



Electroless Metal Photo-Patterning

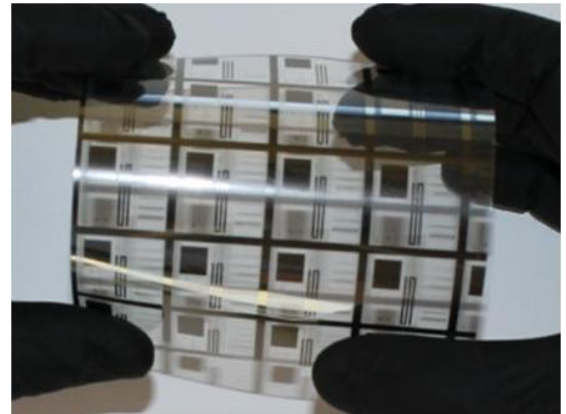
Electroless Metal Photo-Patterning Technology.

NANO3D provides chemicals (cleaning, catalytic resist, developer, plating) and photo-patterning plating services to fabricate metal patterns including transparent metal mesh and fine-pitch interconnects for Display, MEMS, LED & other applications.

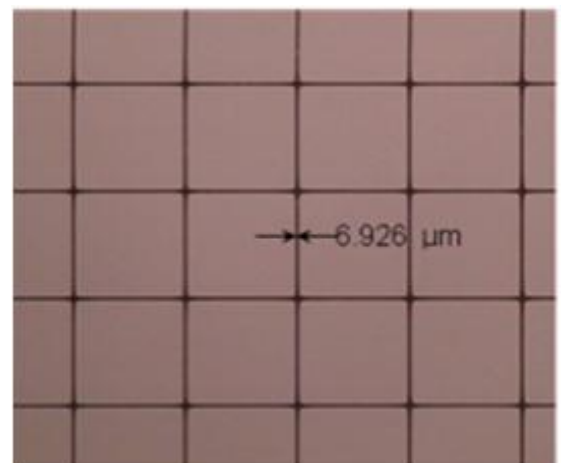
Key Benefits:

- **Selective, conformal and uniform metal patterns**
 - Photo-selective electroless plating to form fine-pitch metal patterns
 - Step coverage of over 95% in high aspect ratios features
 - WIW thickness non-uniformity of $< 2\%$ @ 1 Sigma
- **Optimal surface roughness and texture of the patterns**
 - Smooth surface morphology ($R_a < 10$ nm)
 - Strong (111) texture
- **Wide variety of substrates**
 - The technology is applicable for the metallization of flexible (polymers, glass, ceramic, plastic, silicon et al.), patterned (vias & trenches) & stretchable substrates.

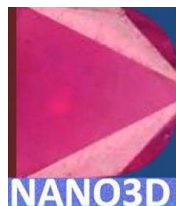
- **Better transparent electrodes**
 - Low cost and sheet resistance that reduces p-cap charge time and enable larger displays as well as increases SNR and linearity
 - High transparency and flexibility



Electroless metal deposition on flexible substrates



Transparent metal mesh fabricated by photo-selective electroless plating



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Advantages of metal mesh vs other conductive transparent electrodes

Parameters	ITO	Metal Mesh	Ag Nanowires	Carbon Nanotubes	Conductive Polymer
Optical					
Visibility	NO	NO at 1 μm	NO	NO	NO
Transparency	88%	Up to 90%	Up to 90%	Up to 90%	BEST
Effect of ambient light	Moderate	Moderate	Increase Haze	Best (lowest reflectivity)	Moderate
Moire Patterns	Yes	NO	NO	NO	NO
Color shift	Yellow color shift (b* > 2)	Lowest (b* < 0.5)	Moderate (1 < b* < 2)	Lowest (b* < 0.5)	Moderate (1 < b* < 2)
Electrical					
Sheet resistance	1 Ω/Sq	<1 Ω/Sq	Low	High	High
Physical Characteristics					
Flexibility	Poor	Good	Moderate	Best (100k times at <1 mm radius)	Best (100k times at <1 mm radius)
Reliability					
Redundancy	NO	Yes	Yes	Yes	No
Corrosion	Good	Moderate	Poor	Best	Moderate
Cost					
Cost	High	Low	High	Moderate	Low

Advantages of NANO3D's metal mesh technology

Parameters	NANO3D Cu MESH	Cu MESH by wet etching	Cu MESH fabricated by nano-imprinting	Cu MESH by flexography
Method	Direct plating on catalytic inorganic resist	Photo-lithography and Cu etching	Nano-imprinting	Flexographic printing
Environmental	OK	Waste from Cu etching	Moderate waste	OK
Adhesion	High	High	Moderate	Moderate
Line resolution	< 1 μm	< 1 μm	< 1 μm	< 1 μm
Cost	Low	High	Moderate cost	Low

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