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Transparent 5G Antennas using Nanostructured Metal Meshes

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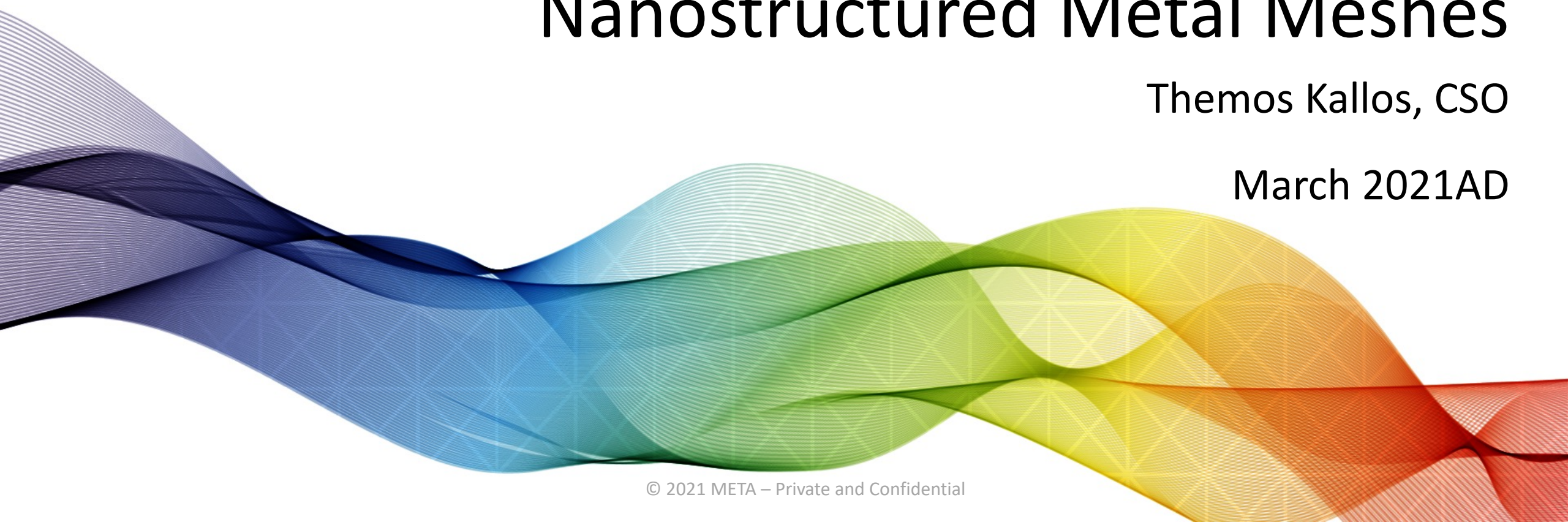

Outline

- Applications
- Technology (Nanoweb)
- Manufacturing (RML)

Applications

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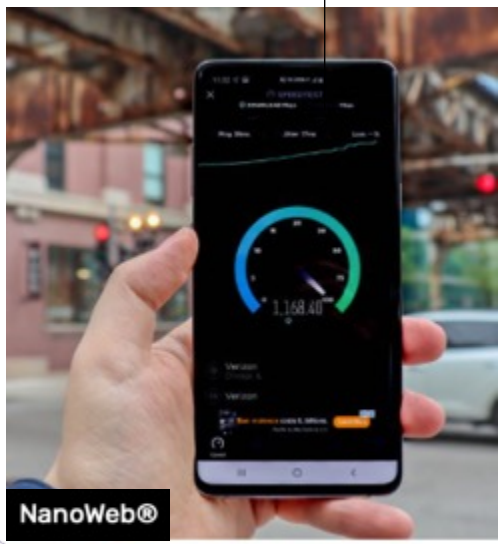
META *Transparent Window Film Transforms Outdoor 5G Coverage*

META Invisible Antenna to Enhance Indoor 5G and Digital TV Reception

Transparent Antennas

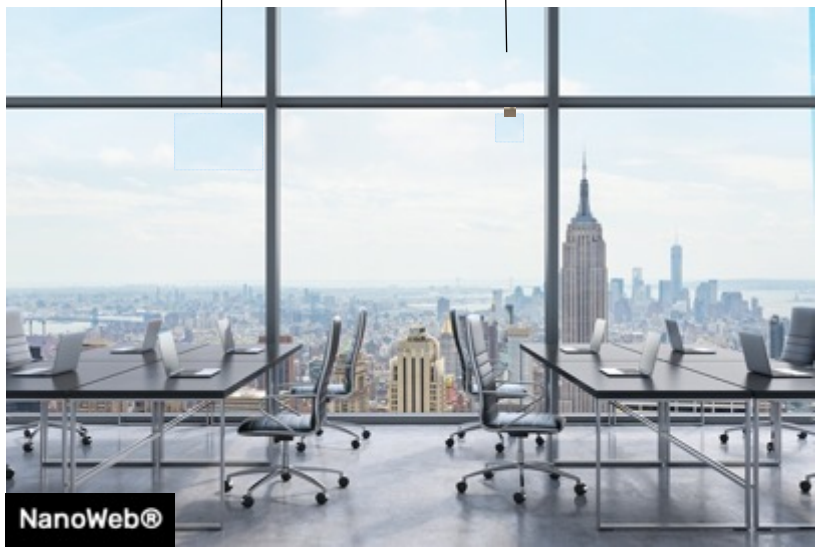
On most substrates
e.g. PET, Glass, Sapphire



Flexible films adapt to
different shapes

Increased performance through
low sheet resistance <10 Ohm/sqr

Up to 98% Transparency



Technology

Nanoweb Metal Mesh

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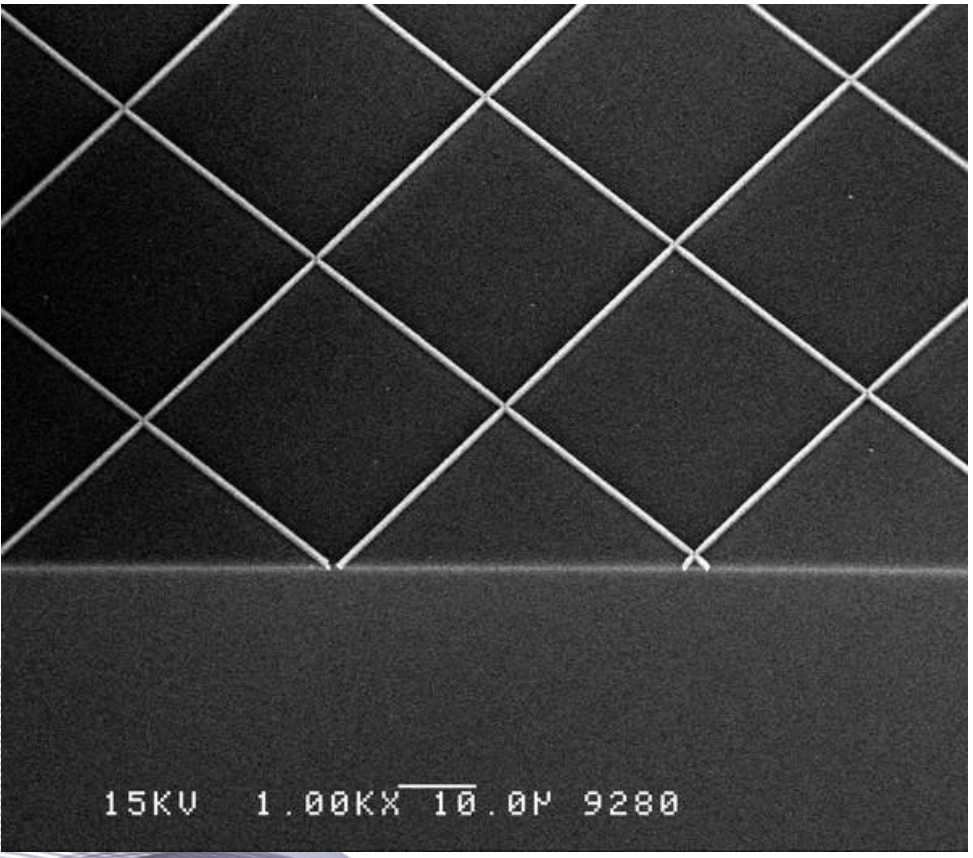
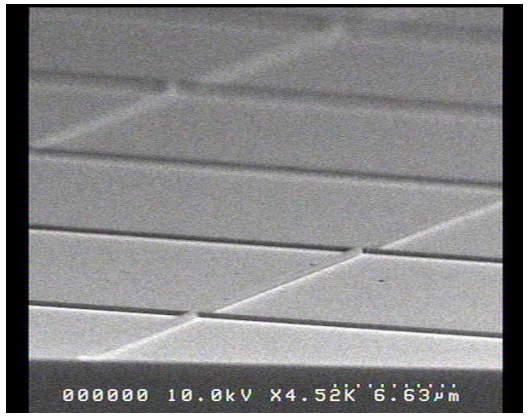
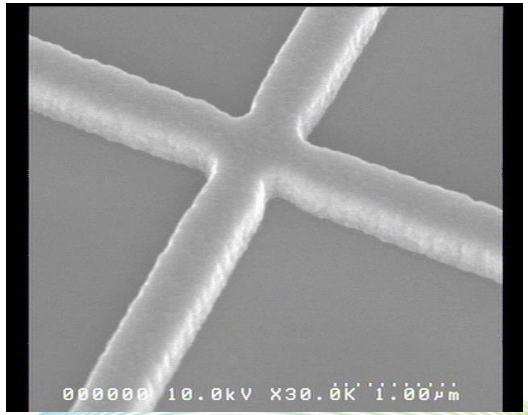
Nanoweb® - Transparent Metal Mesh

Sub-micron transparent metal mesh







Linewidth ~ 650 nm

Adaptable

On most flexible films (PET, PC)
Any rigid substrates (glass, sapphire)
Using any metals (Ag, Au, Al, etc.)
Large area applications

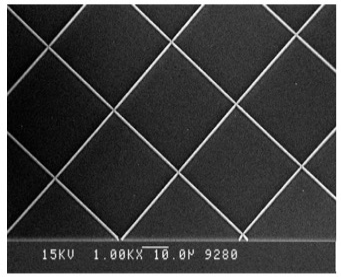
Benefits

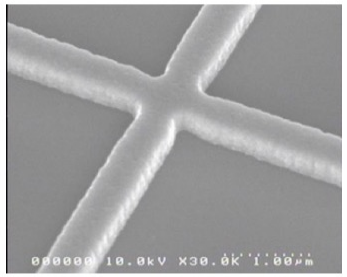
Invisible to the human eye
Higher conductivity (1-20 Ω/sq.)
Higher transmission (>95%)
Color neutral, low haze (<1%)

Nanoweb Comparison

Sub-micron, high transparency, super conductive metal mesh

✓Higher Transmission >95%
Vs. Conductivity 1-20 Ω/sq
✓Low Haze 1-2%
✓Hi Resolution & Control
✓Flexible substrates or directly on Glass, Sapphire

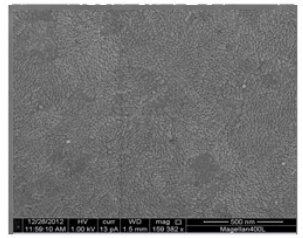




VS.

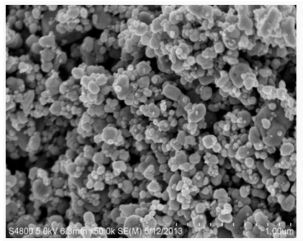
ITO

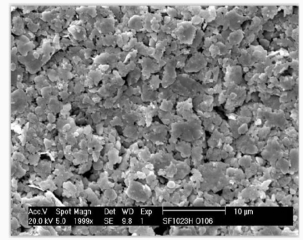
ˣ Lower Transmission Vs. Conductivity
ˣ Not flexible
ˣ Not suitable for large surface areas

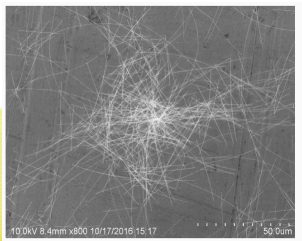


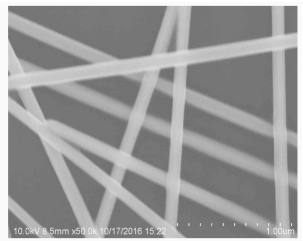
Silver flakes & Nanowires

ˣ High Haze
ˣ Lower Transmission
ˣ Lower Conductivity
ˣ Lower precision





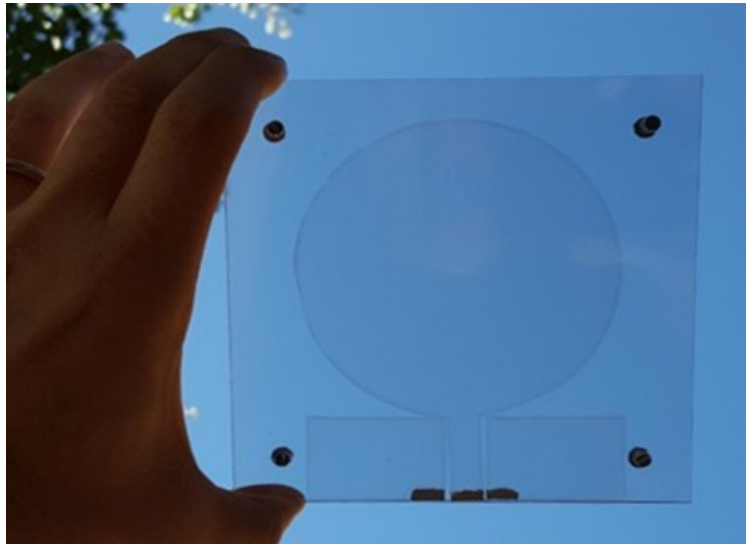


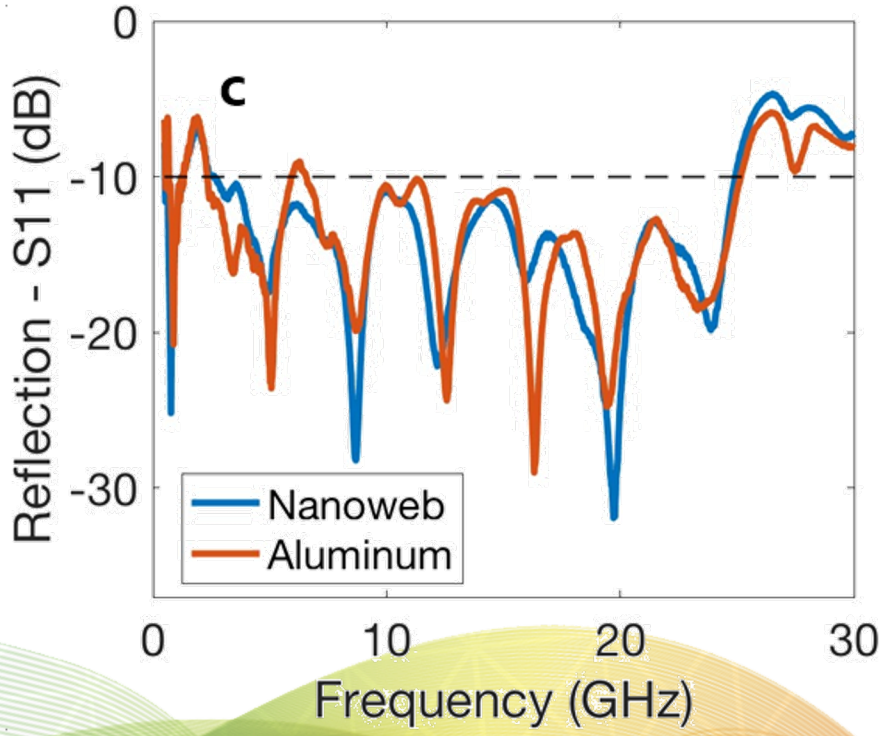


Broadband Monopole 5 GHz

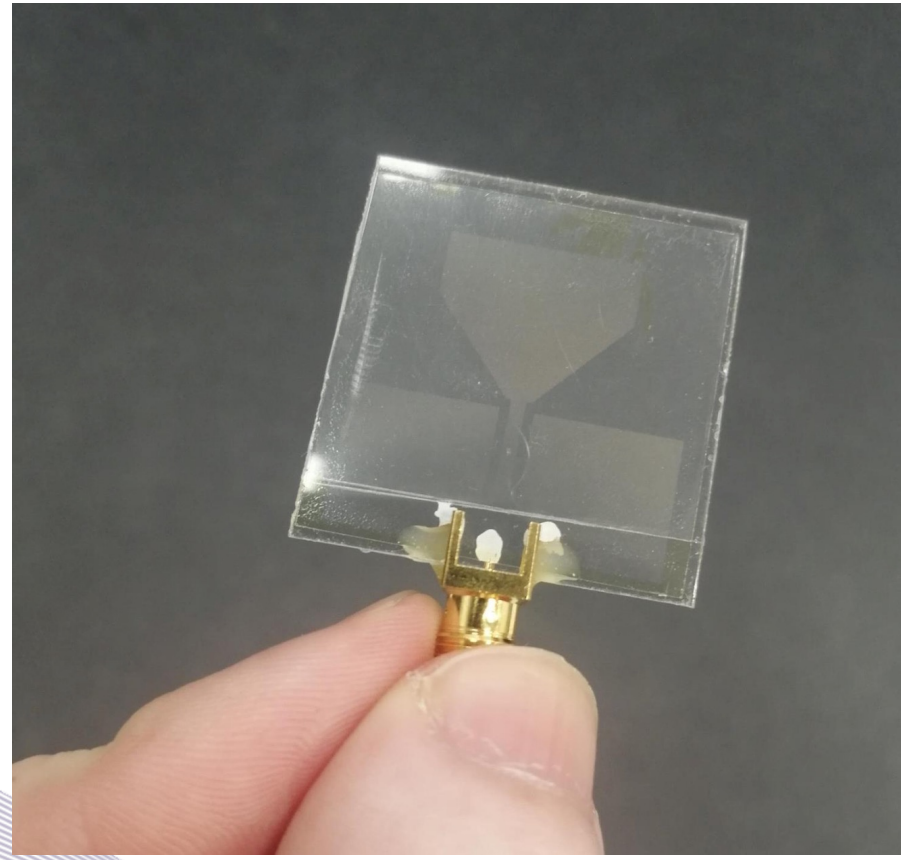
A monopole 5 GHz transparent antenna for communication applications

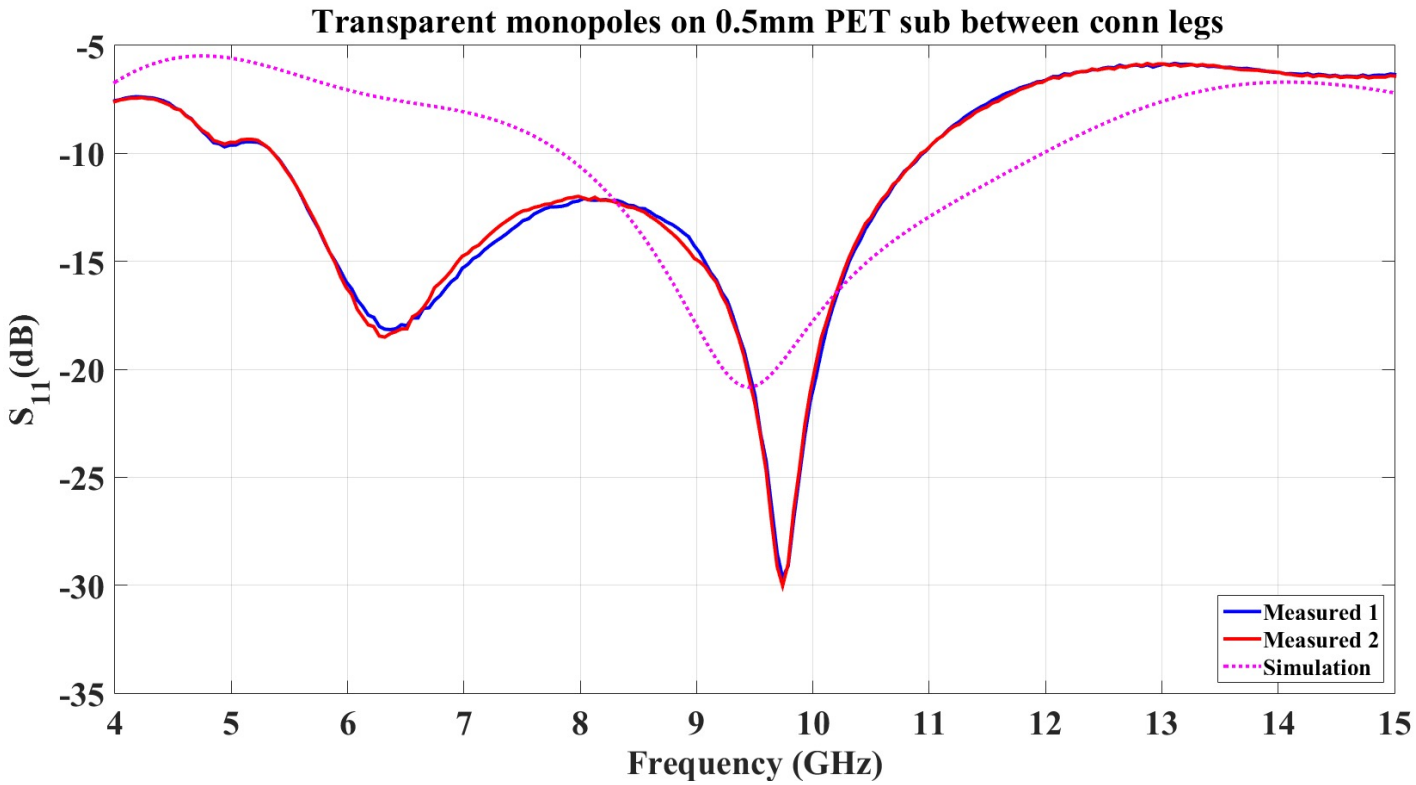
The measured reflection coefficient (S11) is compared to the S11 of an identical metallic antenna



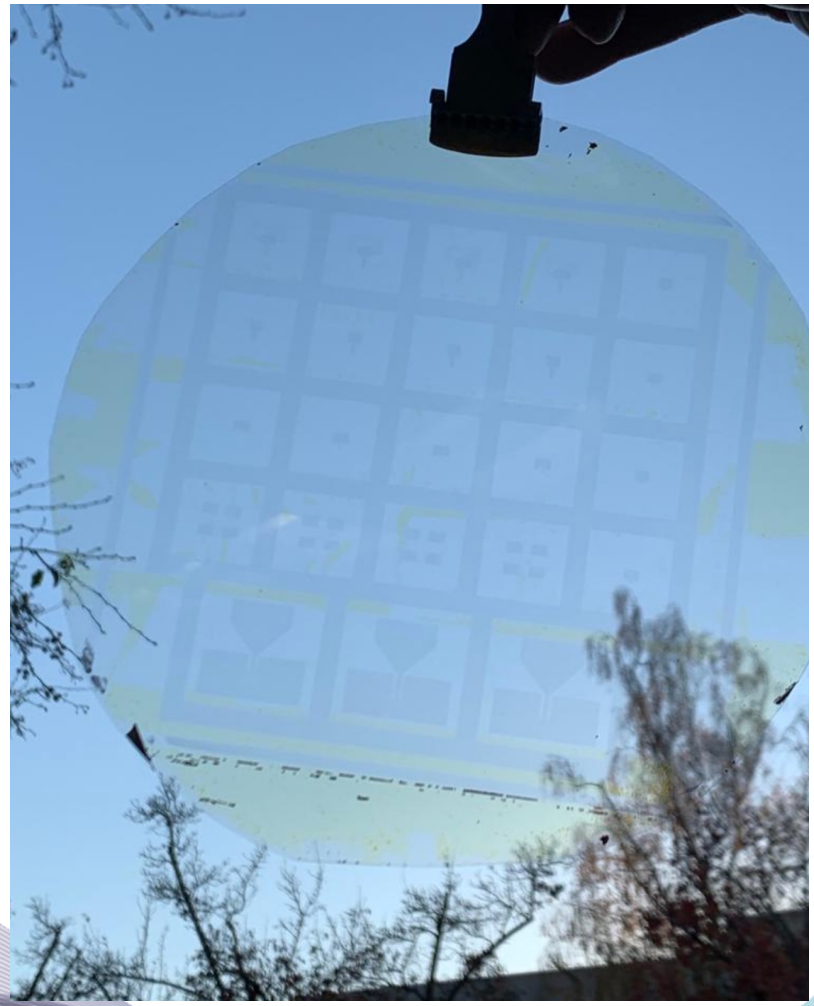


Broadband Monopole 6-9 GHz - Measurement

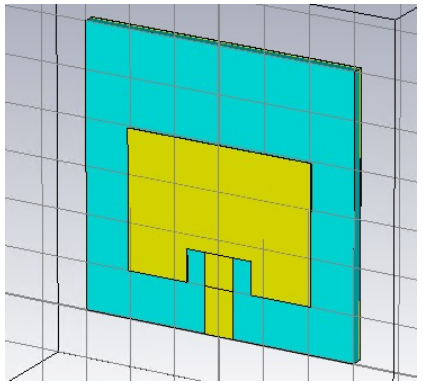


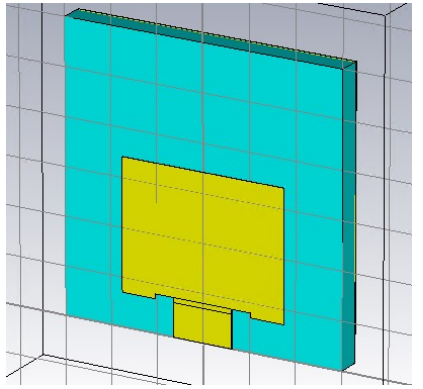


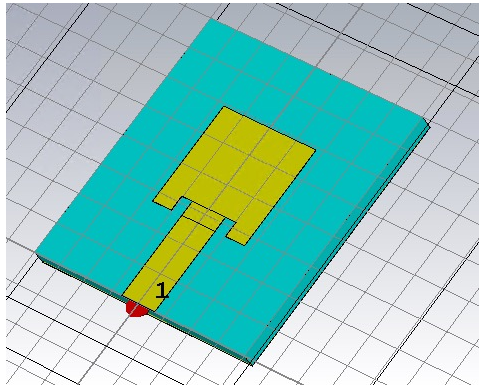
Variety of Transparent 5G Antennas

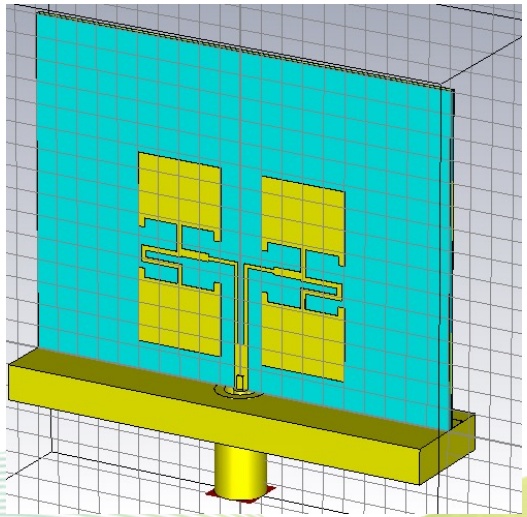


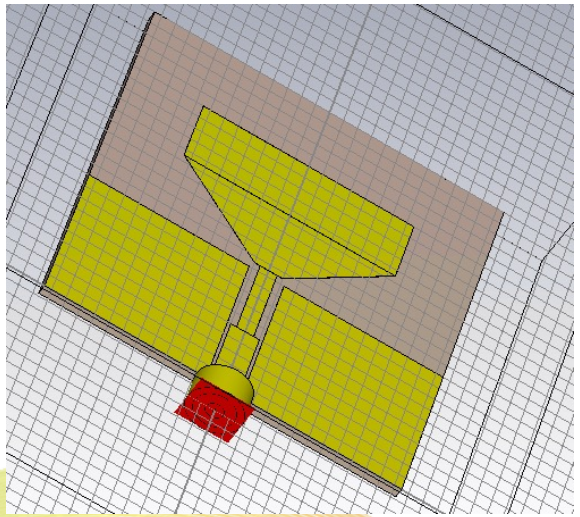
30um pitch











Manufacturing

RML

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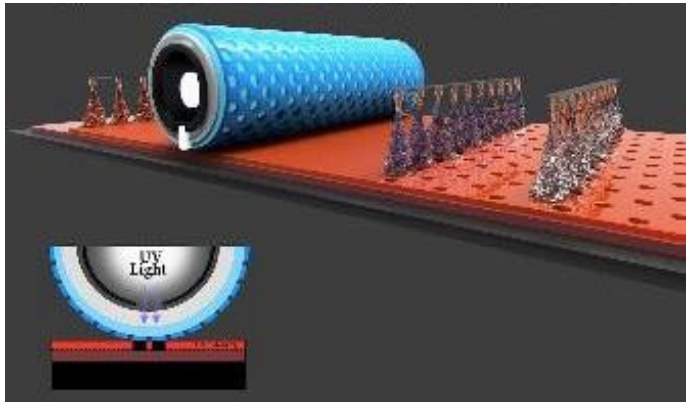
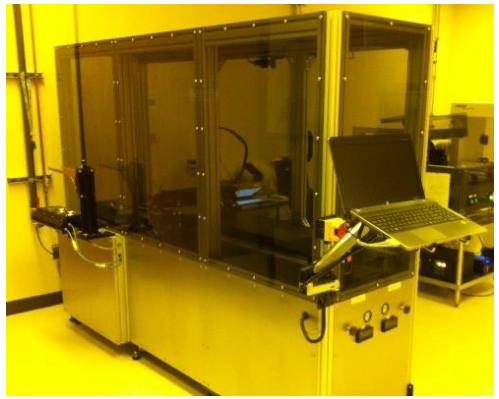
Rolling Mask Lithography



- Continuous and scalable
- **Inexpensive** versus competition
- **Ultra-fast fabrication** (in seconds vs. hours) versus competition

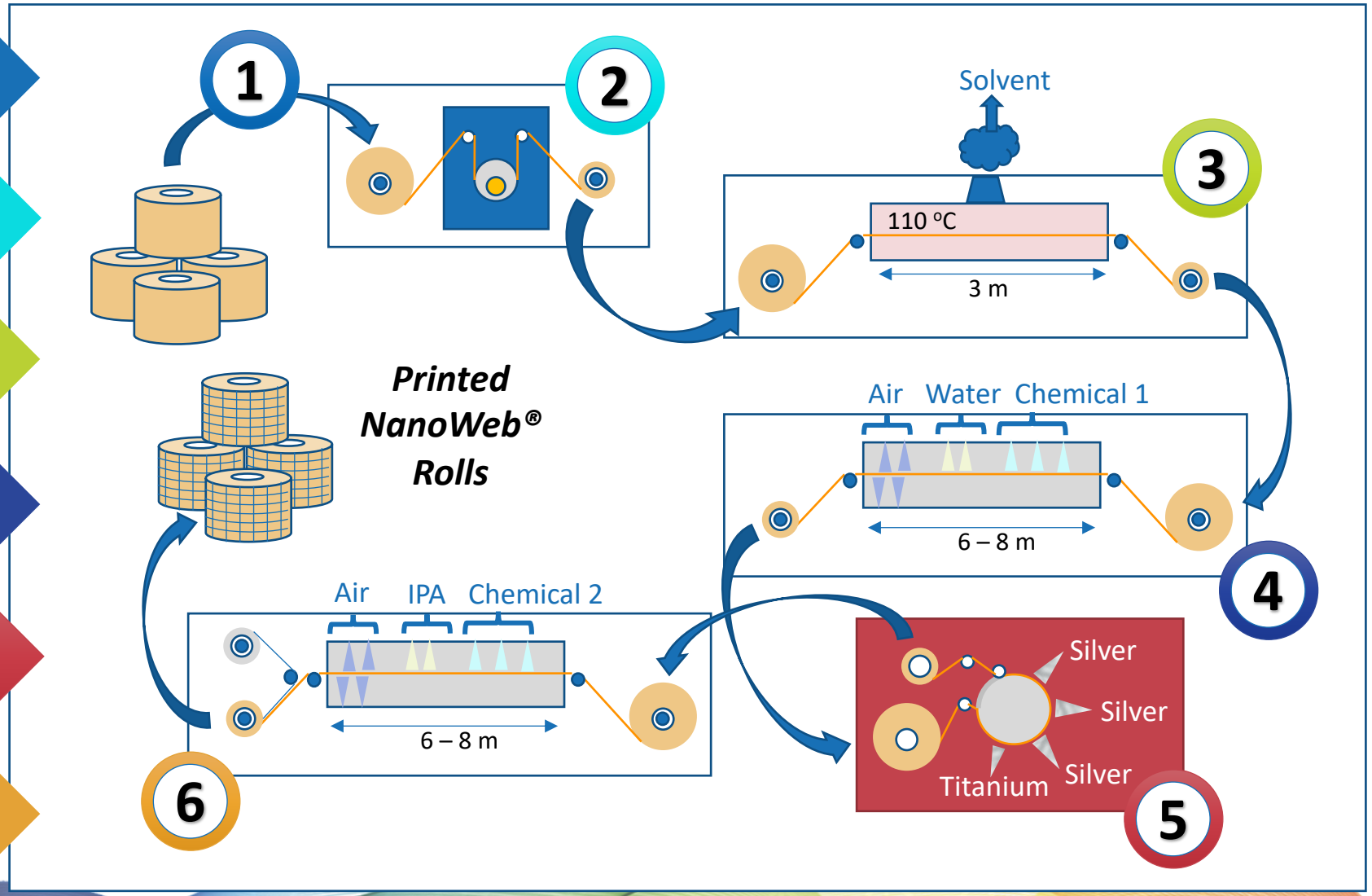


- RML™ proprietary tool substrate size: **1m x 0.3m**
- Resolution: **150nm**
- Capacity: **3m/min**

- **Large scale**, **high-volume** nano-fabrication tools have become cost effective
- META has developed new software (algorithms) and hardware proprietary tools **delivering nano-fabrication solutions at meters scale per minute.**

META R2R Pilot Manufacturing Process Steps

1. **Loading**
   Pre-coated PET film with bi-layer photoresists.
2. **Exposure**
   Printing with RML technology using UV-365nm and proprietary mask
3. **Baking**
   Stabilizing chemistry of printed design in photoresist.
4. **Development**
   Creation of 3D structures in Photoresist.
5. **Metallization**
   Metal in deposition to create continuous metal mesh.
6. **Lift off and Protection**
   Removal of unwanted material and protection of mesh prior to re-winding.



Thank You

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