

UV BASED CONDUCTIVE INKS FOR FLEXIBLE PRINTED ELECTRONICS

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UniPixel Inc

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Who We Are

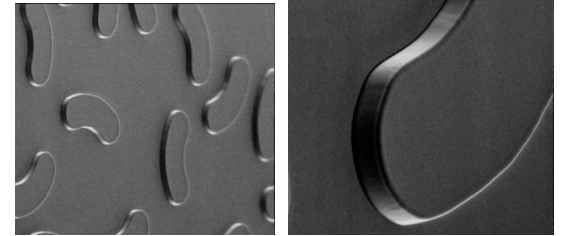


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- **UniPixel is innovative in design and manufacture of *Performance Engineered Films™ (PEF)***
 - **Design, Mastering, R2R Manufacture:**
 - We modify industrial base films at the micro/nano level to effect the surface geometry, chemistry, optical and/or electrical properties
 - Custom formulation of inks and coating materials
 - **UniBoss™ Printed Conductor Technology:**
 - Involves embossed, patterned or planar films
 - Conductive lines <math>< 10\mu\text{m}</math> wide, on one side & both sides of R2R films
 - Initial focus on Flexible Printed Electronic Products :
 - Multi-touch sensors for electronic displays & Touch sensors for other applications
 - Antennas - RFID, etc, Precision flex cables with reduced lead time
 - Available with a variety of coatings
 - **Protective Cover Films:**
 - Diamond Guard™ - Clear Hard Coat, Anti-scratch, Flexible - as a cover glass replacement
 - Finger Print Resistant Film, Anti-Glare Film, Fashion Films
- Major share of UniPixel Performance Engineered Films is made with UV Cure materials

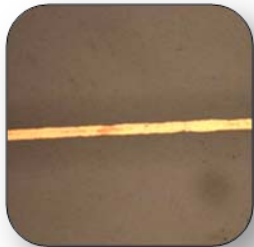
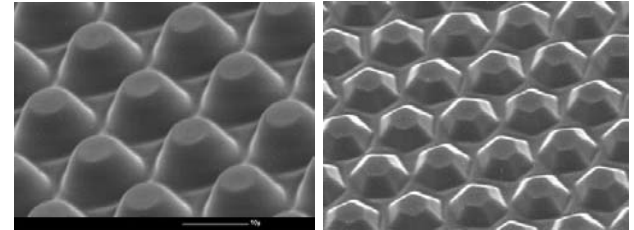
Possible Solutions are Limitless...



Raised surfaces wick away fingerprints to ensure clean displays even with heavy use.

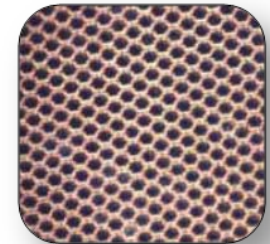


Optical microstructures increase display and lighting efficiency and improve uniformity.



Narrow Width Copper lines allow thin touch sensors to be printed at much lower cost.

Advanced MEMS display film: A 4 μ m conductive mesh surrounding micro-optical structures on ultra-thin film.



METHODS FOR PRINTING CONDUCTORS

- PHOTOLITHOGRAPHY / ETCH
- INK JET
- SCREEN
- GRAVURE
- FLEXOGRAPHY
- MICRO-CONTACT
- LASER PROCESSING

INKS FOR PRINTING CONDUCTORS

Water Based, Solvent Based, Radiation Cured

- **METAL NANO PARTICLES: Ag, Cu, Au**
- **CARBON NANOTUBES**
- **GRAPHENE**
- **CONDUCTIVE POLYMERS**

UniPixel Approach -

Custom formulation of UV cure inks

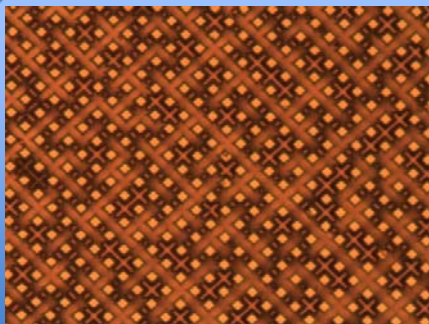
Process Parameters

- Viscosity, Surface Tension and drying characteristics of the Ink
- Print gap, drop volume, print speed
- Film surface energy compatibility with the surface tension of the ink, the pattern to be printed - for selective wetting

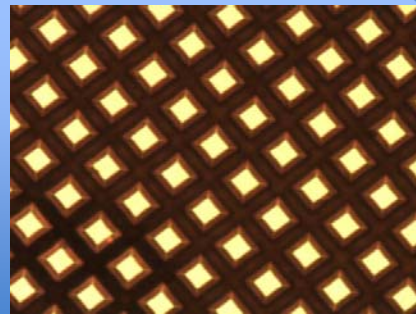
SURFACE ENERGY EFFECTS

Embossed microstructures on PET films – Ink Jet Printed with Metal-Organic Ink

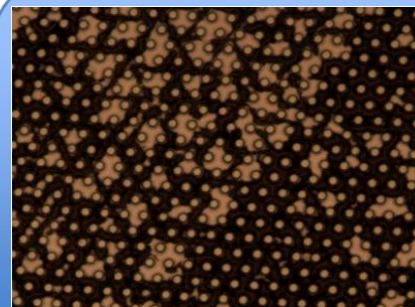
Surface Energy / Surface Tension Compatibility for Wetting characteristics



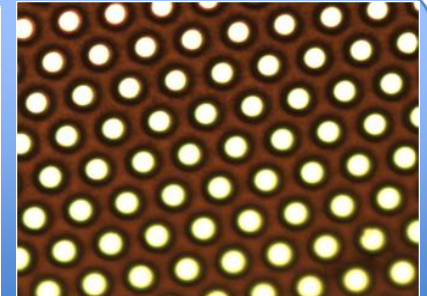
Mismatch



Matched

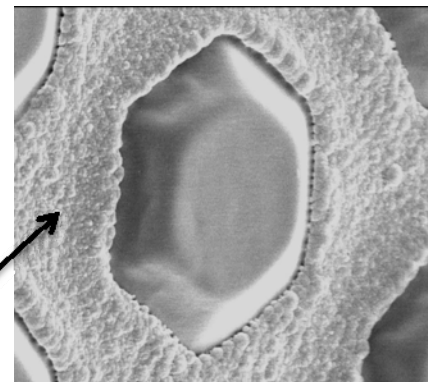
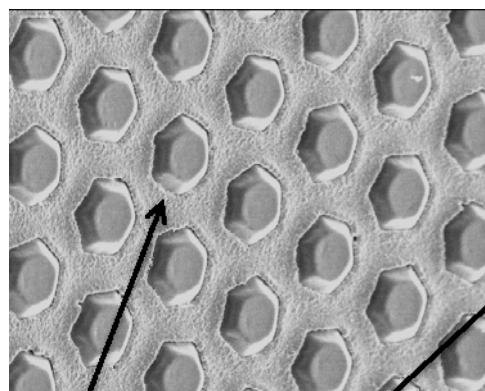
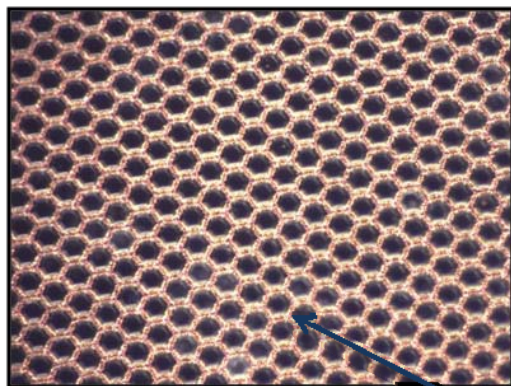


Mismatch



Matched

Ink Jet Printed Conductor - Selective Patterning by Surface Energy Modification

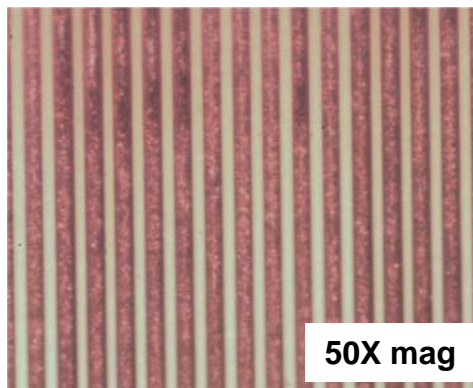
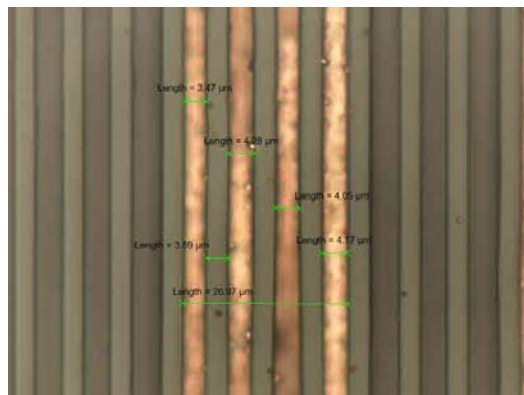


Plated Cu between
lenslets- Clear lens tips

TYPICAL DIMENSIONS
Height = 4 μ m, Tip Diameter = 6 μ m

Cu on embossed lines of UV acrylate film on 125 μ m PET Film

Design: 4 μ m gap between 4 μ m tall, 4 μ m wide. Cu Line Width (μ m): 3.47, 4.28, 4.05, 4.17

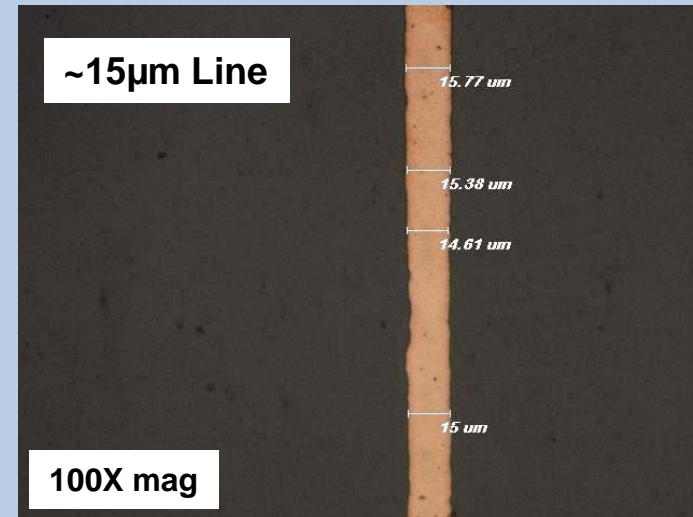
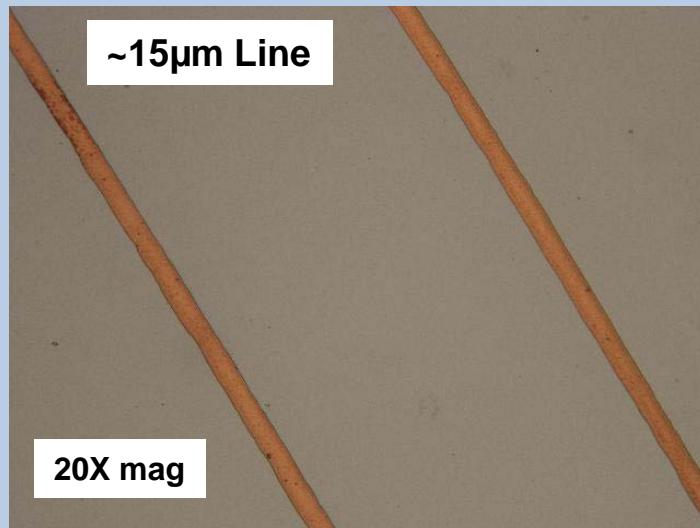
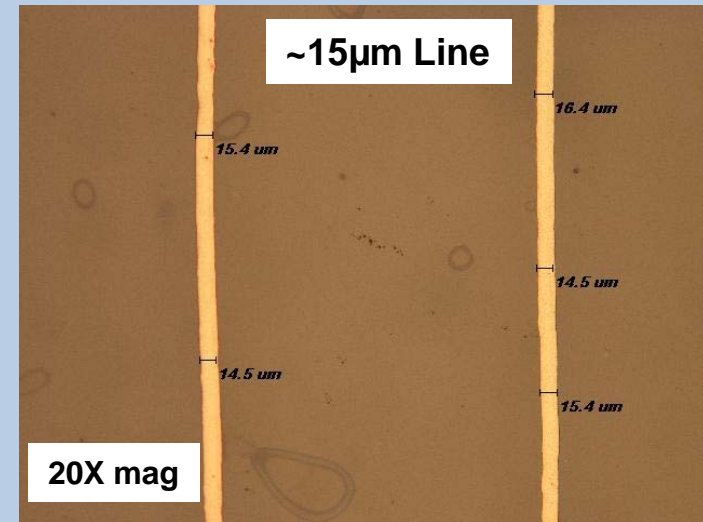
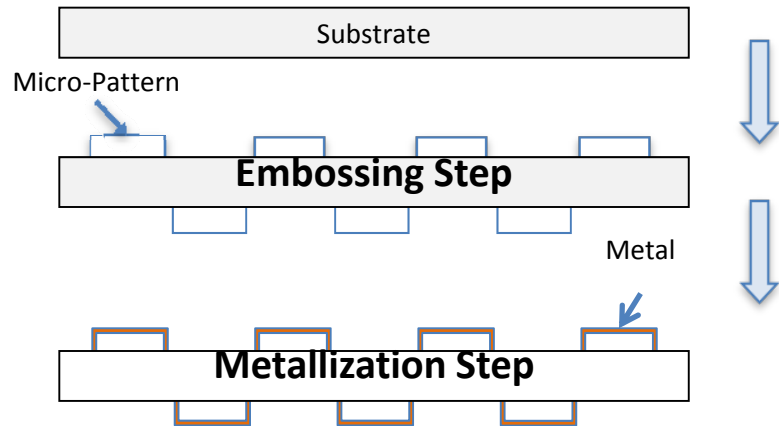


50X mag

- UniBoss™ is:
 - **Proprietary Embossing / Micro-contact Printed Metal Conductors**
 - Custom Ink Formulation
 - Minimum trace/space width: ~10µm / 20µm
 - Roll to Roll (2 mil – 10 mil PET)
 - Multiple substrates
 - Multiple metals
 - Low resistivity
 - Flexibility
 - High throughput

UniBoss™ Production Process for Ultra Fine Line Metal Patterns

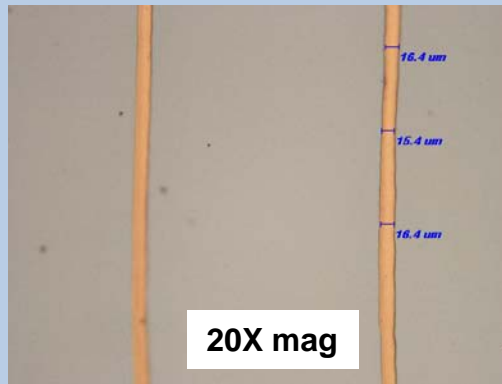
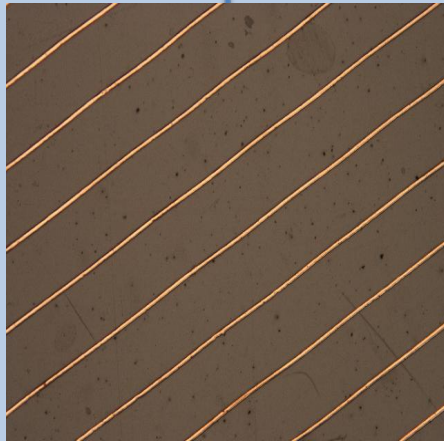
Proprietary UniBoss™ Fabrication Process



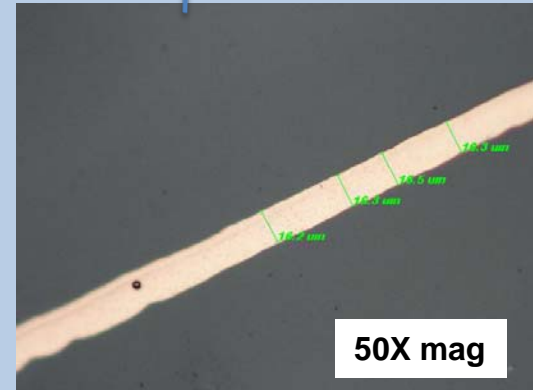
R2R UniBoss™ - Ultra Fine Line Metal Patterns



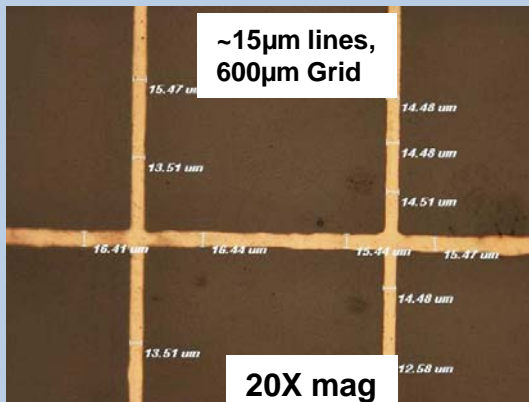
~16 μ m lines



20X mag

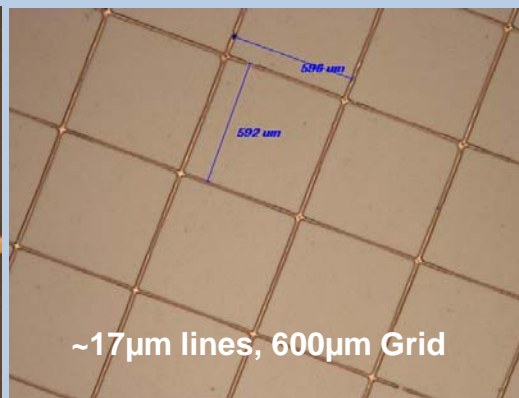


50X mag

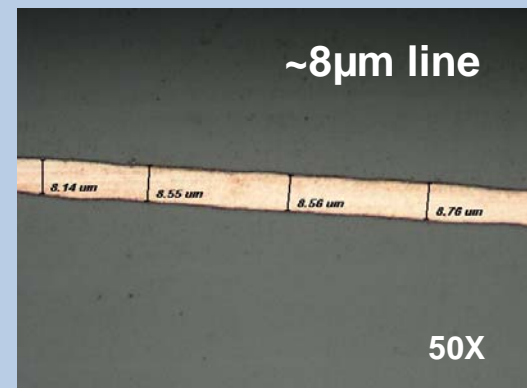


~15 μ m lines,
600 μ m Grid

20X mag



~17 μ m lines, 600 μ m Grid



~8 μ m line

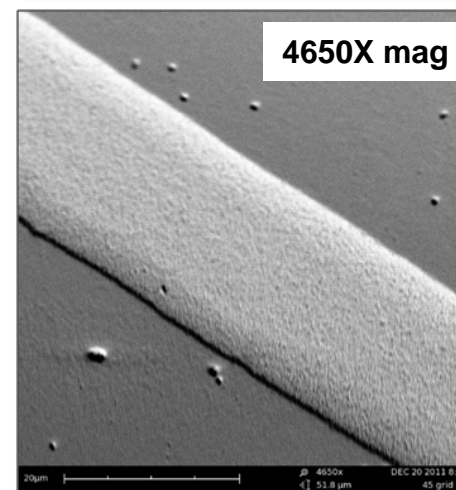
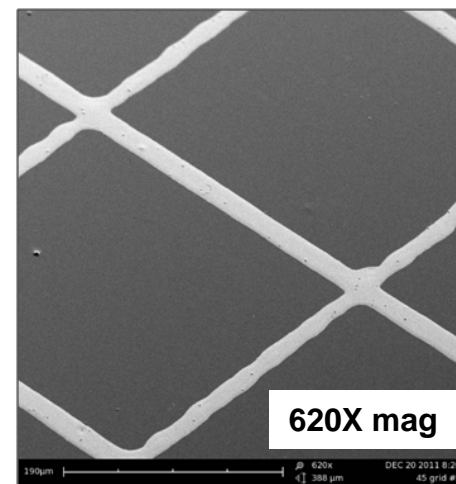
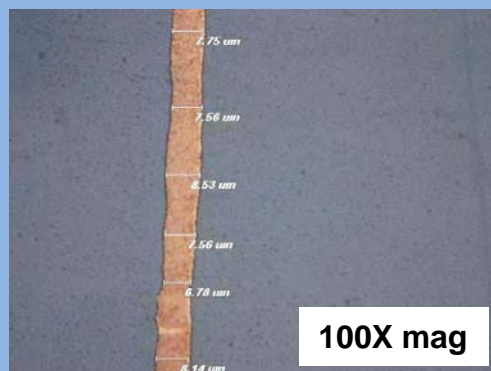
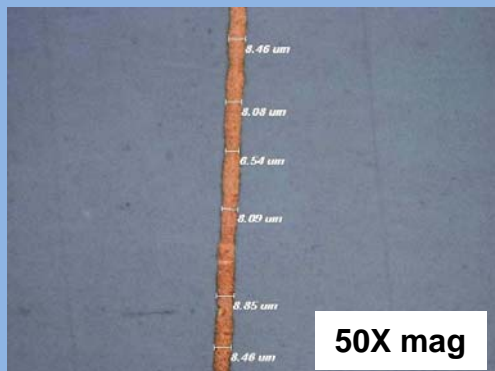
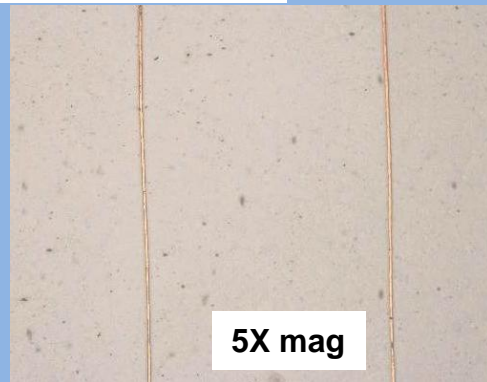
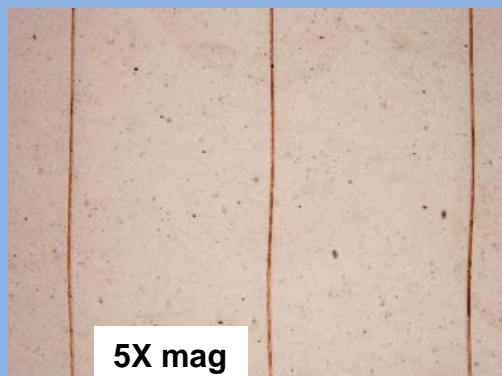
50X

R2R UniBoss™ - Ultra Fine Line Metal Patterns: <math><10\mu\text{m}</math> Copper Lines



SEM Images

~8 μm Conductor Lines



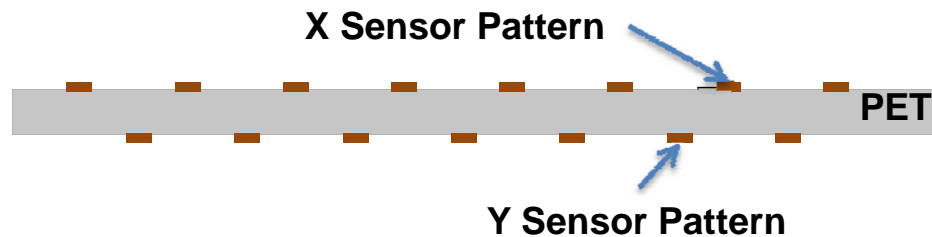
UniBoss™ Technical Specifications



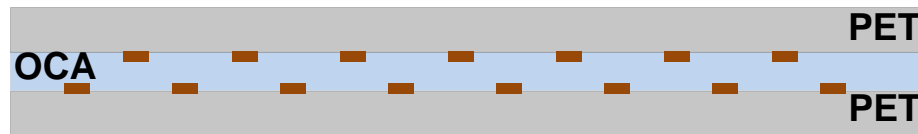
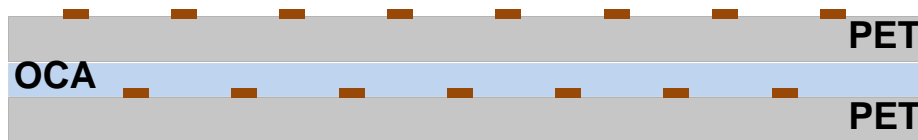
Specification	Value
Trace Thickness	~1µm thick
Trace Width (Minimum)	10µm
Space (Minimum)	20µm
Pattern Area	400mm x 600mm <i>(Process scalable to larger size patterns)</i>
Conductive Layers	Single or Double sided patterned conductors
Base Substrate Film	0.075mm (0.003in) up to 0.250mm (0.01in) <i>(Other thicknesses and film material available as custom order)</i>
Hard Coat	>= 6H available as laminated cover film
Adhesive Layer	Available
Release Liner	Available
Transmittance	up to 90+% <i>(Varies with substrate and pattern density)</i>
Adhesion	Passes Scotch tape test
Operating Temperature	-20°C to +65°C
Trace Conductivity	~0.050 Ohms/sq <i>(for 1µm thick Cu, tunable for different applications)</i>
Example Sheet Resistance	~6 Ohms/sq <i>(15µm line width, 1µm line thickness, 600µm grid spacing)</i>
Base Substrate Films	PET*, PEN, PC*, Cellulosics*, Polyimides, Acrylics, Flexible Glass
Metals	Cu, Ni, Sn, Ag, Au

Touch Sensor

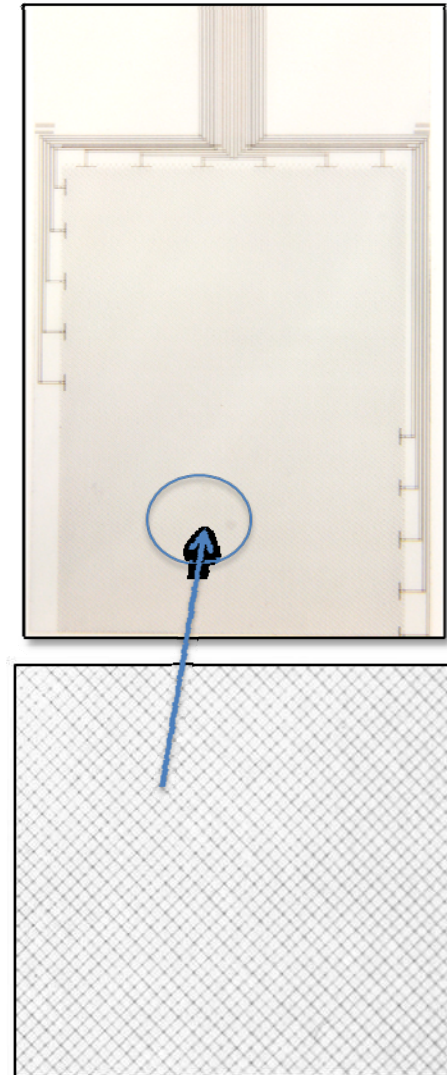
Standard Configuration:



Optional Configurations:



PET = 100μm thick, OCA = 25μm thick



Touch Sensor Technology Comparison



	UniBoss	ITO on Film	ITO on Glass	Conductive Polymer (PEDOT)	Carbon Nanotube	Ag Nanowire	Metal Nanoparticles	Thin Wire	Carbon Ink
	PET	PET	Glass	PET	PET	PET	PET	PET	PET
Offerings	Patterned Film	Coated Film	Coated Glass	Coatings Film Ink	Mesh Grids Aligned Arrays	Nanowire Coated Films	Nanoparticle Coated Films (mostly Ag)	Thin Wire embedded in Substrate	Patterned Film
Patterning Process*	Printing	Photolithography	Photolithography	Photolithography InkJet Screen	Photolithography Laser Ablation	Photolithography Laser Ablation	Photolithography Laser Ablation	Weaving	Printing
Transmissivity**	80% - 92% (Depending on aperture)	81%	88% to 90%	81%	81%	90% - 91%	84%	84%	~75% est.
Haze	<0.6%	1.7% to 3%	0.1 - 0.3%	1.5%	1.5%	0.9% - 1.3%	0.9% - 1.3%	0.9% - 1.3%	0.9% - 1.3%
Color	Black	Yellow	Greyish	Blue	Black	Greenish	Silver	Copper	Black
Transparent Material	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No
Resistance	<0.05 Ohms/sq	200 to 600 Ohms/sq	50 to 500 Ohms/sq	200 to 800 Ohms/sq	400 Ohms/sq	150 to 270 Ohms/sq	1 to 150 Ohms/sq	< 0.4 Ohms/sq	0.4 to 1.0 Ohms/sq
Flexibility	High	Semi-Rigid	Rigid	Flexible	Flexible	Flexible	Flexible	Rigid Frame	High
Feature Size	10µm	1mm	1 mm	80µm to 100µm	1mm	30µm	20µm	10µm wire	15µm
Health & Safety Concerns	No	Yes (Indium compounds)	Yes (Indium compounds)	No	Yes (Lung damage by	Yes (Ag absorption by	Yes (Lung damage by	No	No
Scalability	50" +	23"	23"	7"	?	?	?	105"	?
Issues	• Less costly to integrate in	• Brittle • Requires toxic	• Brittle • Requires toxic	• Requires encapsulation	• Resistance spikes at	• Flexing effects • Plasmon effects	• High heat for sintering	• Difficult to manufacture	• Opaque • High resistance

* All technologies require contrast management to achieve pattern invisibility

** Assumes single PET or glass substrate configuration

All data based on publically available information

UniBoss Value Proposition



UniBoss™ Copper compared with ITO based touch panel

Performance Advantages		ITO	UniBoss™ Copper
Lower power			Much lower power ($P = CV^2f$) (up to 1/10,000 the capacitance)
Higher scan speed	~60 – 300Hz		up to 10,000x faster scan rate
Larger form factor	up to 17"		up to 80"
Thinner	requires glass to protect from cracking		no glass
Lower weight	requires glass to protect from cracking		no glass
Cost Advantages			
Manufacturing			
Deposition method	Vacuum		Normal atmosphere, roll to roll
Patterning process	Subtractive - Batch photo-lithography (100% of surface area covered, x2 layers)		Additive - Roll to roll plating process (~1% area covered, x2 layers)
Materials	Indium = \$800.00/kg (Indium is 75% of ITO by weight)		Cu = \$7.31/kg
Assembly	Silver silk screen / lamination / flex cable attach		Optionally, fully integrated circuit

- UniBoss™ brings Value-Add solutions to;
 - Transparent Touch Sensors
 - Precision flex cables with reduced lead time
 - Micro-Antenna
 - RFID, cell phones, RF, WiFi, Bluetooth, remote video, etc.
 - Transparent EMI/RFI shielding
 - OLED backside electrode grid
 - Solar electrode grid
- More under development...

