A-GAS® 25 years
TOGETHER WE CAN

Innovations in Transparent, Flexible Lighting

A-GAS® Electronic Materials

CHASM™

www.agas.com

TCF Industry Standard

- **ITO** (Indium TinOxide)
- ITO currently dominates both Glass & Flexible Substrate segments – limited capability for flexible applications
- 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

Historically the patterning of ITO based TCF technologies has been dependent on high resolution laser ablation capabilities to enable pattern structures.

ITO Alternative Categories

Market Needs

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

PEDOT	CNT (SIGNIS™)	AgNW	MM	CNT Hybrid (AgeNT™)
○ Limited	○ Limited	✓ Excellent	✓ Excellent	✓ Excellent
✓ Excellent	✓ Excellent	○ Limited	○ Limited	✓ Good
○ Limited	✓ Excellent	✓ Good	✓ Excellent	✓ Excellent
✓ Excellent	✓ Excellent	○ Limited	○ Limited	✓ Excellent

AgeNT™ CNT Hybrid TCF Materials

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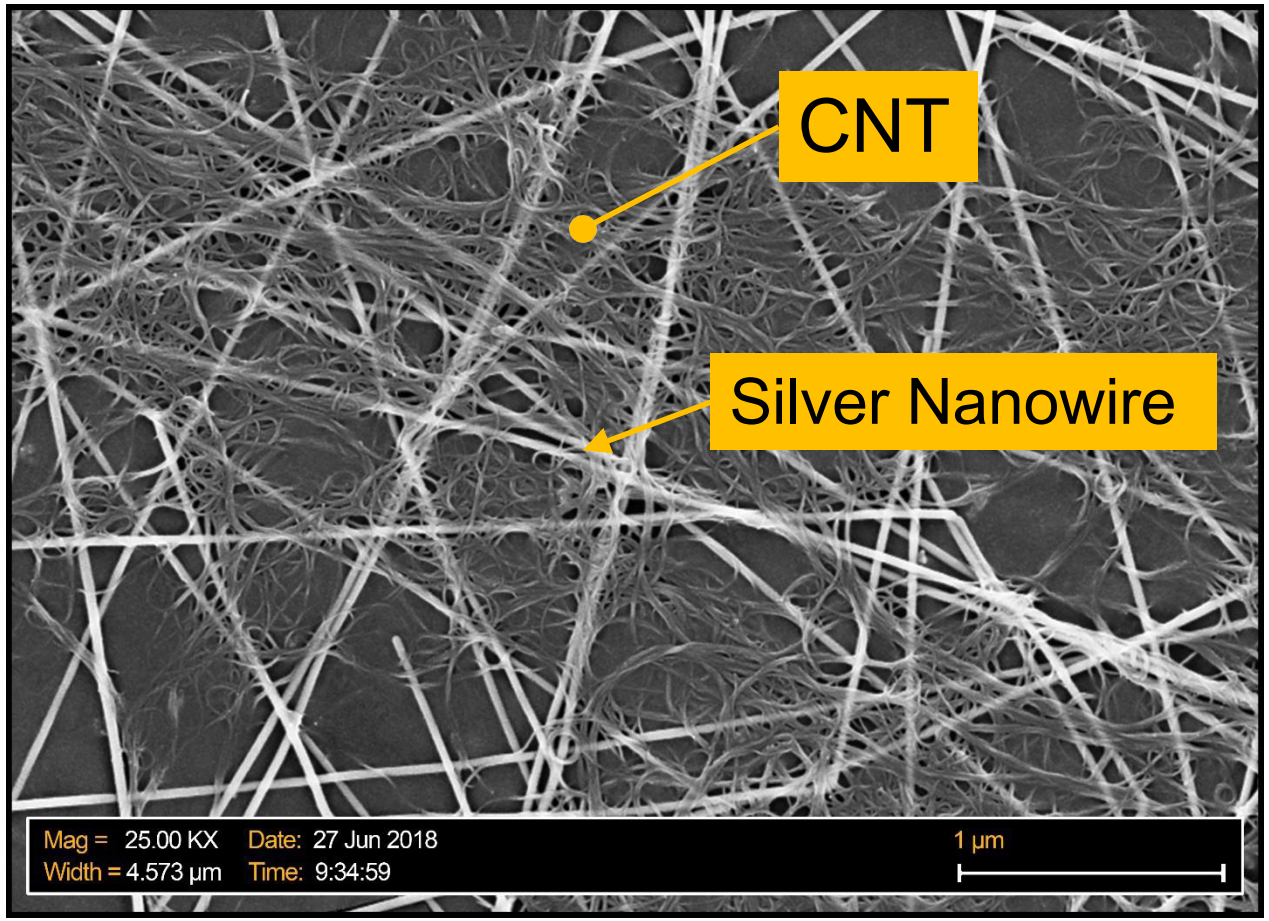
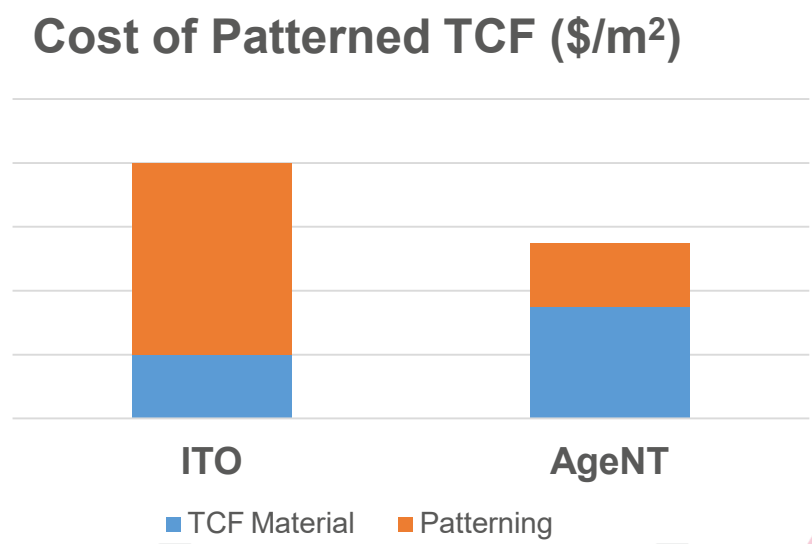
The best flexible printed electronics you'll never see





- Better Performance
- More Affordable

Fabrication and Process requirements

Processing Equipment

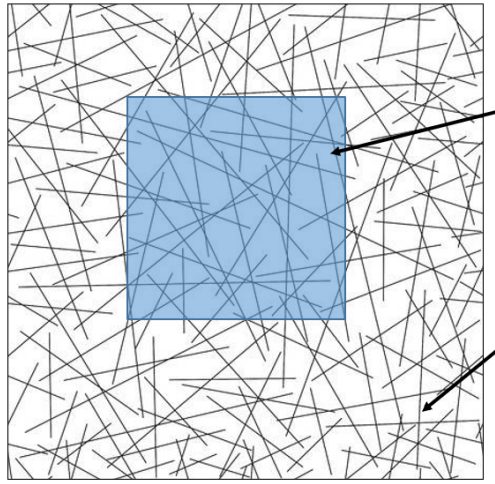
AgeNT™

INK + FILM

- Screen Printing Press
- Convection Oven
- Ventilation Systems

- Conveyorized Etcher

AgeNT™ Low-cost Patterning

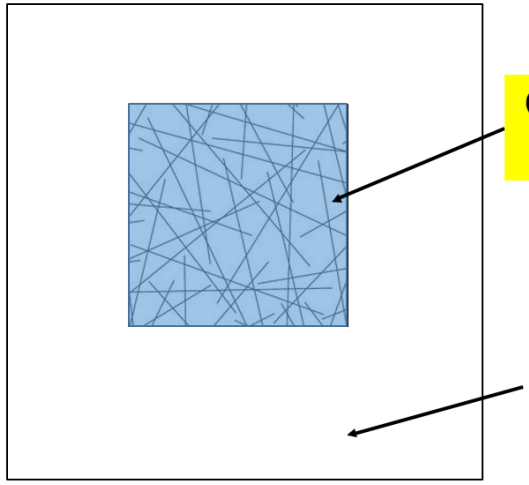


CNT ink

AgNW film

CNT ink is screen printed onto R2R coated AgNW film

Exposed AgNW areas are etched away to create Patterned TCF



CNT Hybrid TCF

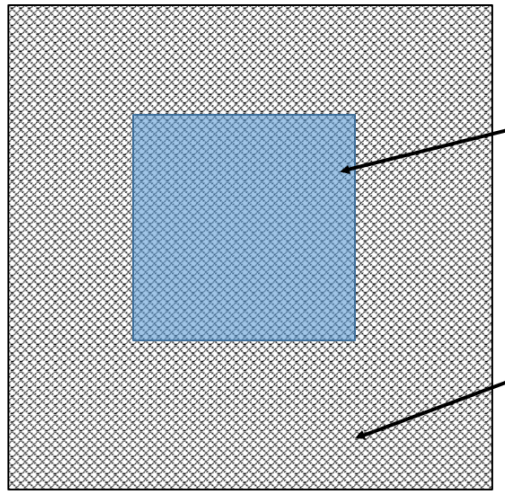
AgNW etched away
(Ferric Nitrate)

Three versions:

75 Ω/□
98% VLT

30 Ω/□
95% VLT

10 Ω/□
90% VLT

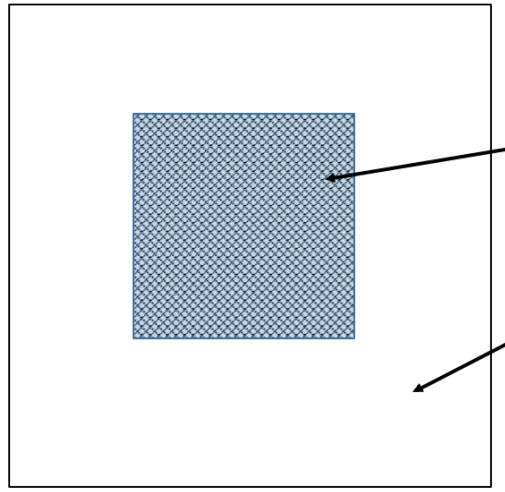


CNT ink

Metal Mesh (MM)

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

Exposed MM areas are then etched away to create Patterned TCF



CNT Hybrid TCF

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

1 Ω/□
>94% VLT

PRINT 1 ETCH 2 DONE 3

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APPLICATIONS

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

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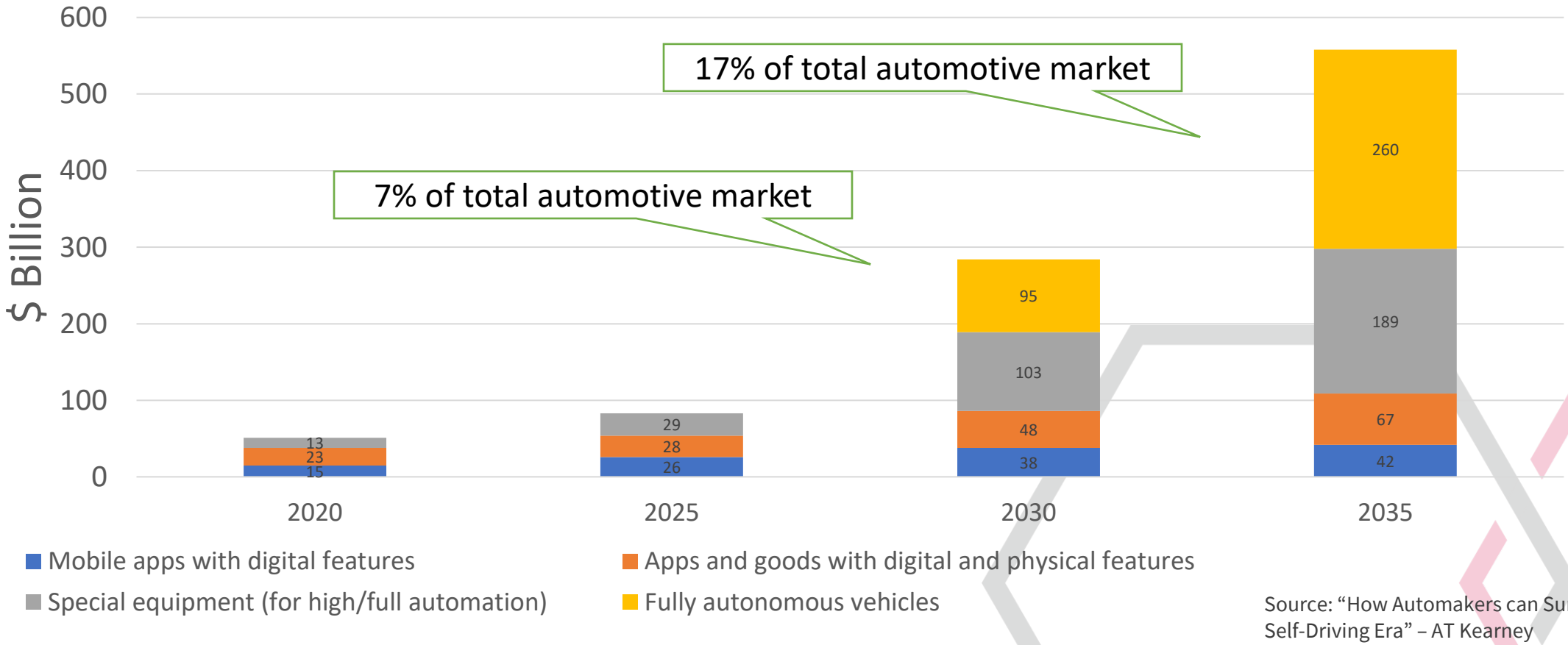
Transparent Heaters Opportunities

Global Market for Automated and Autonomous Driving, Including Related Services

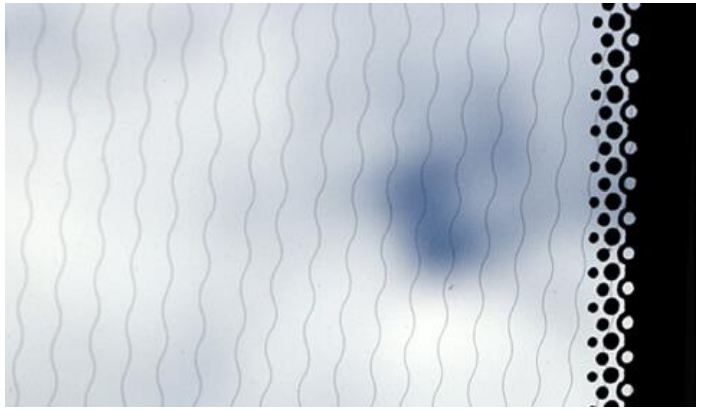


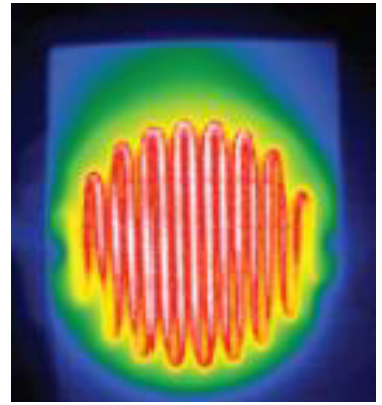
Source: "How Automakers can Survive the Self-Driving Era" – AT Kearney

Conventional “Transparent" Heaters

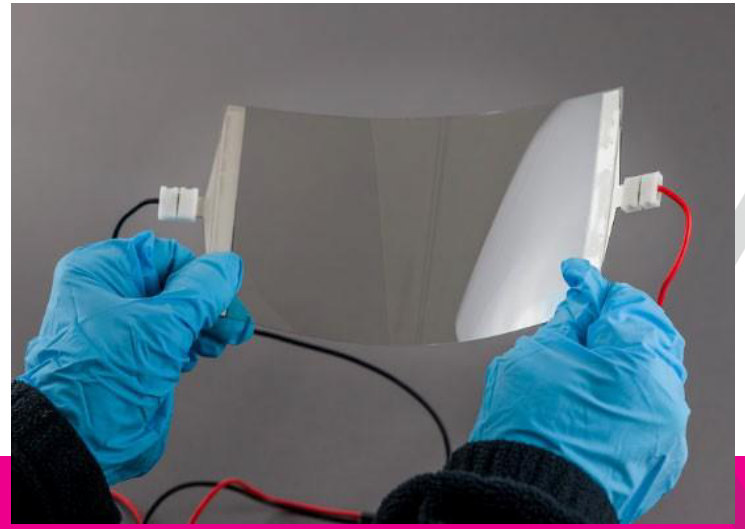
Conventional automotive heater pain points which are resolved with printed transparent systems

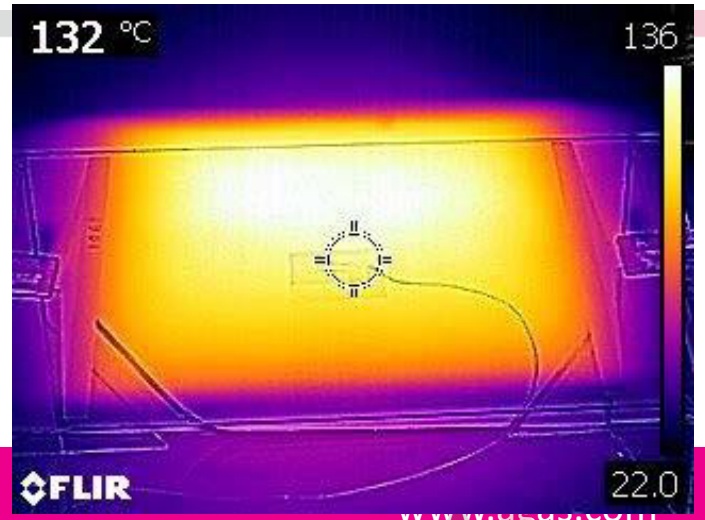
- Uneven heat distribution
- Visible wires
- Single point of failure





Printed systems also offer utilisation of existing deposition methods and a reduction in weight

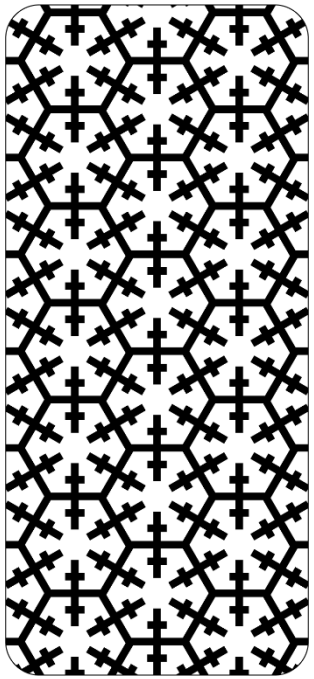




Demonstrator kits are also available

Transparent Antennas

Numerous applications areas to apply the technology - 5G, IoT, TV signal, broadband RF shielding and beyond



Broadband FSS for RF shielding

Transparent Lighting Films & Opportunities

Opportunity for transparent LED films, currently driven by the retail industry for cutting-edge digital signage advertising displays

Colour LEDs offering an eye-catching shop front displays whilst allowing the customer to also see through.

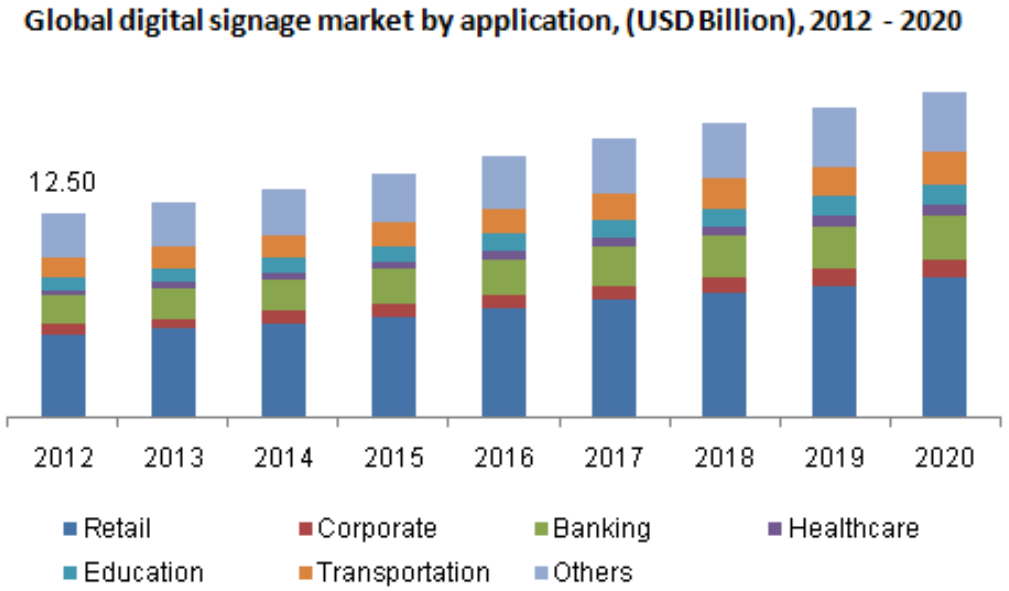
(Photo source: Digital Media Systems 2021)

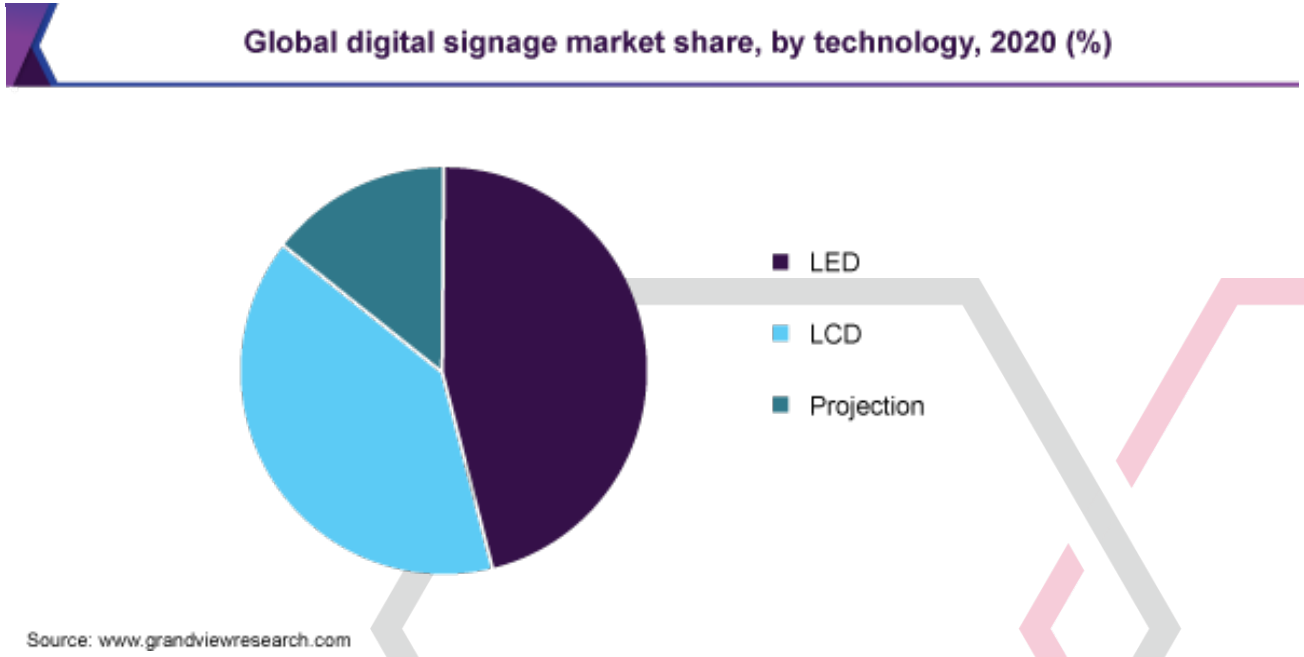
Other applications and locations include:

- Hospitality
- Workplace
- Museums
- Tradeshows
- Sports arenas
- Restaurants
- Real estate
- Government

Overall Market - Digital Signage

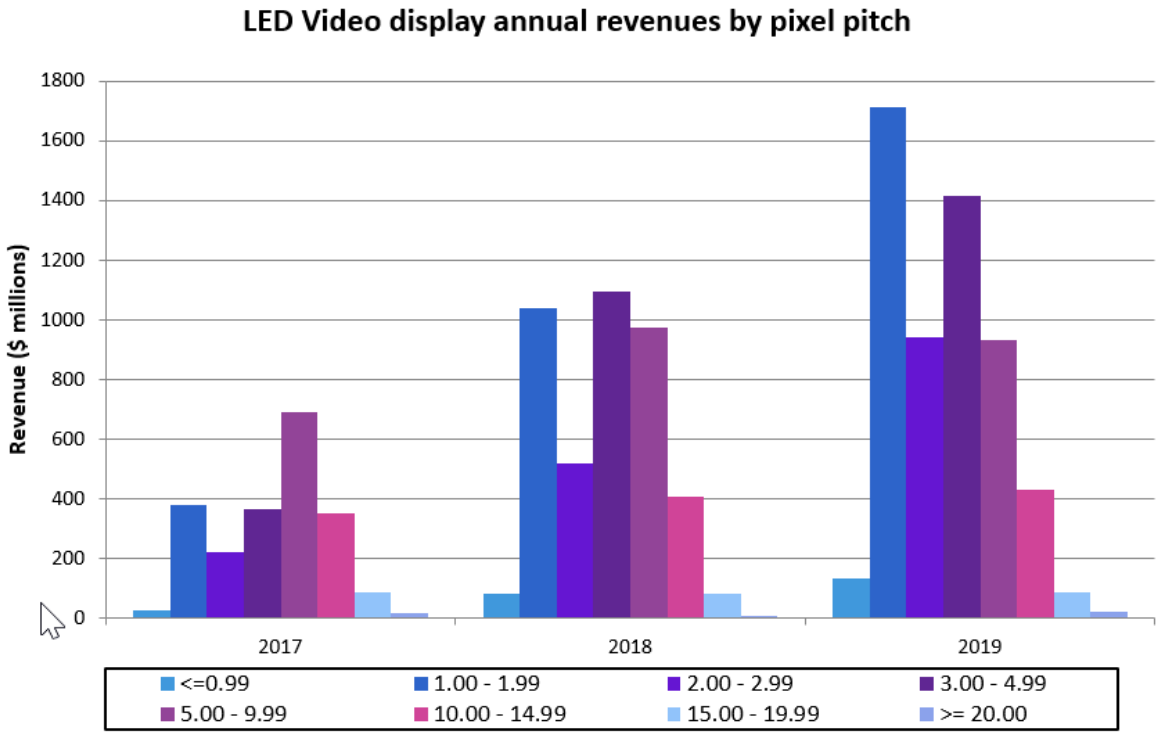
- Overall market for large format digital advertising displays is approximately $15Bn
- According to Samsung's survey in 2018 the **most exciting technologies** for the industry are bezel-less, interactive signage, and LEDS.
- More than **1/3rd of the market** is now LED displays





Direct View LED Displays

- Size of the market today for LED displays is ~500,000 m2 of display area (Source: IHS), approximately $6 Bn
- Market grew by 34.7% in 2019 (Source: Omdia)



Source – Omdia LED Video Displays Market Tracker – Premium, Q4 2019

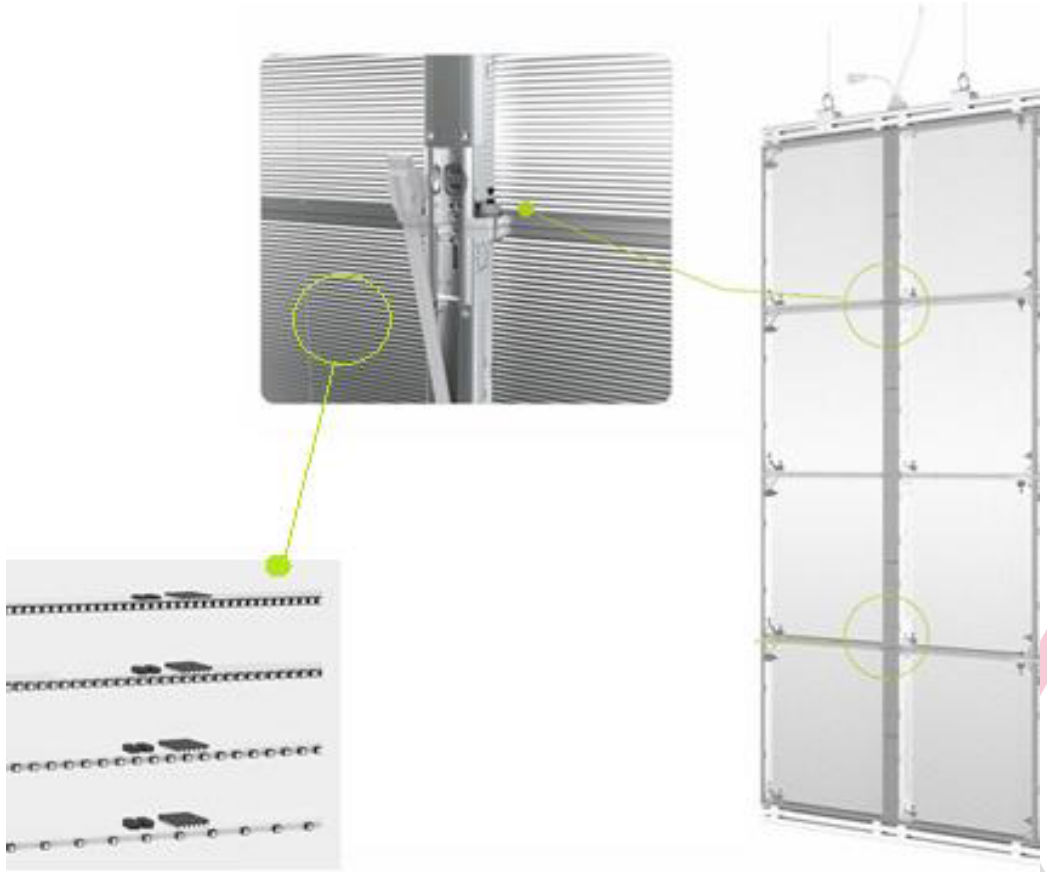
Transparent LED screens are expected to emerge as **the fastest-growing segment of the market** (Source: Grandview research)

Conventional “Transparent” LED Displays

Conventional solution for “transparent LED Films”:

Assembled LED strips in a mesh array

- Visible LED strips, especially from the back
- Obstruction of light, limited VLT%
- Not flexible, limited application
- Heavy, requires mechanical supports

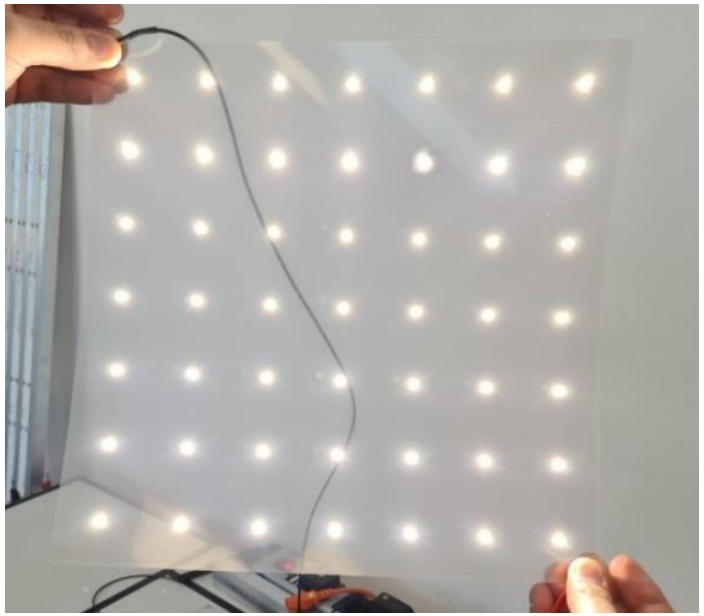


The Next Step Forward in Transparent LED Films

AgeNT transparent LED Films
Totally transparent “wiring”
Can be laminated between glass or applied onto glass or plastic by adhesive film

- Environmentally stable
- Highly Flexible
- Highly Transparent
- Uniform Lighting
- Lightweight

(Photo Source: Lumitronix, CHASM)



- Base film for LED array (AgeNT-1)

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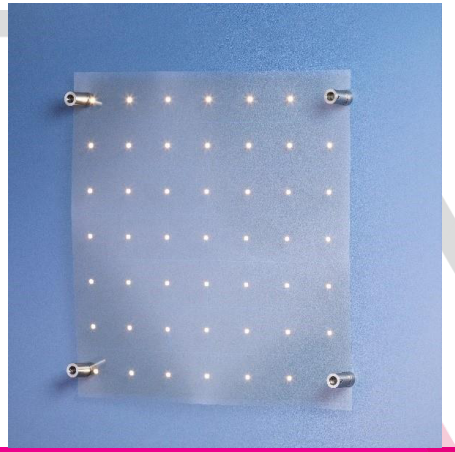
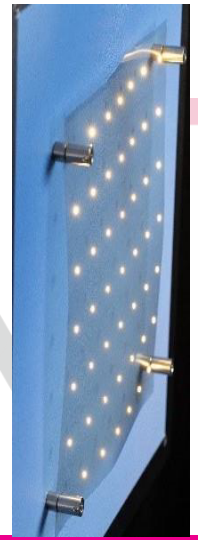
Summary

- 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 with industry standard processing technologies
- Enabling technologies providing access to a wide range of new and existing markets
  - Options for diversification of product and application portfolios
  - Potential for diversification of the existing customer base





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You can also join us on LinkedIn by searching for "Dr. David Shaw", "Tom Eldridge", "A-Gas Electronic Materials" and "Chasm Advanced Materials" to continue the conversation.