ClearOhm™ Film Reliability

Reliability: ClearOhm™ G4 Film



Recent customer film qualification
Bare film results – no encapsulation in the device stack

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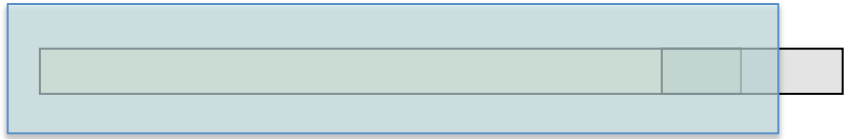
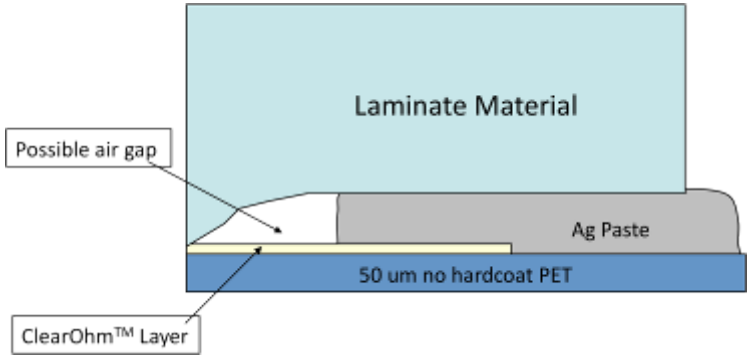
Ag Paste Reliability Simulated Devices

Top View

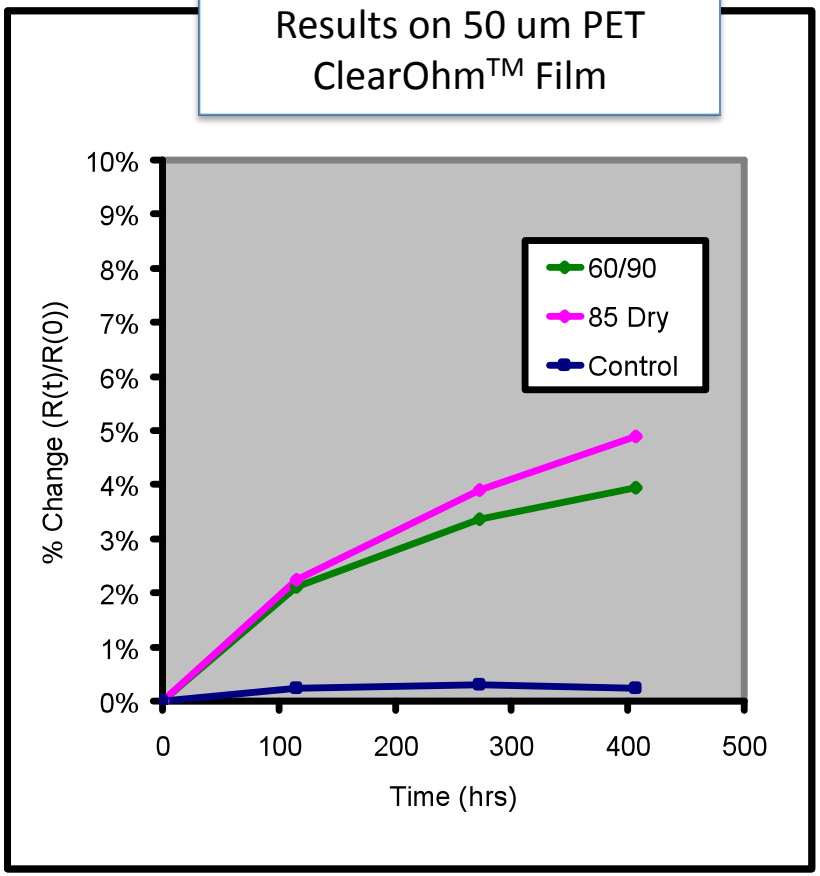


Cross Section



Schematic of the Ag paste contact

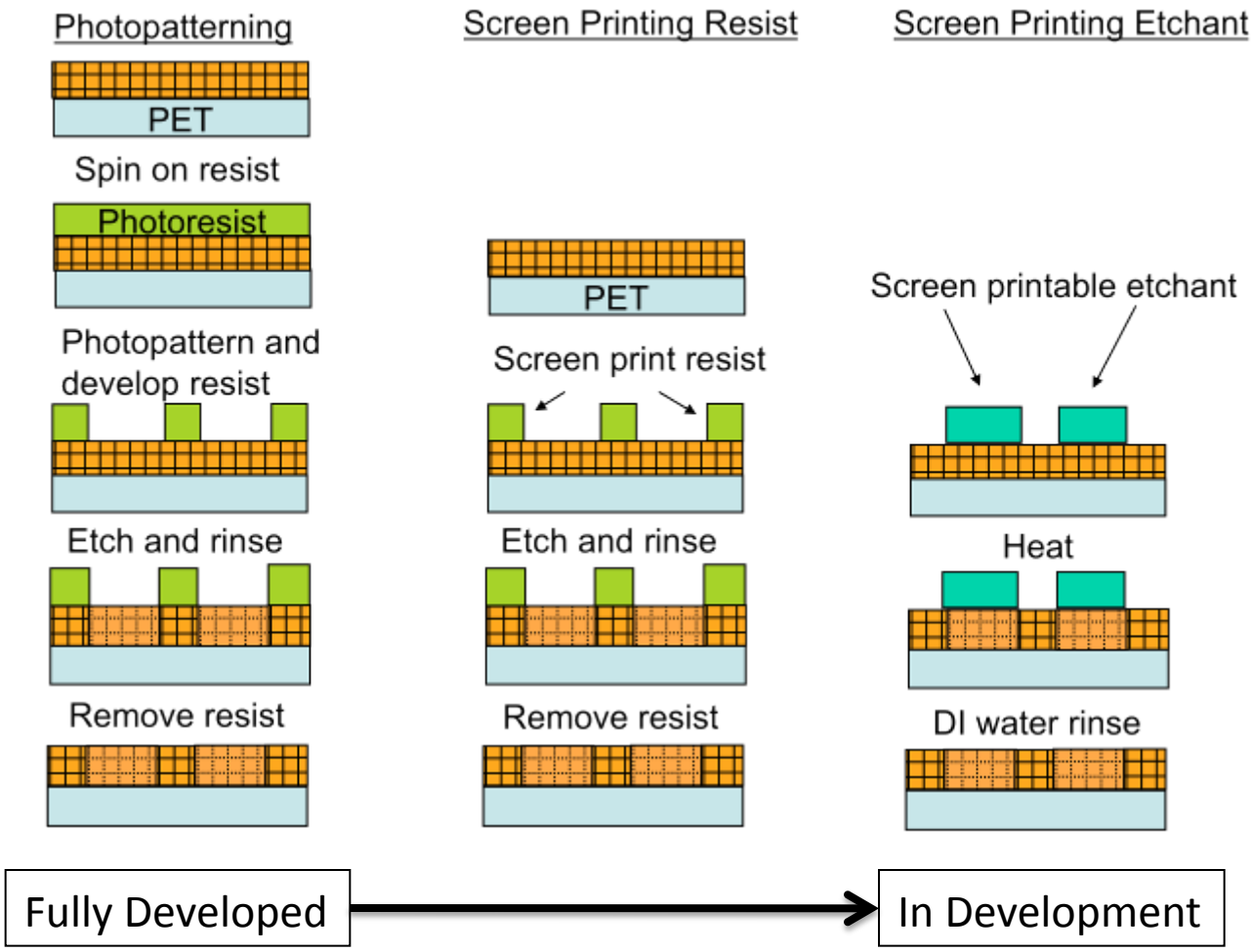
Results on 50 um PET ClearOhm™ Film



Patterned line reliability in the laminate structure is excellent

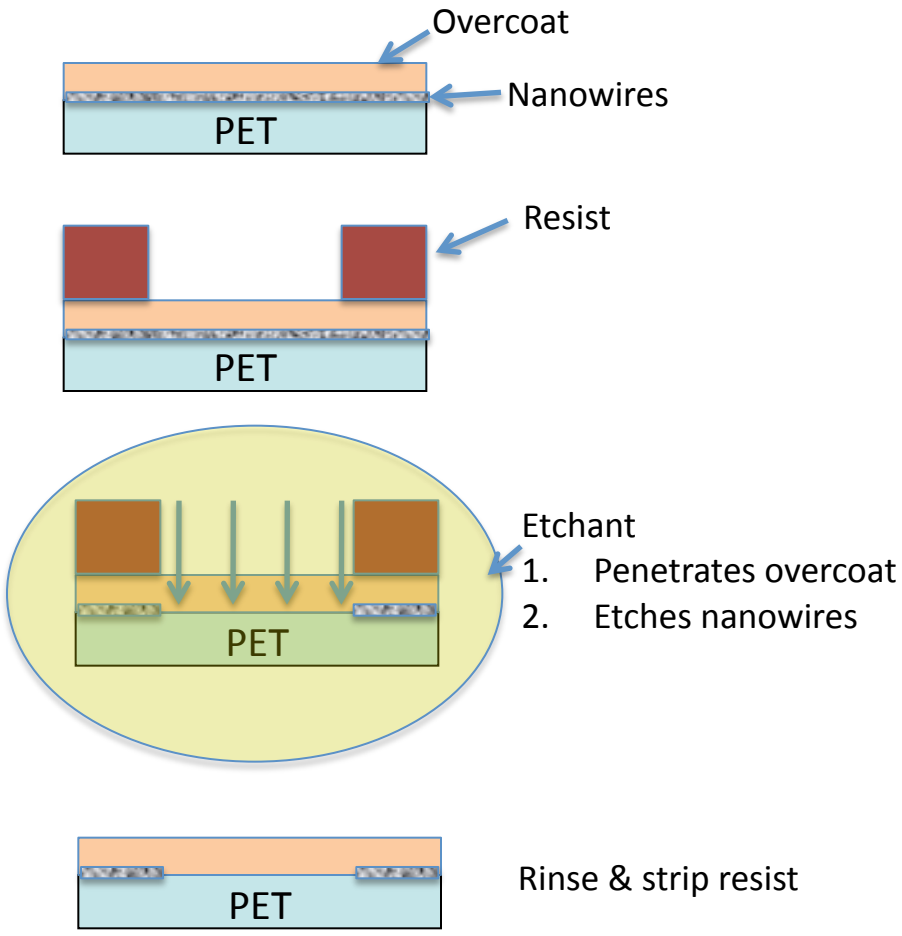
Patterning Methods

Patterning ClearOhm™ Film

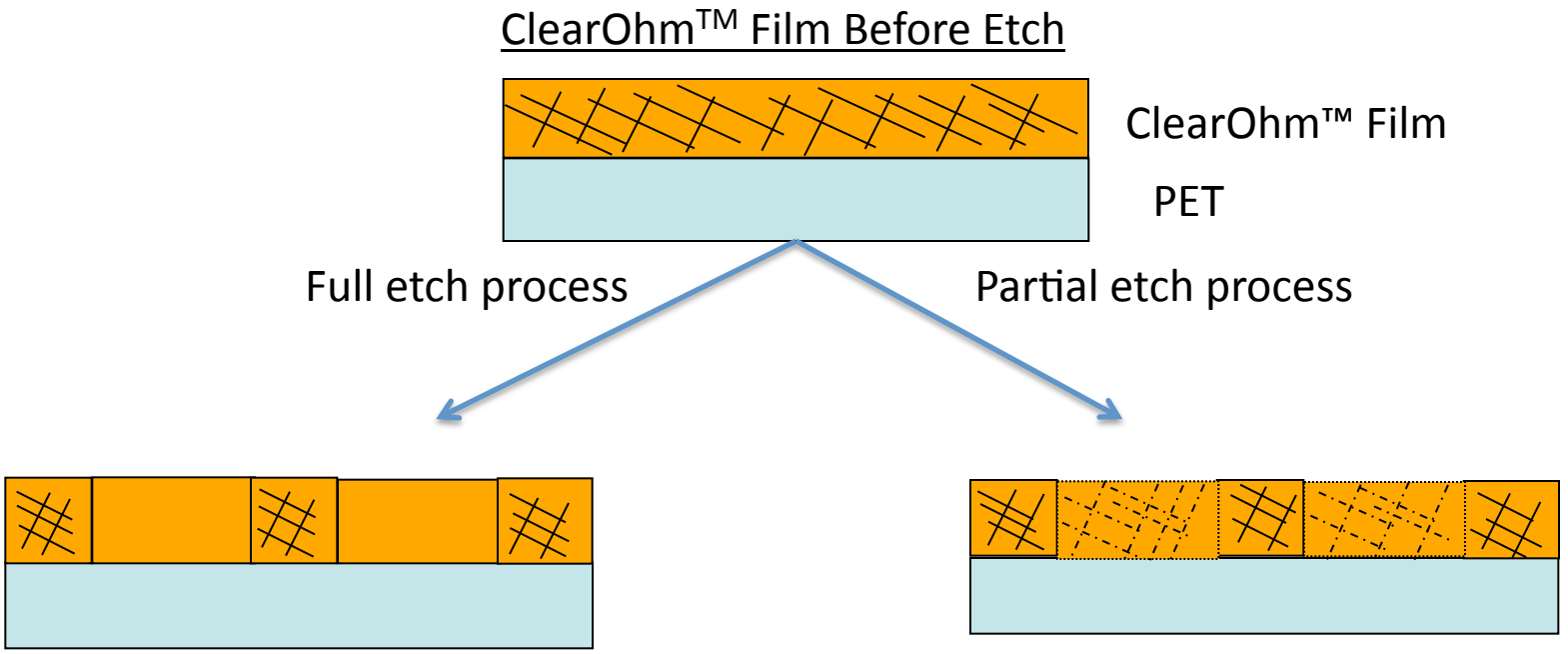


Wet Etching ClearOhm™ Film

- Photoresist or screen printable resist is applied to the ClearOhm™ film to protect the conductive regions
- The etching solution penetrates the overcoat layer and etches the nanowires
  - The etch rate is typically very slow at room temperature
  - Faster etch rates are achieved at higher temperature
- The etchant is removed from the overcoat after rinsing with DI water
- The reliability of the etched pattern after this process is excellent



Wet Etching:
Full Etch and "Partial Etch"



With full etch, nanowires are completely removed.

With partial etch, cuts made in nanowires. Wires stay, but the material is non-conductive.

Low Visibility Pattern: Partial Etch Process

- For projective capacitive touch panel applications, low visibility transparent conductive patterns are essential
- In the non-conductive region, the nanowires are cut into smaller segments
- Compatible with coarse patterning methods, e.g. screen printing

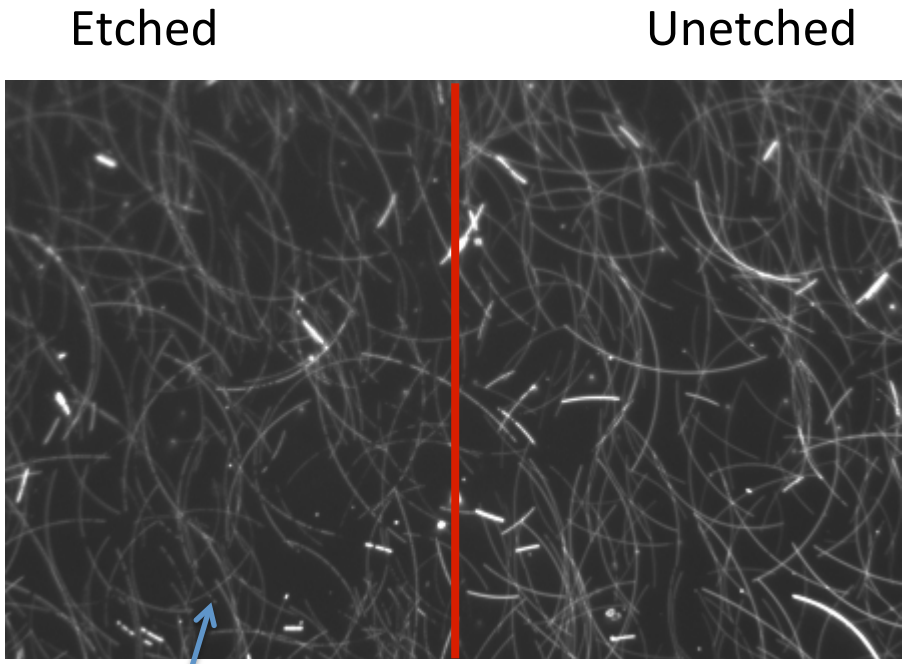


Photo-patterning on Glass Substrates

Coat Metallic Nanostructures

↓

Soft Bake

↓

Standard Photopatterning Process

↓

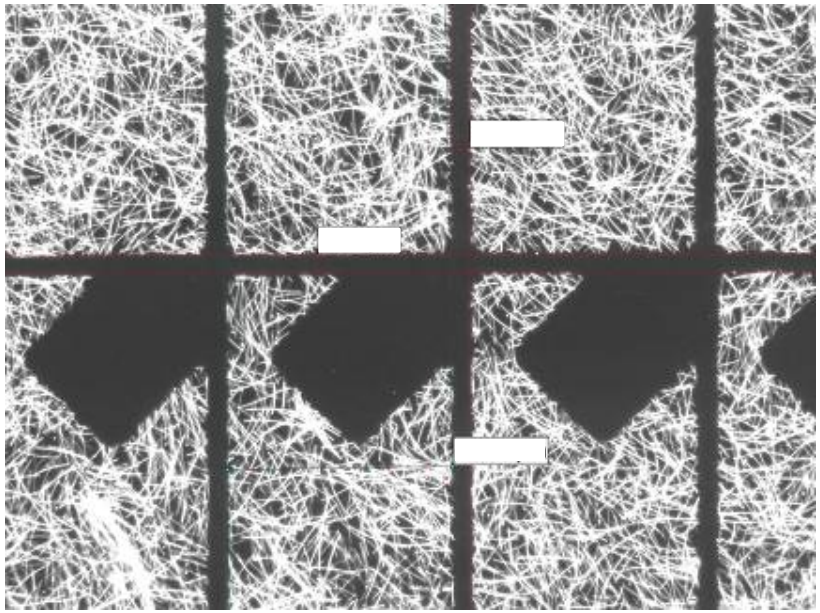
DI Rinse / Dry

↓

Overcoat

↓

Hard Bake



Standard Photolithography Process
5 micron resolution demonstrated
Gen II glass (37 x 47 cm)

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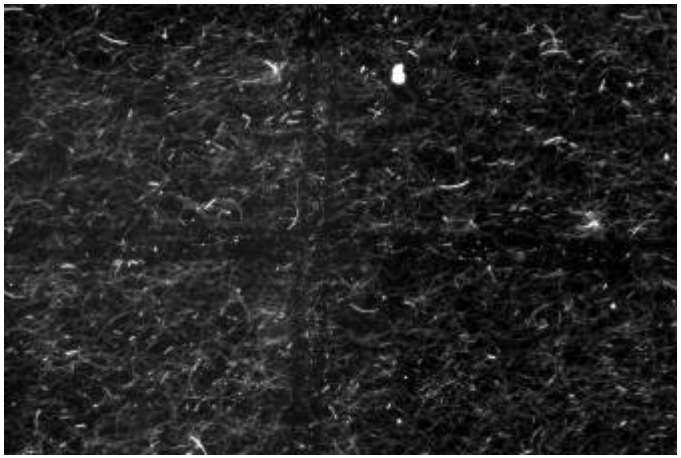
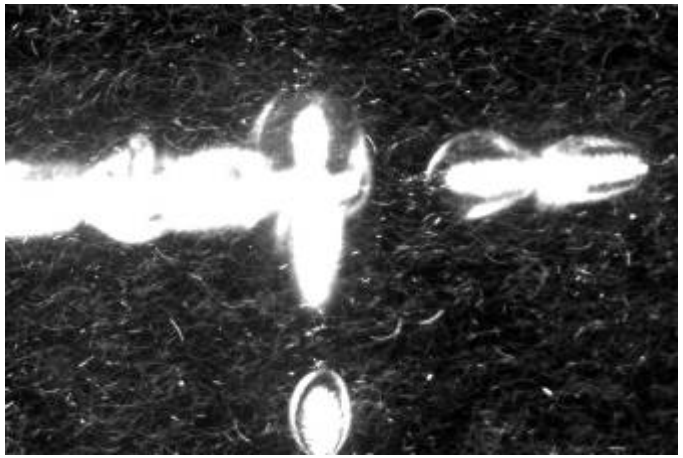
Laser Patterning ClearOhm™ Film



- Optimum power
  - Invisible Pattern
    - No damage to PET
  - Complete electrical isolation



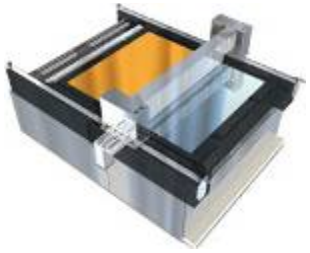
- High Power
  - Visible Pattern
    - Damage to PET
  - Complete electrical isolation

ClearOhm™ Material TFT-LCD Displays (Under Development)

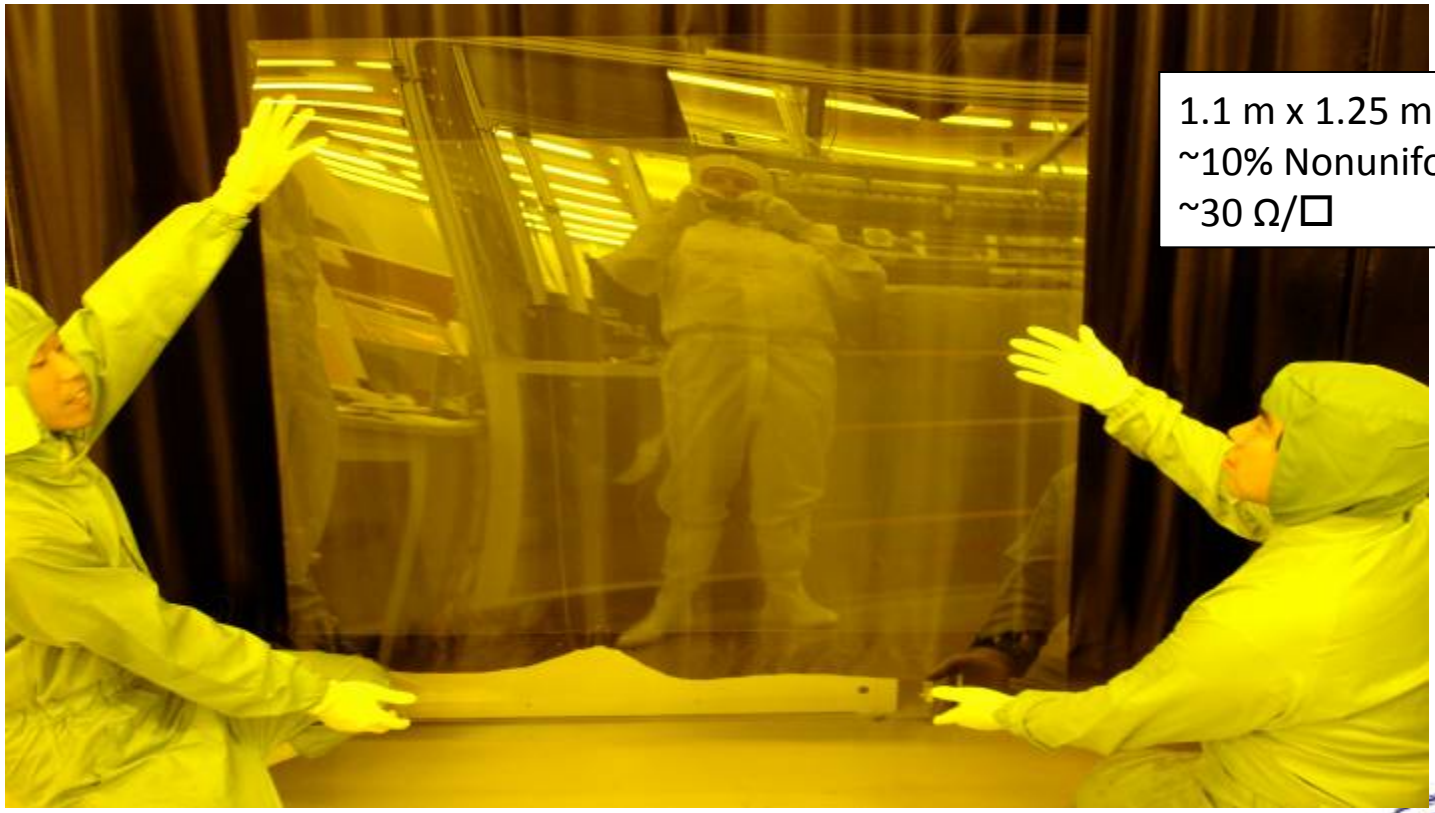
SCREEN

DNS Gen 5 Coating Trials

SK Series
Capable of processing 4th- to 8th-generation substrates



Linearcoater®



1.1 m x 1.25 m x 0.7 mm
~10% Nonuniformity
~30 Ω/☐

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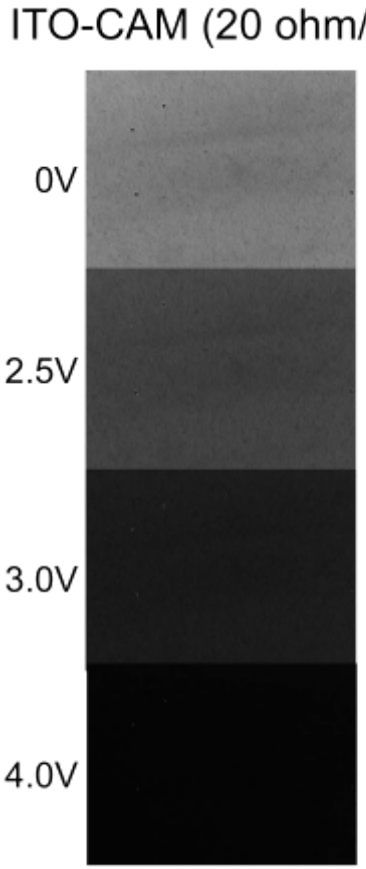
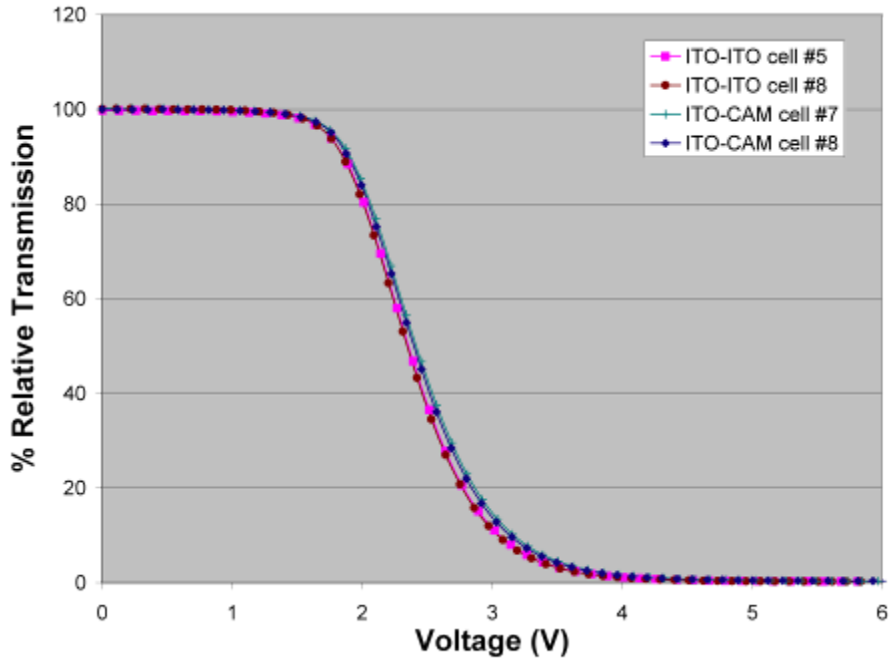
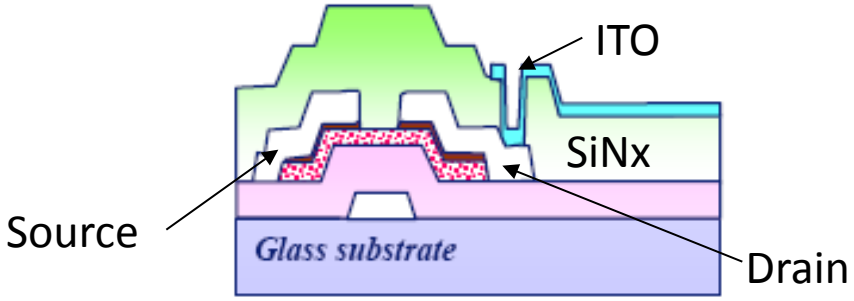
Voltage-Transmission Curves
TN Type LCD Cells



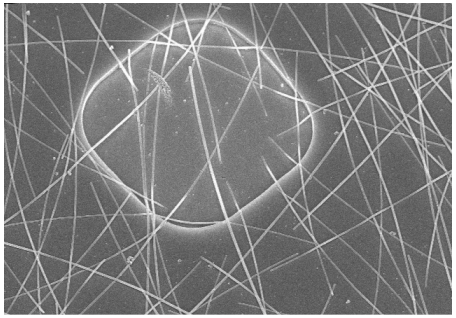
200X Microscope Image

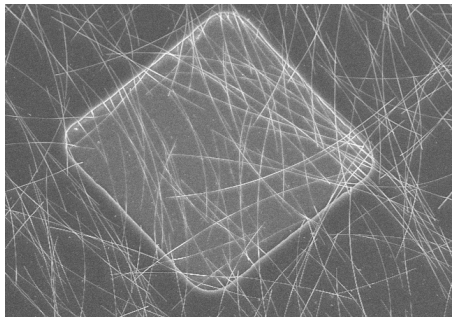


Conformal Via Contact



TFT (bottom gate, back channel etched)





TFT-LCD Display Demonstration*

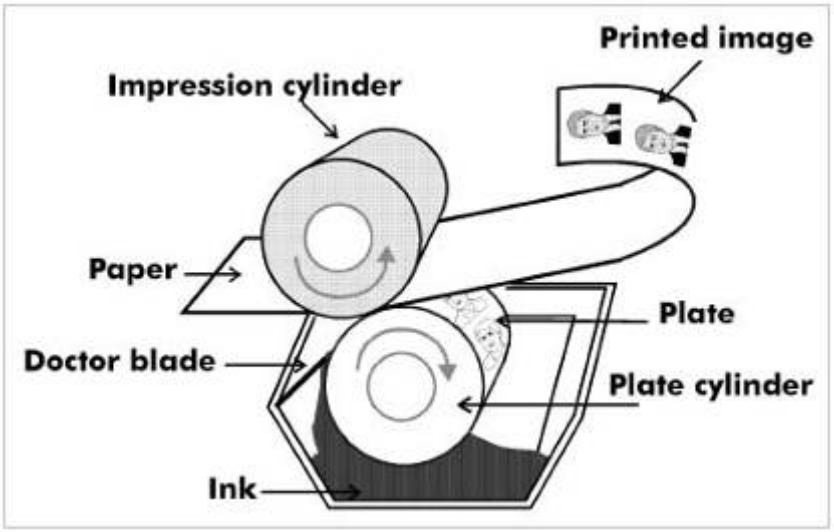
4.1” QVGA TFT-LCD Display with ClearOhm™ Pixel Electrode

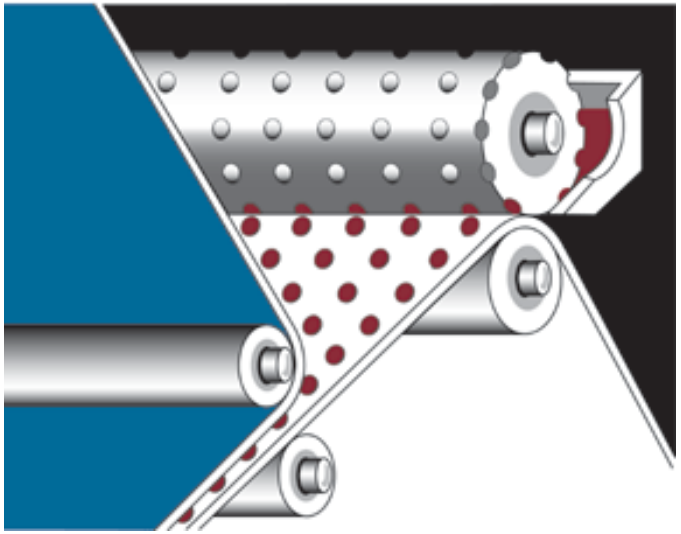
*Fabricated by TTLA, Hsinchu, Taiwan

OLED Lighting

Gravure-Printed Anode for OLED

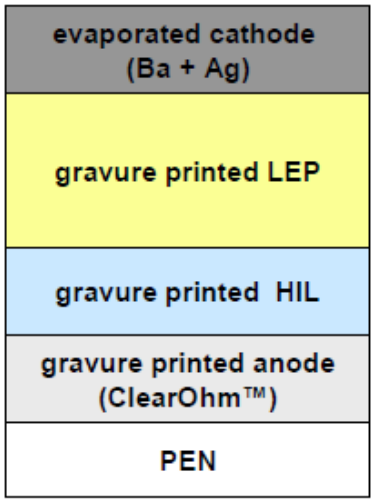
Printing and device manufacture performed at
VTT Technical Research Center of Finland (Dr. Riikka Suhonen)

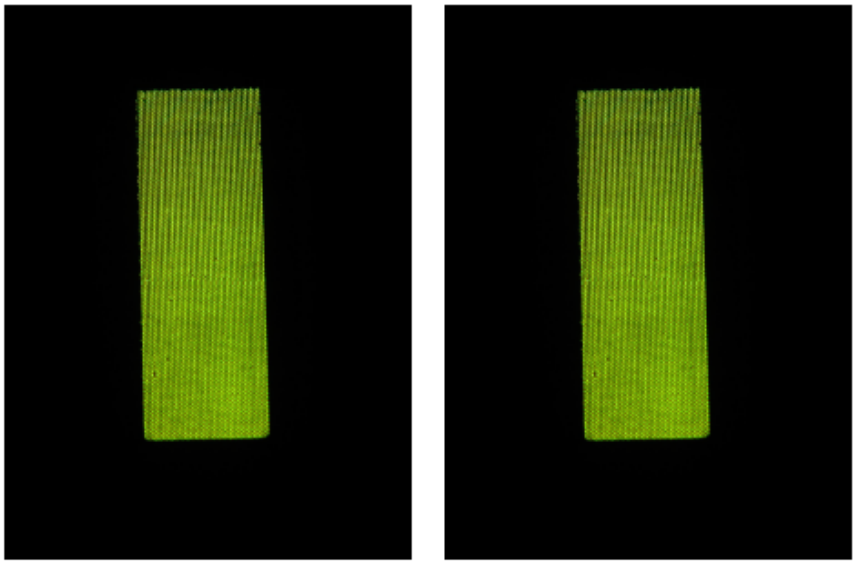




Printed OLEDs with ClearOhm™ anode

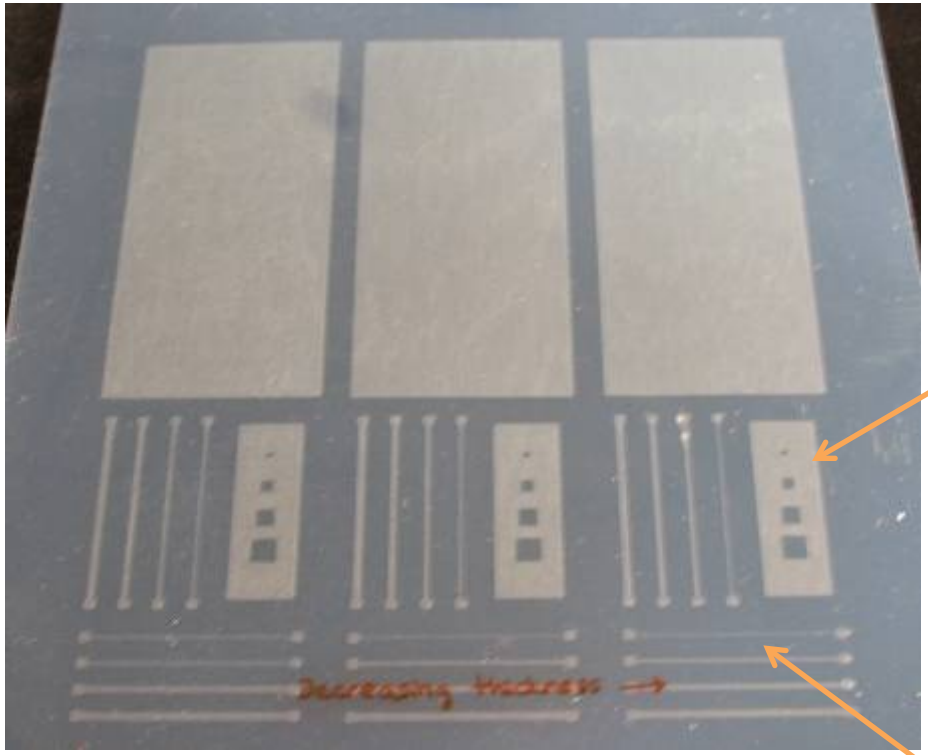
- OLEDs with 3 gravure printed layers processed at VTT
- Both ClearOhm™ and LEP printing patterns slightly visible in EL





ClearOhm™ printing direction →
HIL, LEP printing direction ↑

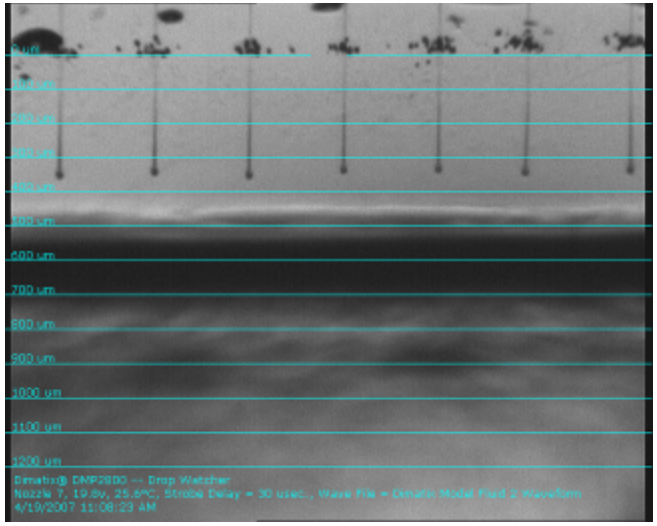
Optical Characterization

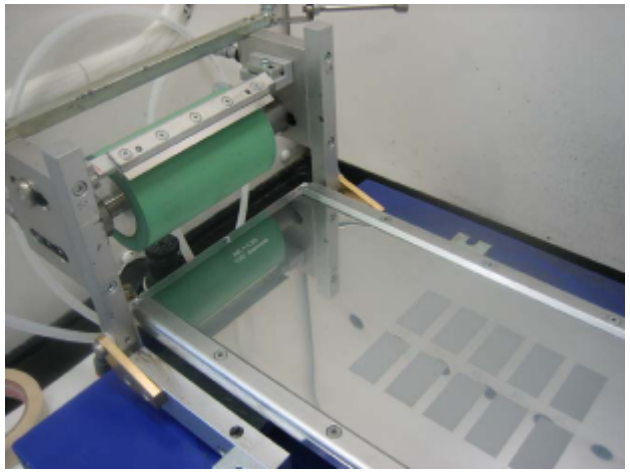


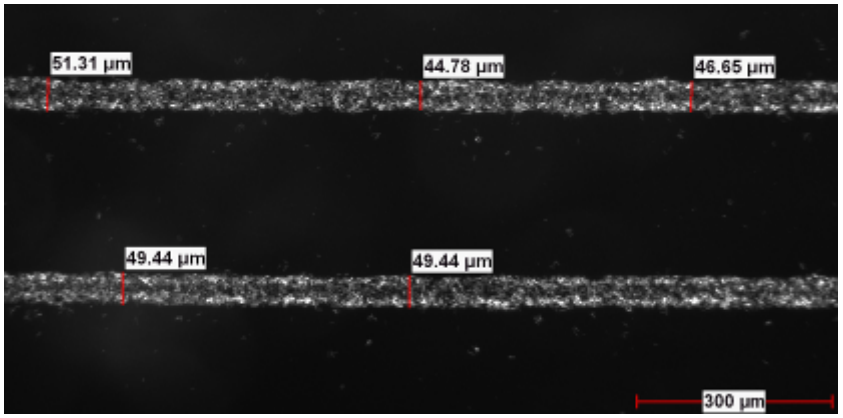
Printable Demonstrations

Printable ClearOhm™ Ink: Feasibility Established

- Ink-jet
- Screen Printing
- Gravure Printing
- Reverse Offset Printing







Summary: Cambrios 2011

- **Commercial liftoff**: products for multitouch
  - First consumer electronic product launch in 1Q2011
- Visibility on growth in **other applications**
  - LCD, OLED, PV
- **New standard** in transparent electrodes
  - Large existing market with needs for a better solution
  - Rapidly emerging, huge new market categories