



# A Clear Advantage: Innovative Transparent PCB Materials for New Markets

CHASM Advanced Materials & A-Gas Electronic Materials



# TCF Industry Standard

## ITO (Indium Tin Oxide)

- Dominates both Glass & Flexible Substrate segments
- Will continue to dominate on Glass
- Will be displaced on Flexible Substrates (Plastic Films)
  - ITO is not flexible, formable or stretchable
  - ITO is not as transparent & conductive on Plastic
  - ITO can be costly to create circuit patterns on Plastic

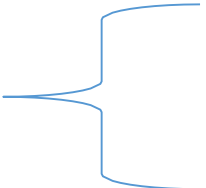


# ITO Alternative Categories

## Market Needs

- 1. Transparency / Conductivity
- 2. Affordability
- 3. Environmental Stability
- 4. Flexibility / Formability

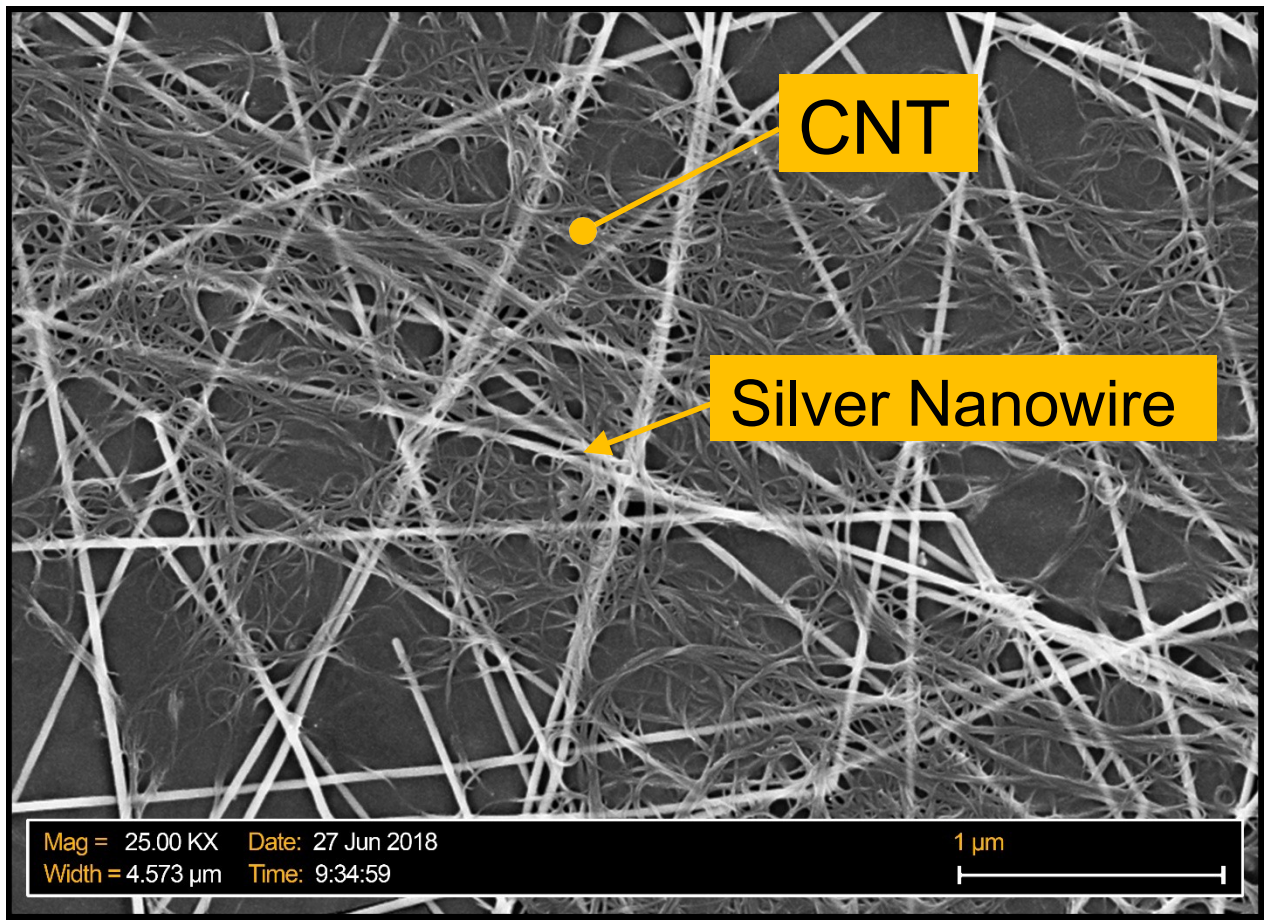
## Key Players



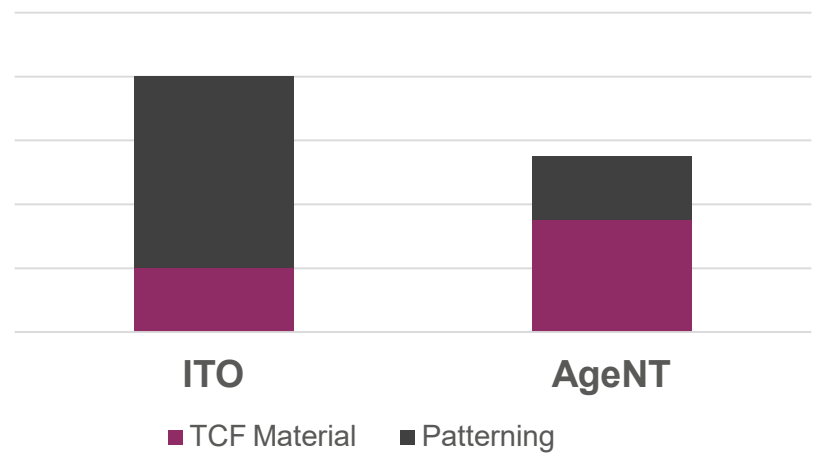
	PEDOT	SIGNIS™ CNT	AgNW	MM	AgENT™ CNT Hybrid
1. Transparency / Conductivity	o Limited	o Limited	✓ Excellent	✓ Excellent	✓ Excellent
2. Affordability	✓ Excellent	✓ Excellent	o Limited	o Limited	✓ Good
3. Environmental Stability	o Limited	✓ Excellent	✓ Good	✓ Excellent	✓ Excellent
4. Flexibility / Formability	✓ Excellent	✓ Excellent	o Limited	o Limited	✓ Excellent
Key Players	Heraeus AGFA	CHASM Canatu	C3Nano Cambrios	Toppan Fujifilm	CHASM



# AgeNT CNT Hybrid TCF Materials

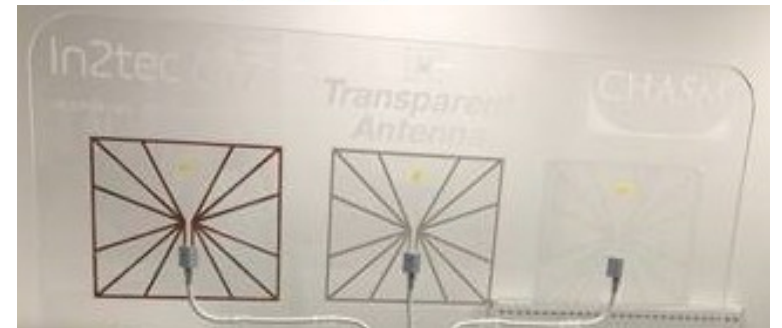
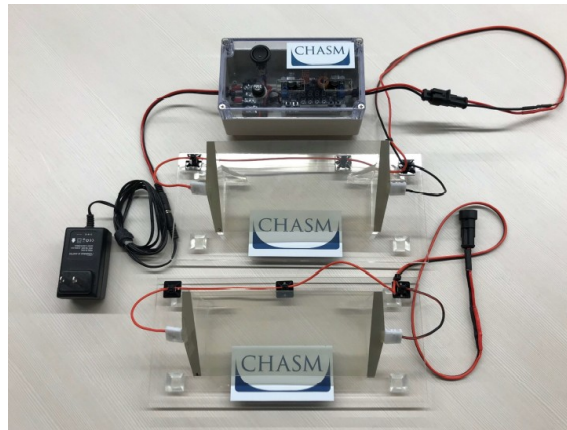
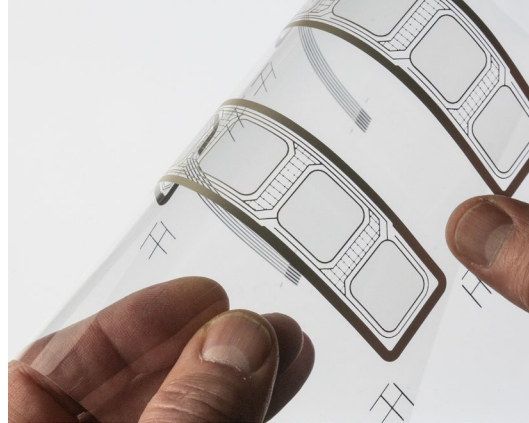
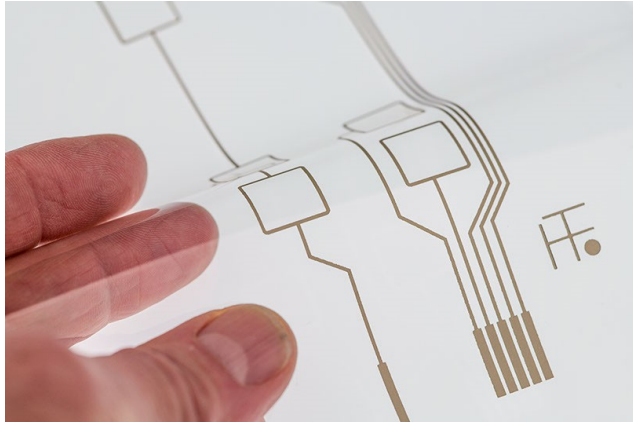


Cost of Patterned TCF (\$/m<sup>2</sup>)



- Better Performance
- More Affordable

# Transparent Flex Printed Circuits





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# Fabrication & Process Requirements

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# Fabrication & Process Requirements

- Systems already present in industries such as a PCB shops or a Printed Electronics manufacturer – minimal equipment capital cost to open new markets
- Hybrid material structure – combination of ink and film to form a hybrid material
- Ink acts as pattern mask and is a functional part of end product, therefore no mask removal stage

# Processing Equipment

“Print, Etch, Done.”

**AgeNT™**



INK + FILM

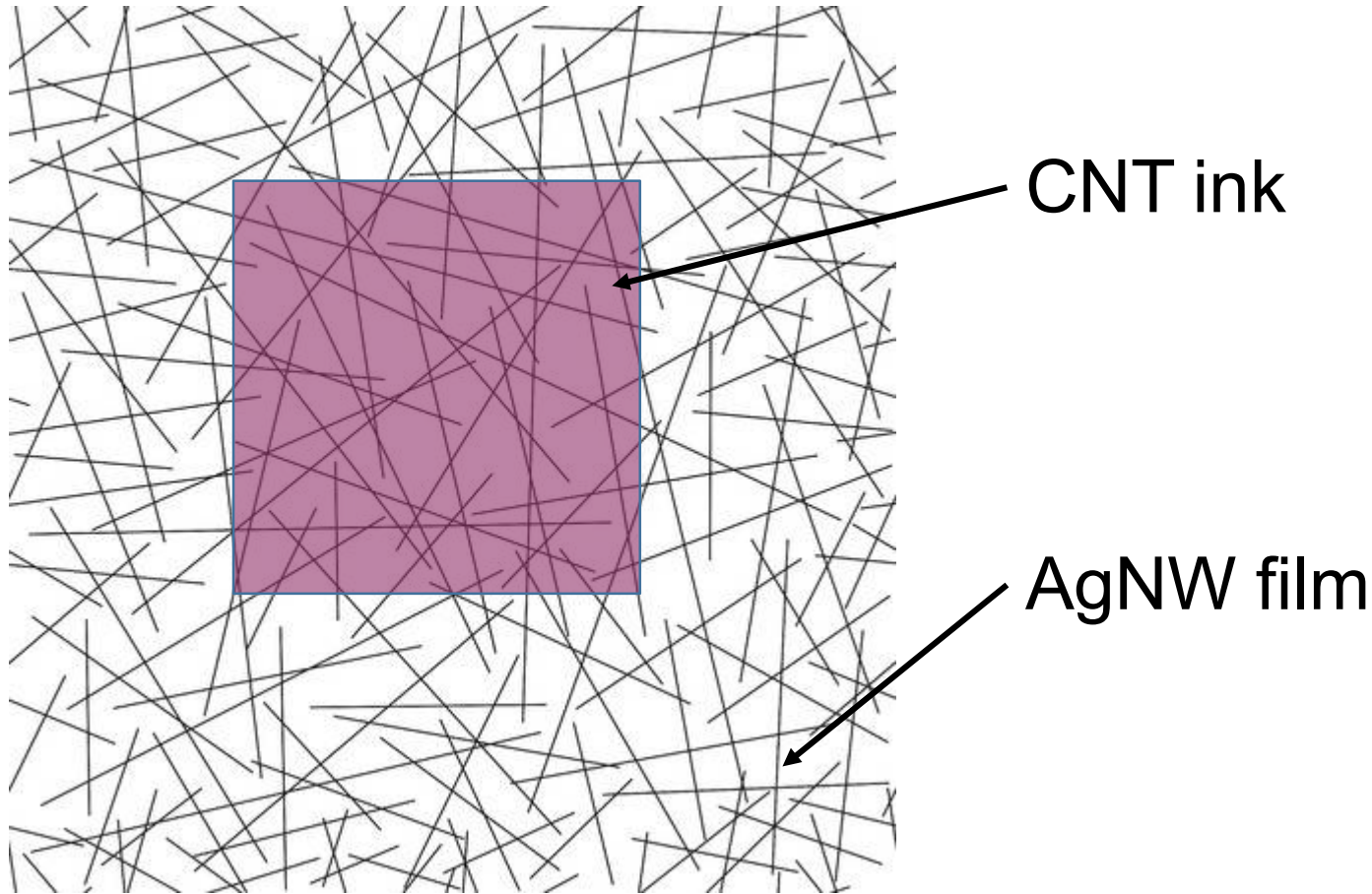


- Screen Printing Press
- Convection Oven
- Ventilation Systems

- Conveyorized Etcher



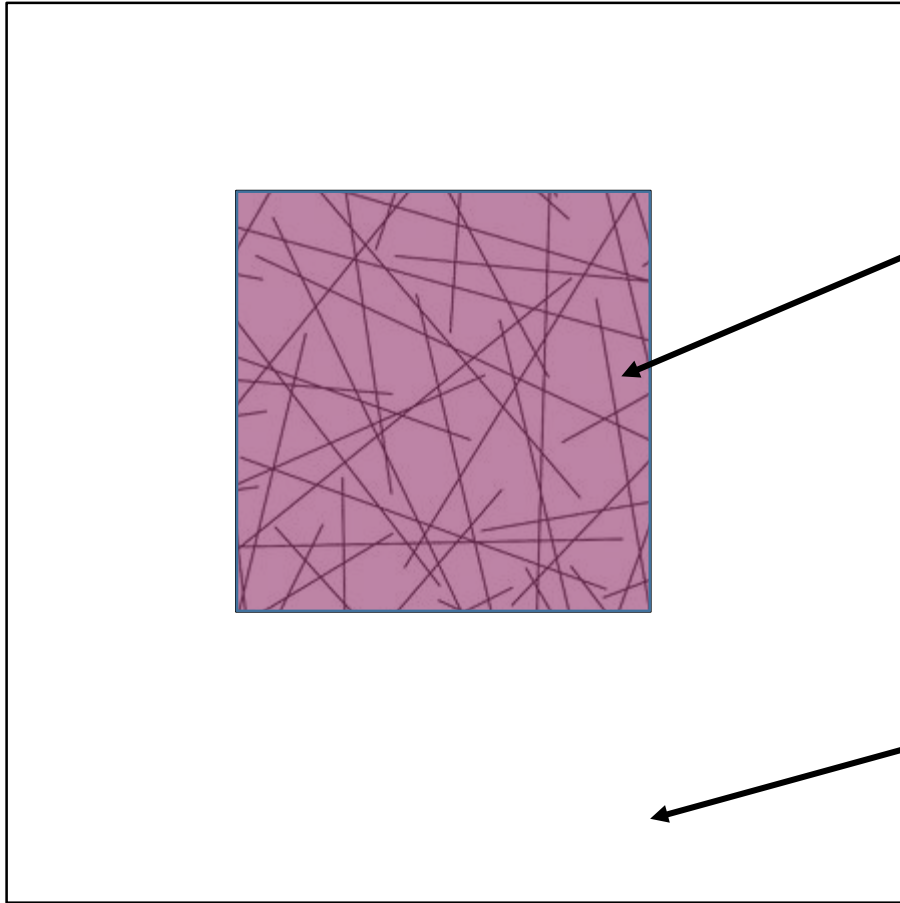
# Low Cost Patterning



*CNT ink is screen printed onto R2R coated AgNW film*

*Exposed AgNW areas are etched away to create Patterned TCF*

# Low Cost Patterning



CNT Hybrid  
TCF

AgNW  
etched away  
(Ferric Nitrate)

Three versions:

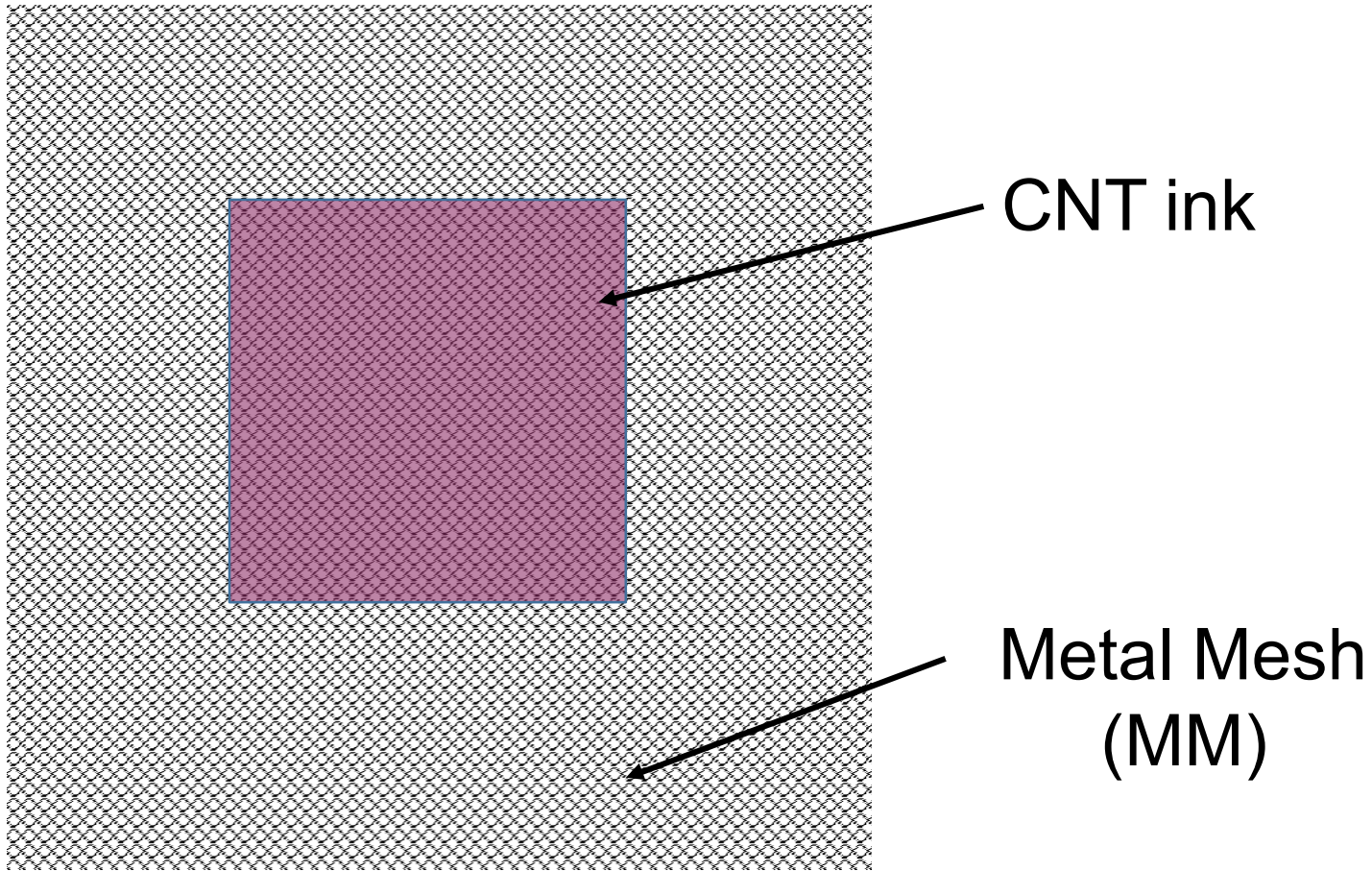
75  $\Omega/\square$   
98% VLT

30  $\Omega/\square$   
95% VLT

10  $\Omega/\square$   
90% VLT

"Print, Etch, Done."

# Low Cost Patterning

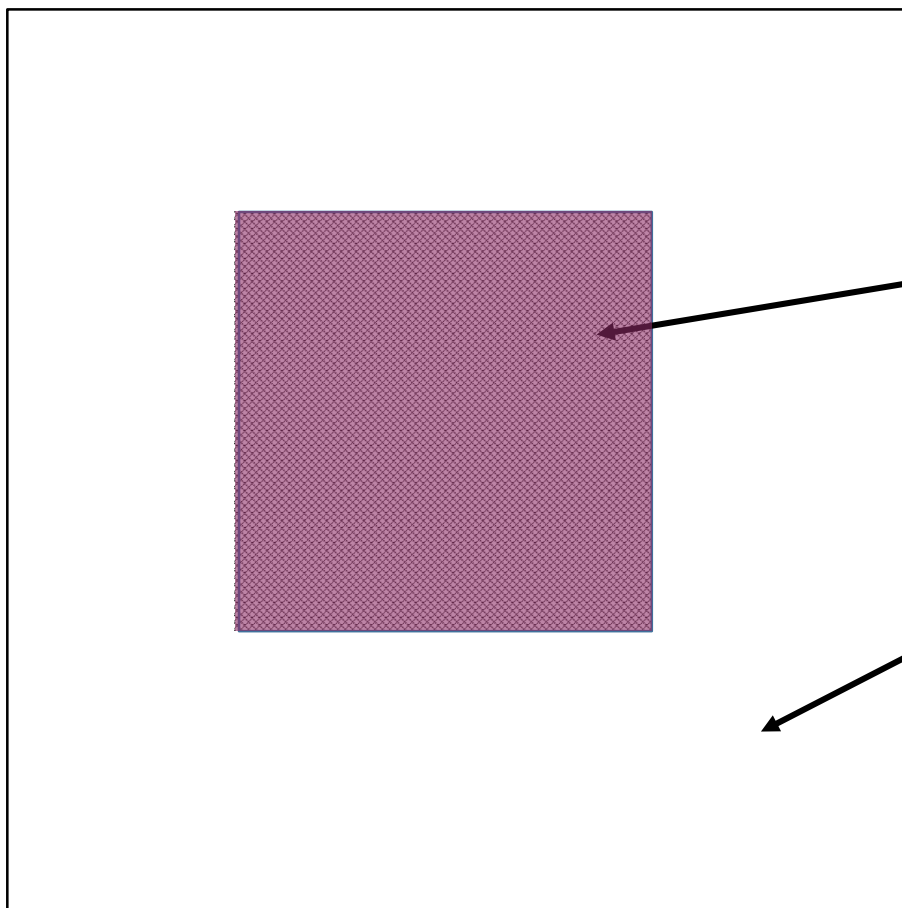


*CNT ink is screen printed onto MM Film made from Cu mesh*

*Exposed MM areas are then etched away to create Patterned TCF*



# Low Cost Patterning



CNT Hybrid  
TCF

Metal Mesh  
etched away  
(Ferric Nitrate)  
(Ferric / Cupric Chloride)

1  $\Omega/\square$   
>94% VLT

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# Application Spotlight: Transparent Antennas

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# Applications

Numerous application areas and opportunities for growth and application diversification:

1. Transparent Heaters
2. Transparent Antennas (IoT, 5G etc)
3. Transparent Lighting Films
4. Transparent Touch Sensors

Some applications to be covered in a future presentation so stay tuned.....





# Transparent Antennas

Communications industry opportunity for transparent antenna solutions, driven by growth in:

1. 5G Networks

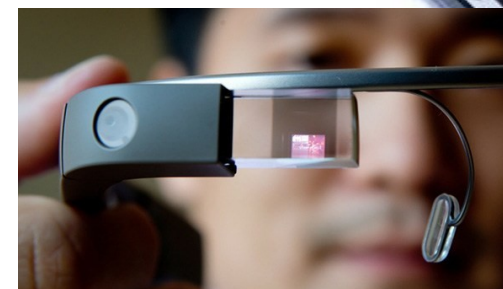
Boosting data throughputs, by increasing the number of antennas. Incorporating into indoor network architectures whilst keeping unobtrusive appearance (e.g. lights and windows).

2. AR/VR

Limited space for antennas on lightweight wearables which must be highly transparent and connective.

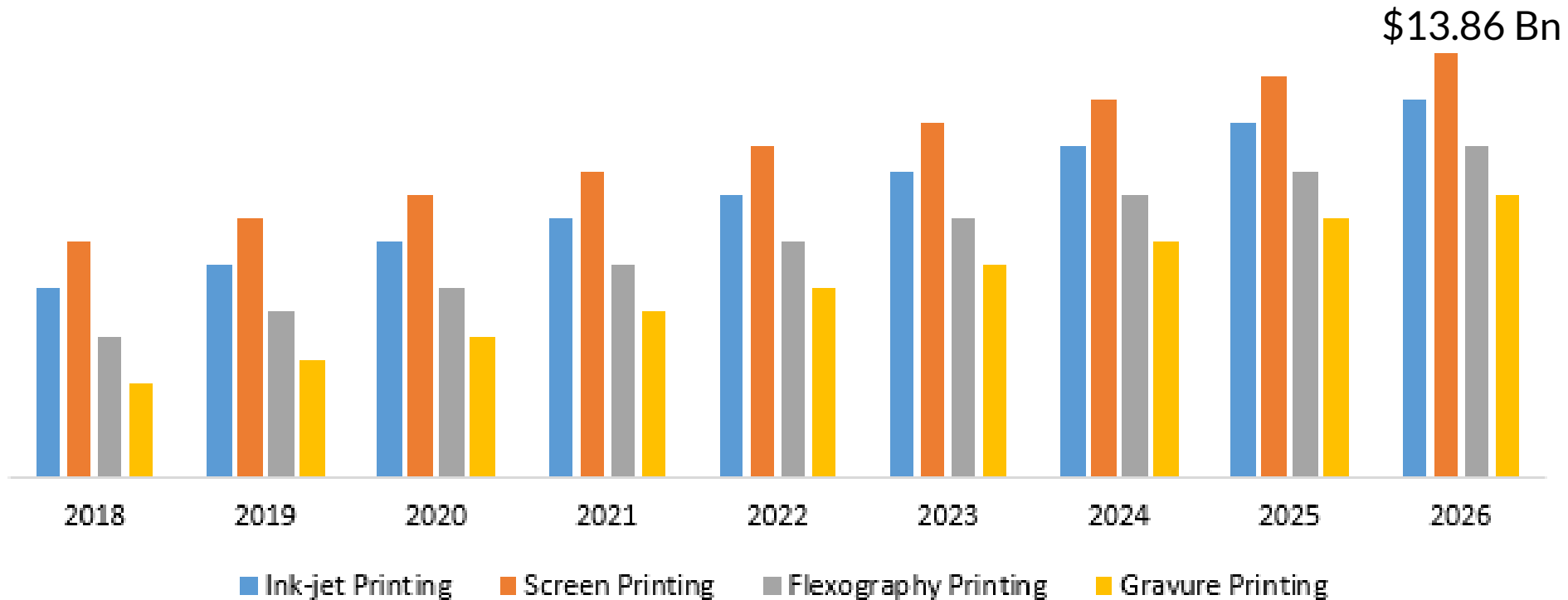
3. Smart Devices/IoT

Devices which need to communicate with the network often have metal housing (smart meters, smart factory etc.)



# Printed Antennas Market

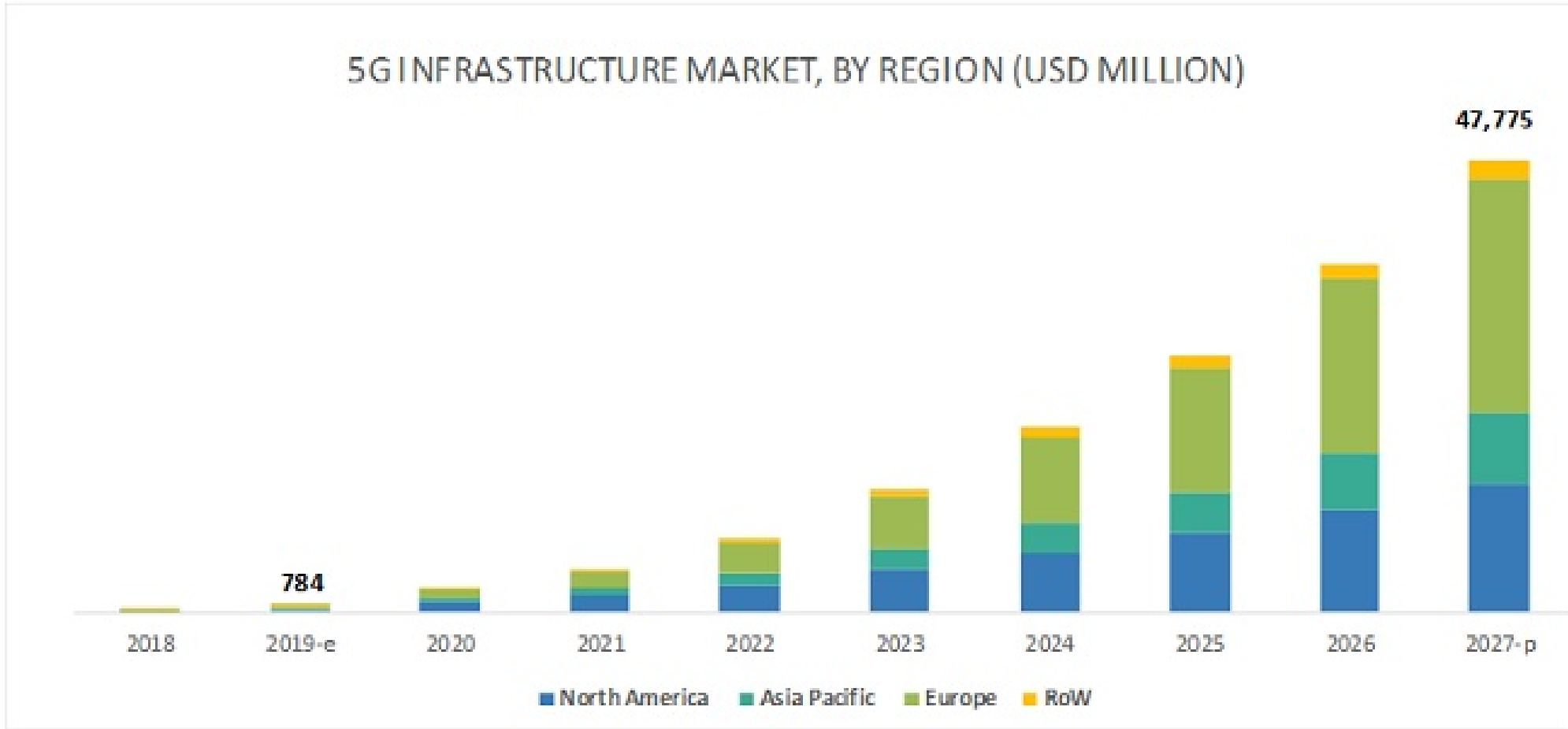
Global Printed Antenna Market, by Printing Technology



Source: Maximize Market Research, 2019

A

# 5G Market Growth Opportunity



Source: Markets&Markets, 2019

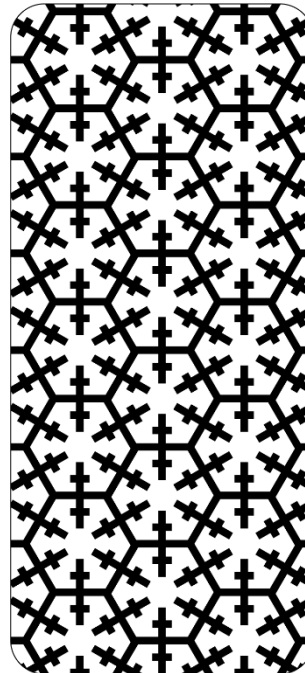
e-estimated, p-projected



# Transparent Antennas

Driven by 5G and IoT // enabled by AgeNT-1

Make it with  
**AgeNT™**



Broadband  
FSS for RF  
shielding



# Conventional Flex Antennas

Side by side Comparison to AgeNT transparent flex antennas



*(Demo created in partnership between CHASM and In2tec)*

# Summary



- AgeNT hybrid technologies offer a solution to the issues of ITO for flexible applications
- Ease of processing route for large scale manufacturing
- Low capital cost possibilities for current PCB manufacturers and Printed Electronics manufacturers
- Options for diversification of product and application portfolios
- Potential for diversification of the existing customer base



# Contact Us



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