

Advanced Display Manufacturing Technology

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September 28, 2017

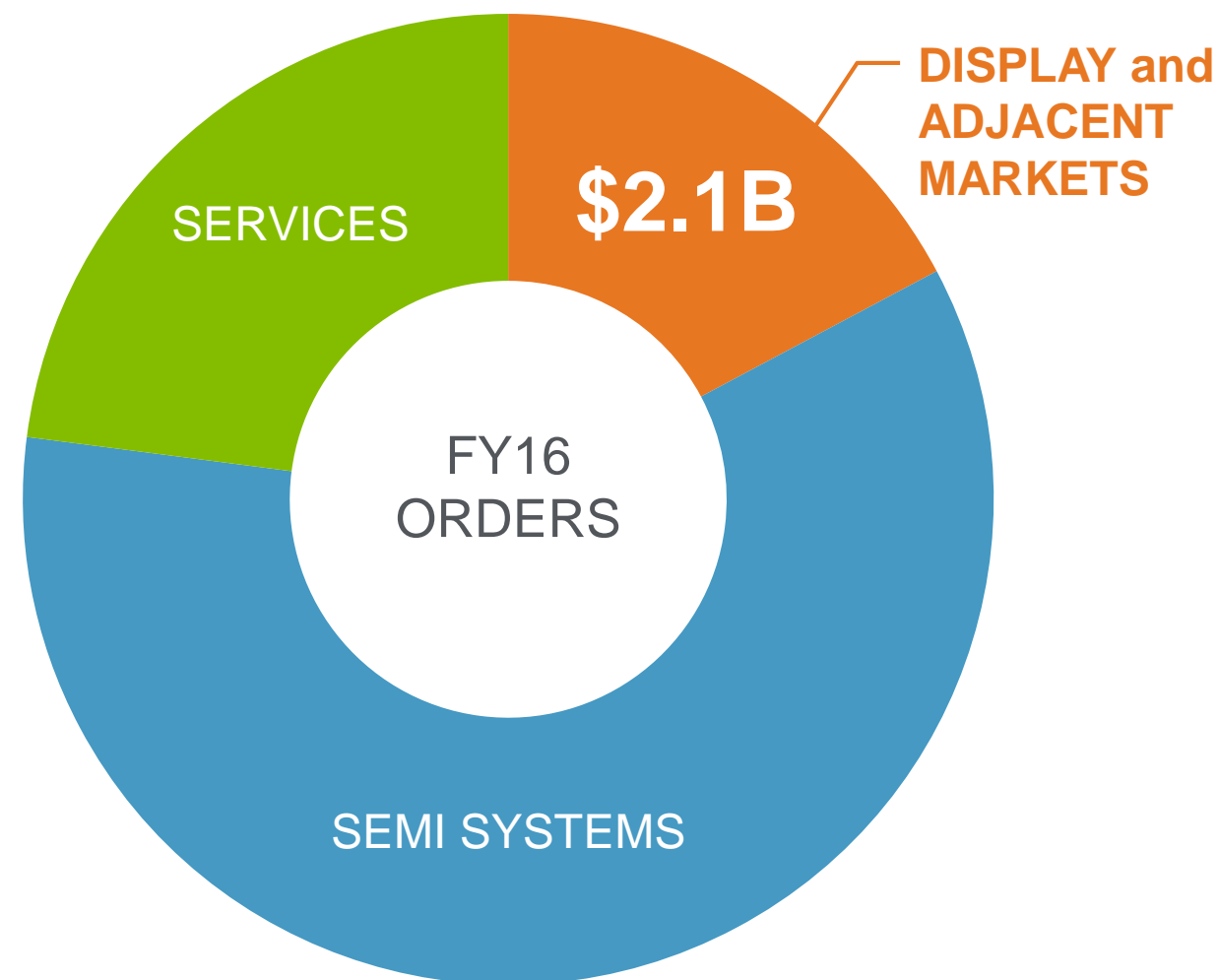


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50 years
of materials
innovation

APPLIED TODAY



Applied Materials is the world's leading display and flexible electronics equipment manufacturer with **25 years of materials engineering experience on large area rigid and flexible substrates**



GEN 10+
GLASS

9.9m²



300mm Wafer

2.9m

3.4m

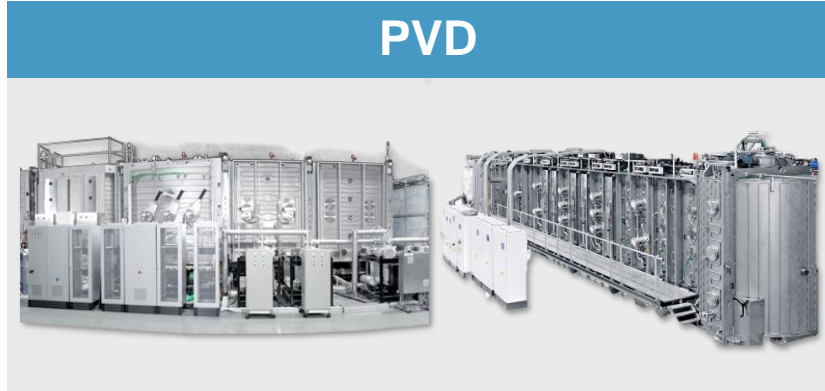
Applied's Display and Flexible Technology Products

CORE PRODUCT PORTFOLIO

CVD



PVD



Thin Film Encapsulation



E-Beam Tester



Roll-to-Roll E-Beam Evaporation PVD CVD



In-Line SEM Review



HUMANS CRAVE INFORMATION

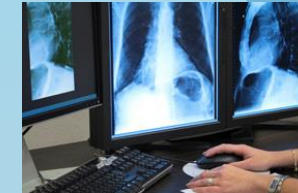
Social Networking



Productivity



Health



Fashion



HUMANS ARE VISUAL



Entertainment



Education



Safety



Displays are the Window to the Information Universe

New Display Era on the Horizon

LCD Era CRT Replacement



Laptop PC



Monitor



Large Screen TV

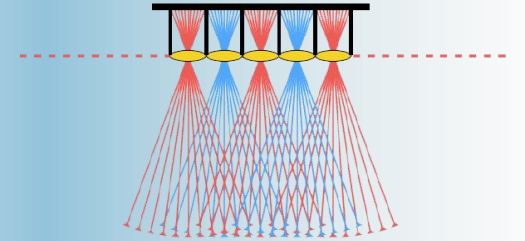
TODAY



OLED Era



Advanced 3-D Era



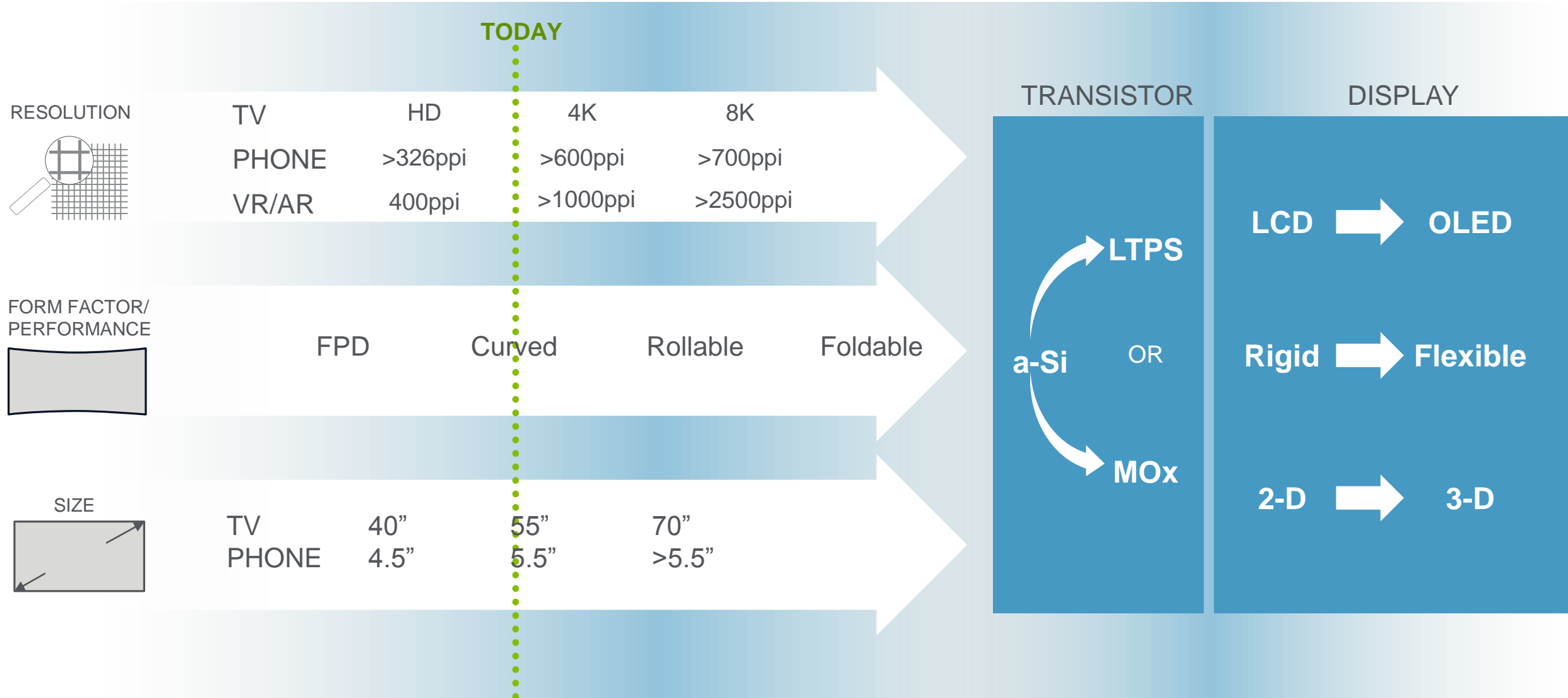
SCALING

RESOLUTION

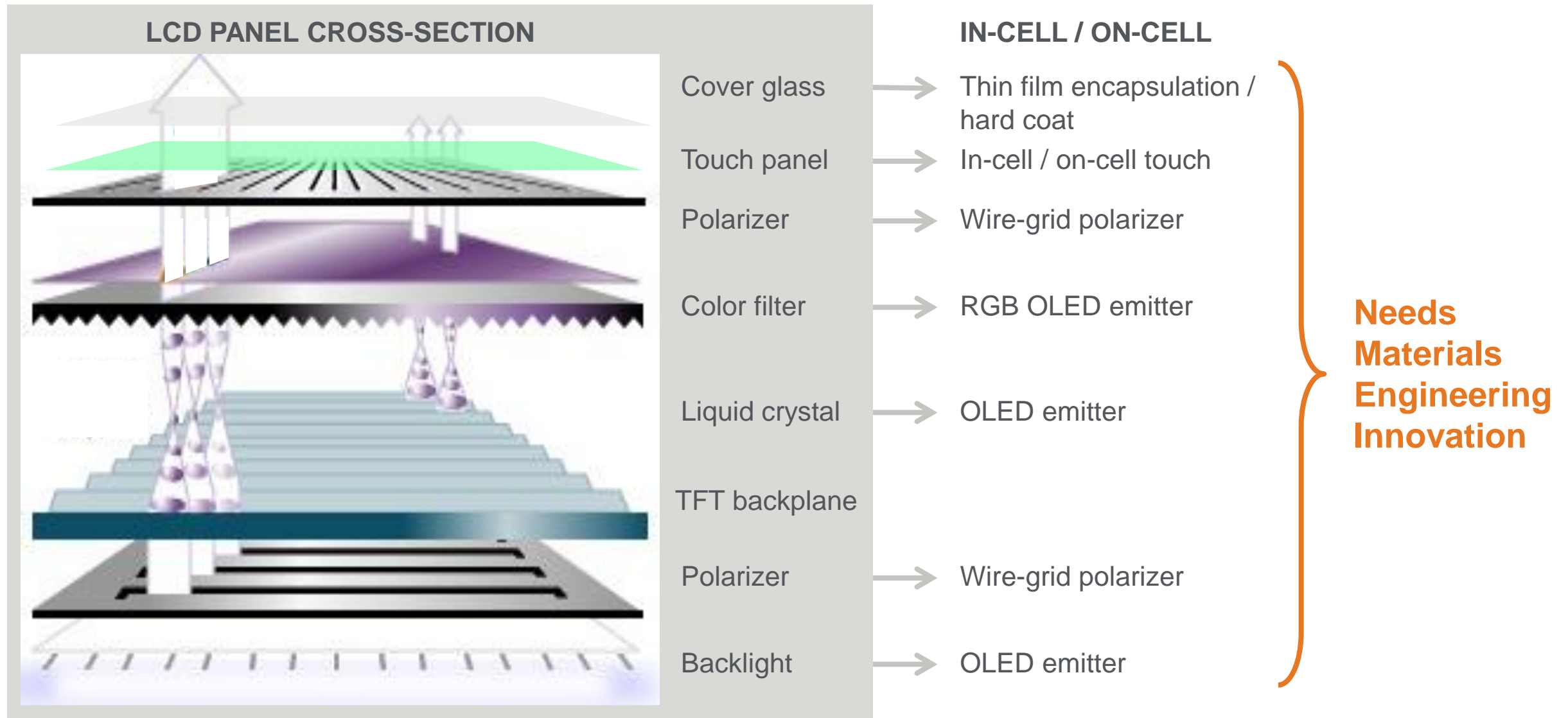
FORM FACTOR / VISUAL PERFORMANCE

2-D → “NATURAL” 3-D

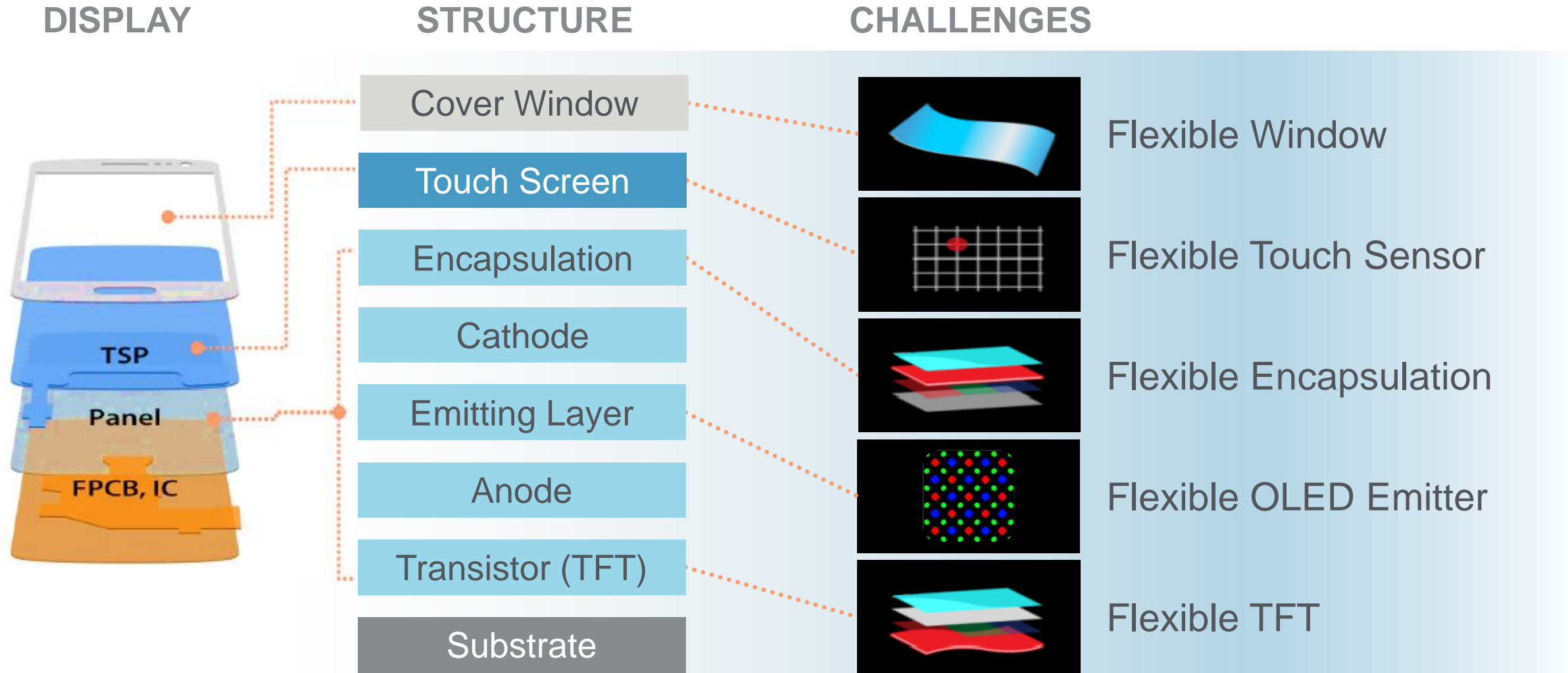
Display Technology Roadmap



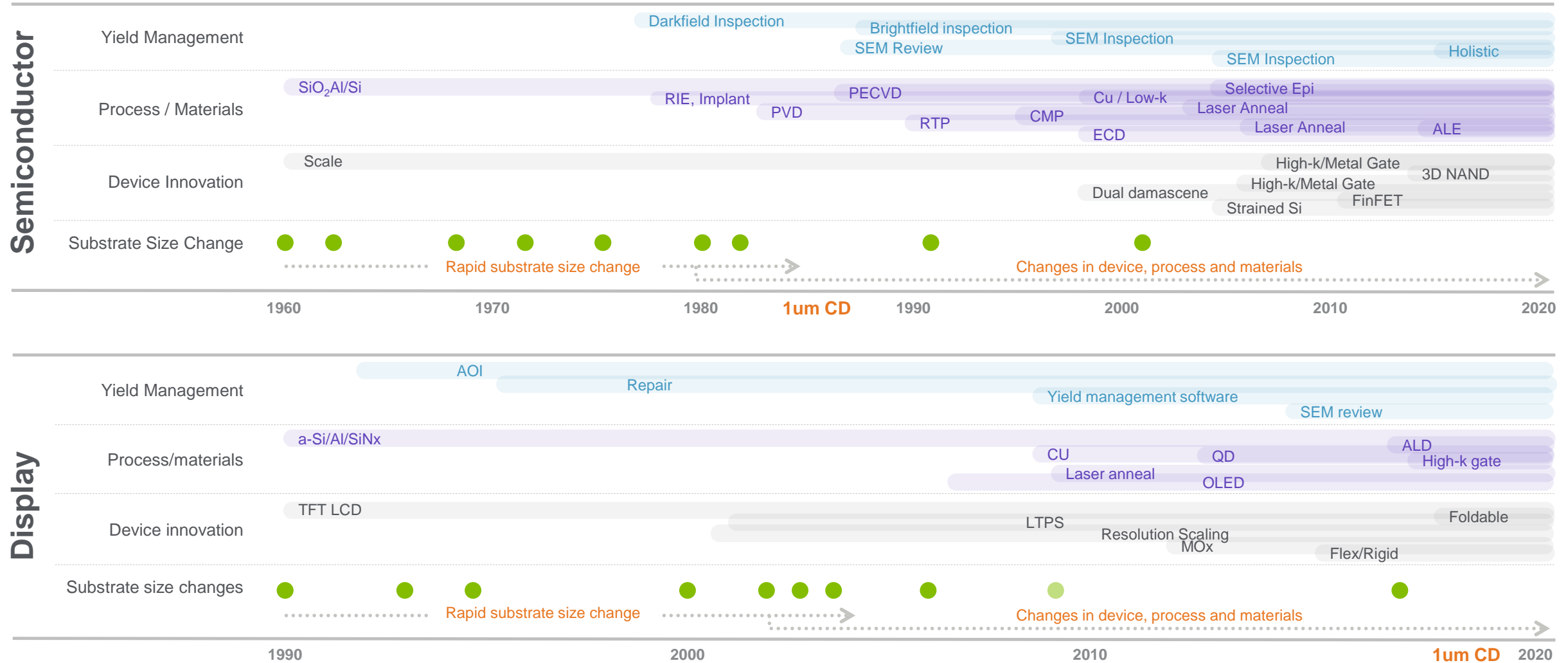
Display “Mega-Trend”: Components to Process



Key Technology Challenges for Flexible Displays

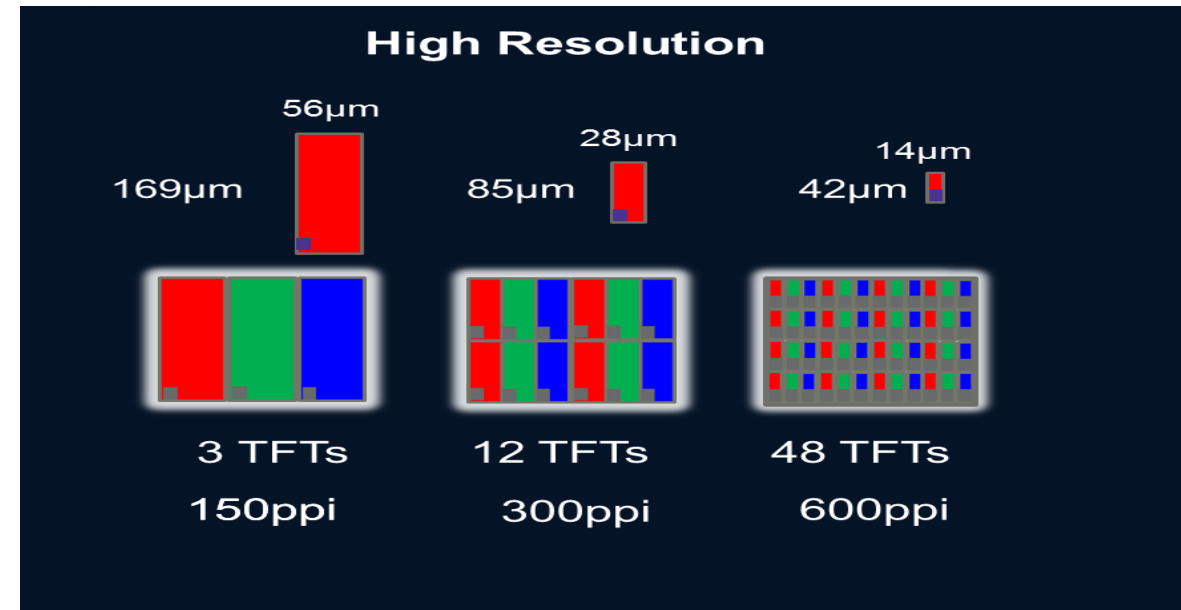
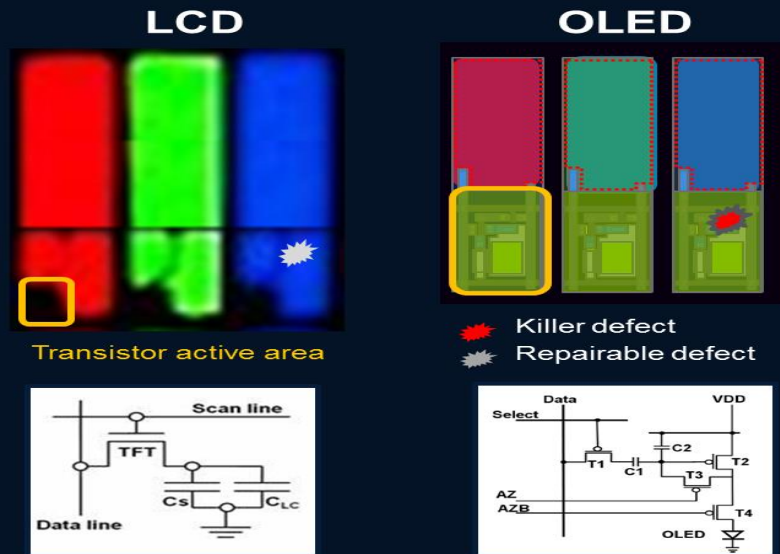


Increasing Complexity in Semi...and Display

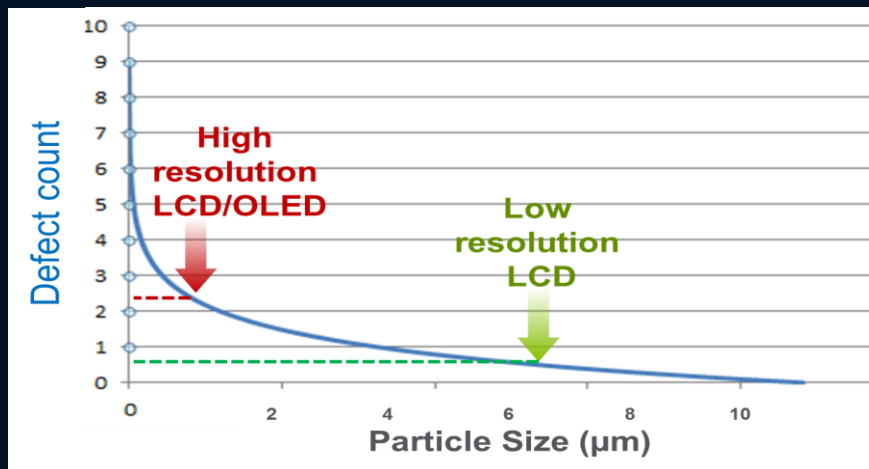


Display can Leverage 30 Years of Semi Technology, Methodology and Knowhow

Backplane Yield Challenge Example: Particles



Smaller TFTs have more (& smaller) killer particles



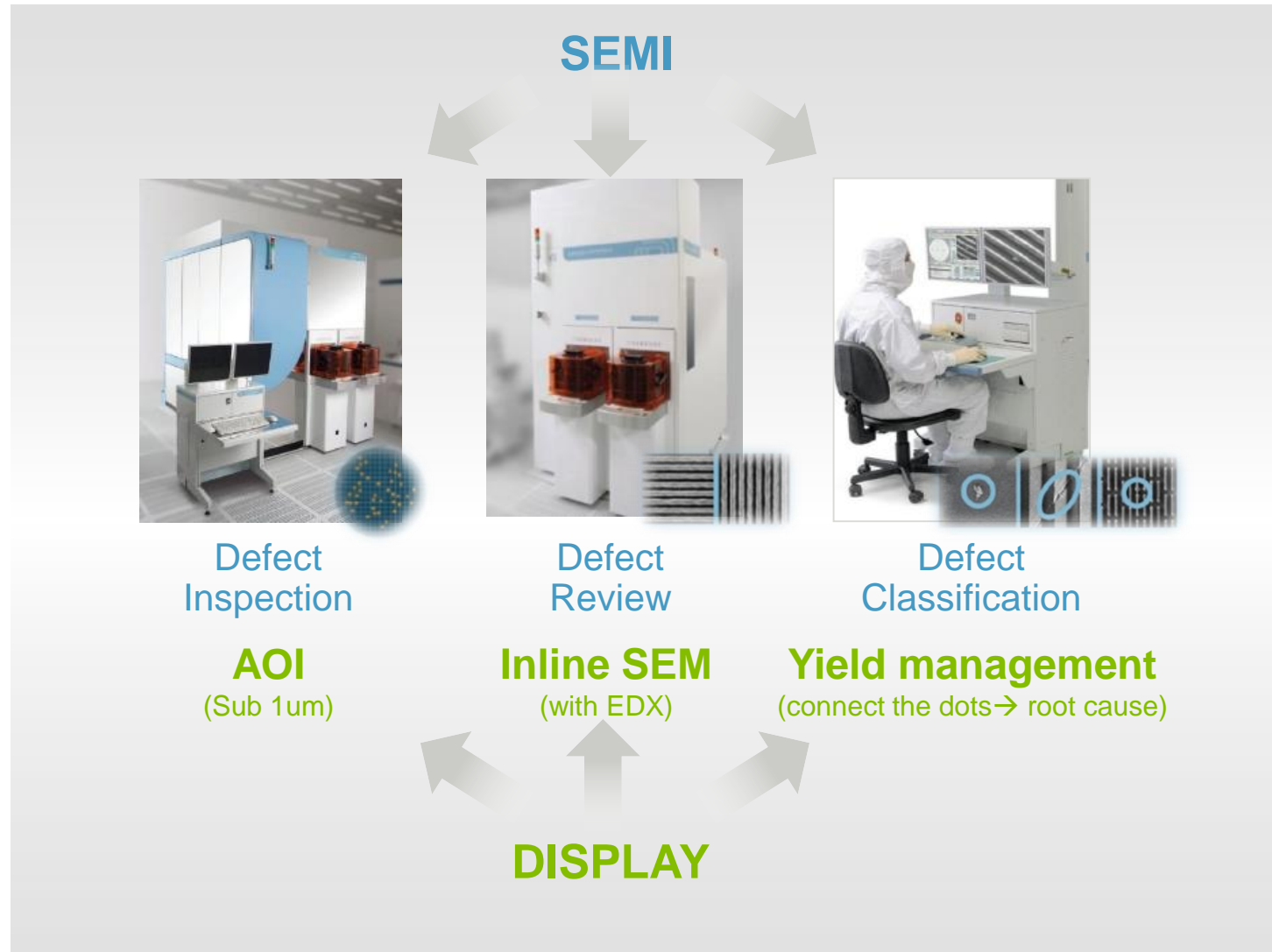
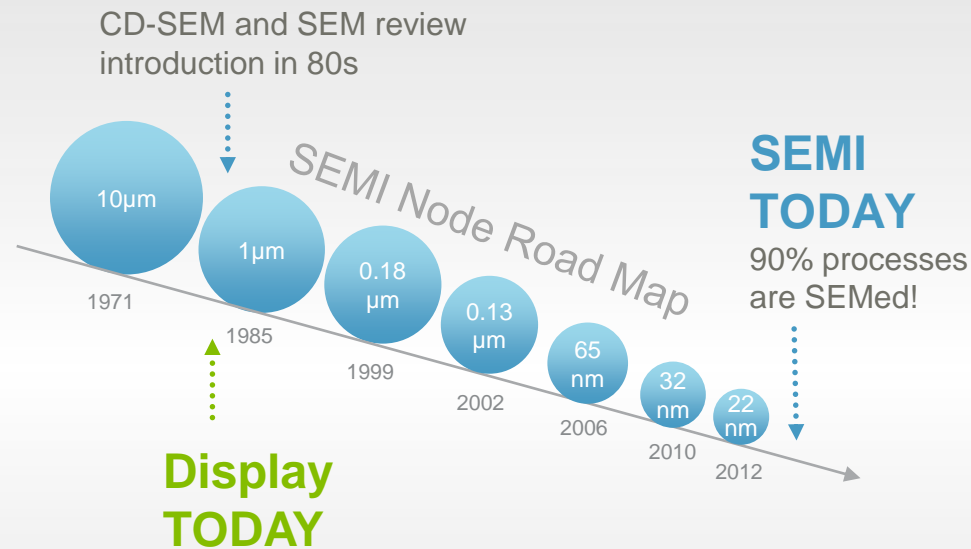
- OLED TFT active area larger than LCD increasing chance of “killer particle”
- Increasing resolution increases # transistors/area → requires smaller TFT → increases # of killer particles

Semiconductor Methodologies for Advanced Displays

Example: Yield Management

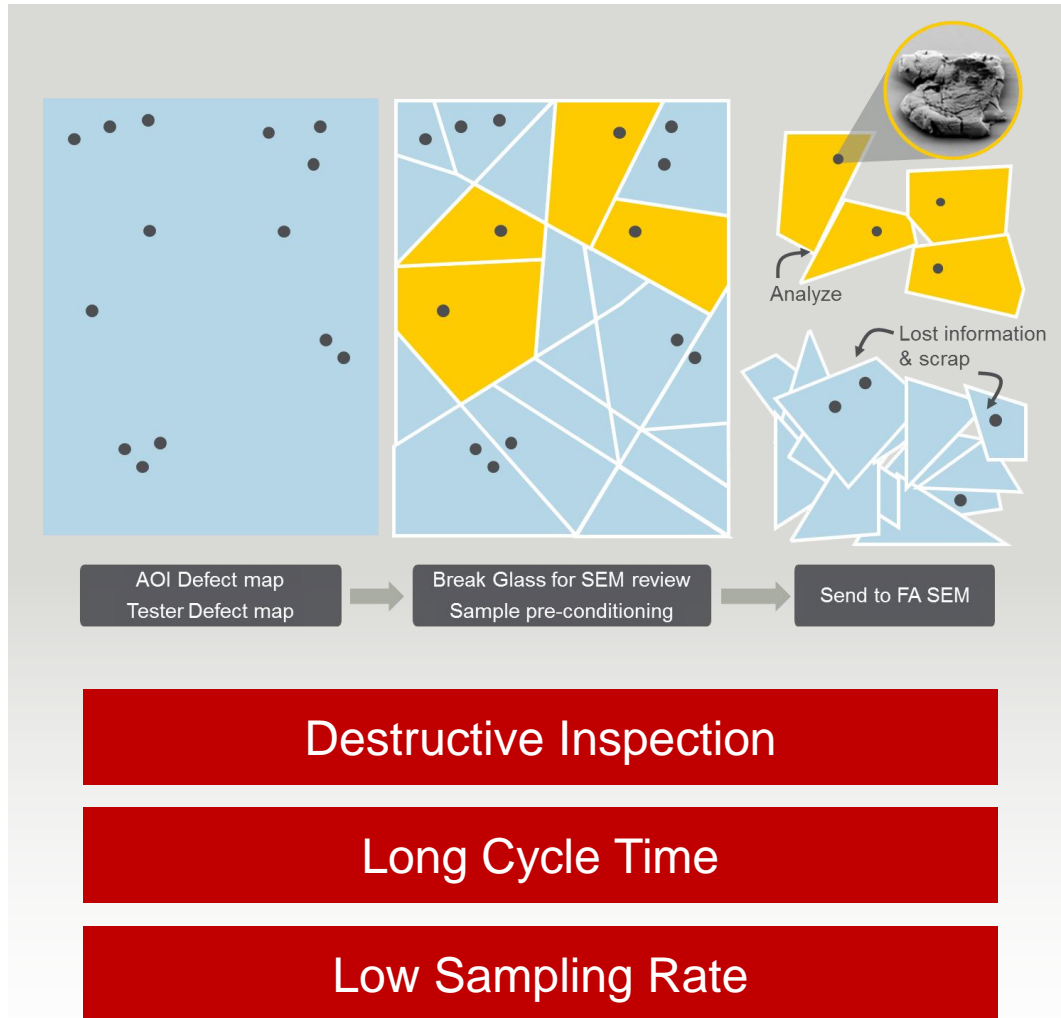


Semiconductor Yield Management: Enabled by Inline SEM

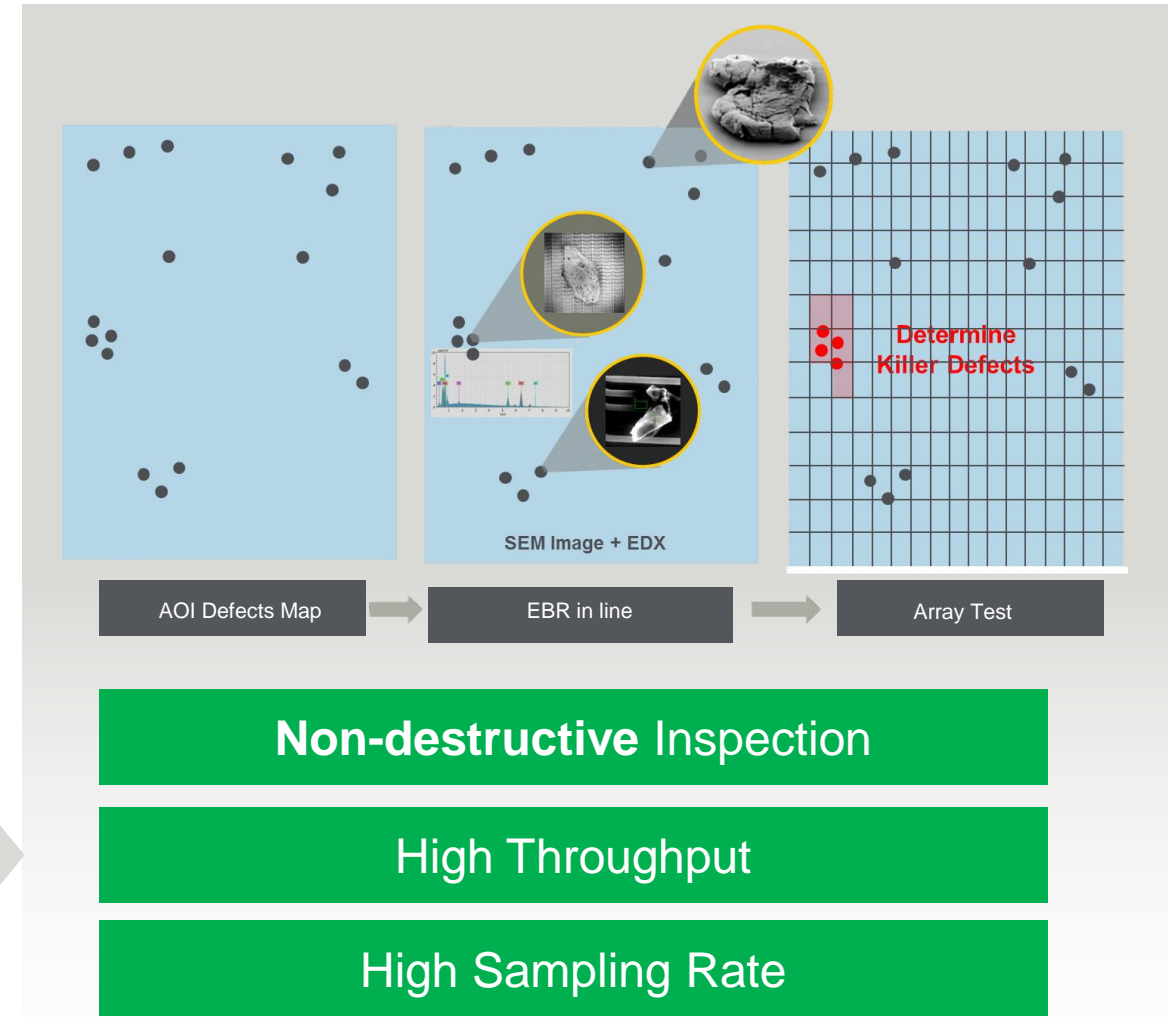


New Inspection Methodology for Advanced Displays

Old way (Lab SEM)



New way (Inline SEM)



Inline SEM Brings Semi Methodologies to Display

Inspection & Review (defects)

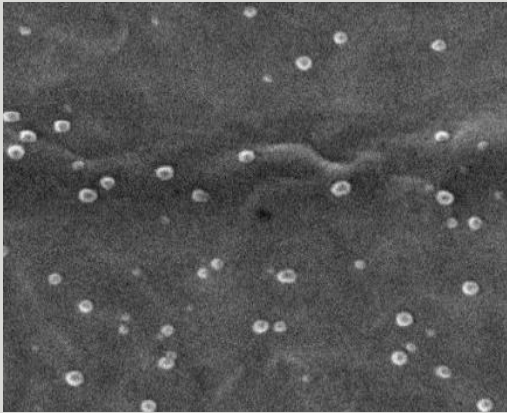
Metrology

Auto Process Inspection (API)

Auto Defect Review (ADR)

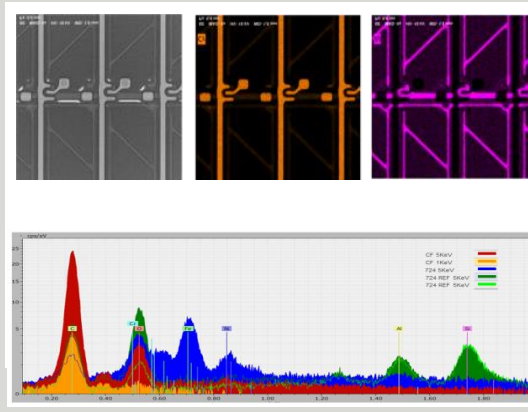
Auto-CD (ACD)

Process & Defects



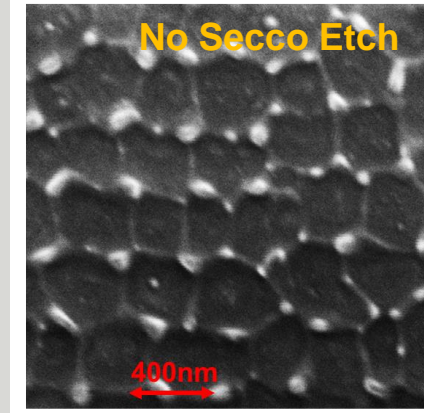
ITO residue

Composition Analysis



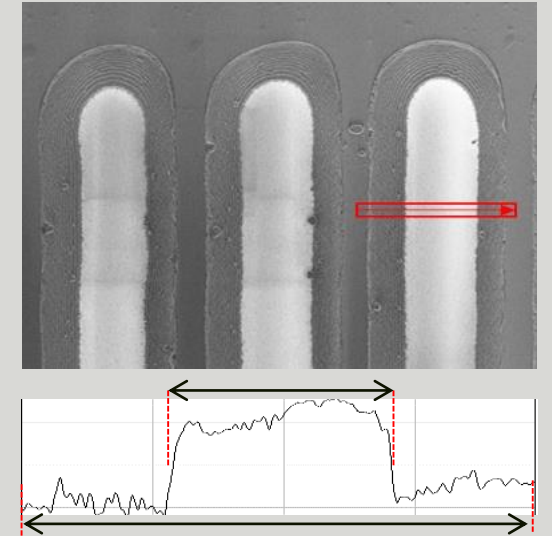
EDX & BSE

LTPS Grain Analysis



ELA in-line Monitoring

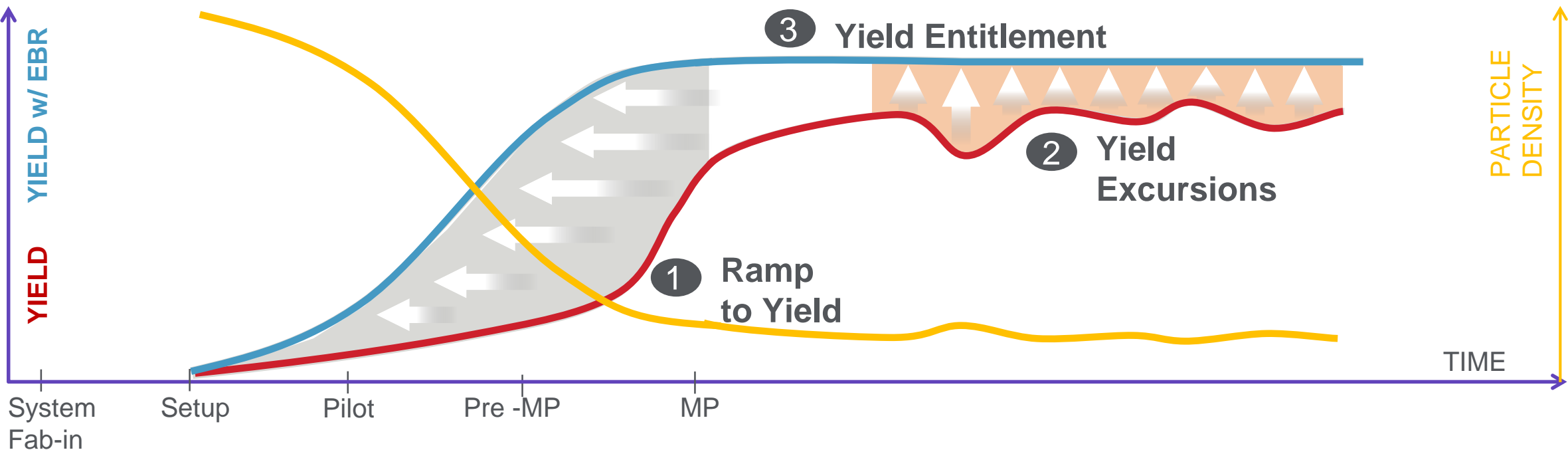
CD Measurements



Accelerates yield by “connecting the dots”

Inline SEM + yield management software → fast ramp & high yield

EBR Time Machine



[w/o EBR]

- Process time \leq 60sec
- Inspection \leq 60 sec
- Measurement \leq several mins
- Analysis \geq several hours or days

P	I	M	Analysis
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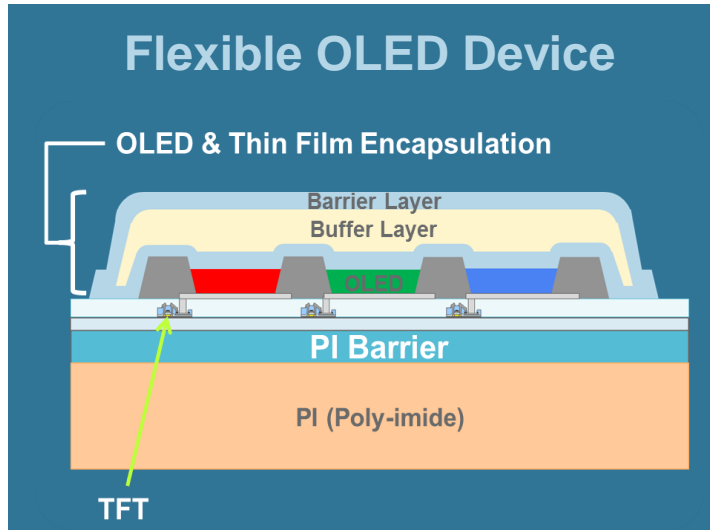


[w/ EBR]

- Process time \leq 60sec
- Inspection \leq 60 sec
- Measurement \leq several mins
- Analysis \sim several mins

P	I	M	Ana
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Thin Film Encapsulation (TFE) Requirements



Barrier Performance
Stress Control
Optical Transmittance

Mask Depo

Buffer Technology

PROCESS	REQUIREMENTS	PURPOSE
Depo temperature	<100°C	Device protection
Mask depo	Mask deposition	Bonding pad
Water vapor transmission rate (WVTR)	<1E-6g/m ² ·day	Long lifetime
High deposition rate	>2,500Å/min	High throughput
Low stress	~ 0	Avoid cracking of metal electrodes or film itself
High visible light transmittance	>90% at wavelength ≥400nm	Increase brightness
Good adhesion	No film peeling	Device integrity
High flexibility	Mechanical duration	Tolerate mechanical bending through lifetime
Conformal particle coverage	No voids or diffusion channels	Eliminate water and oxygen permeation

Enflexor Gen6H TFE Solutions for High Resolution Flexible OLED

SUBSTRATE SIZE

925 x 1,500mm²

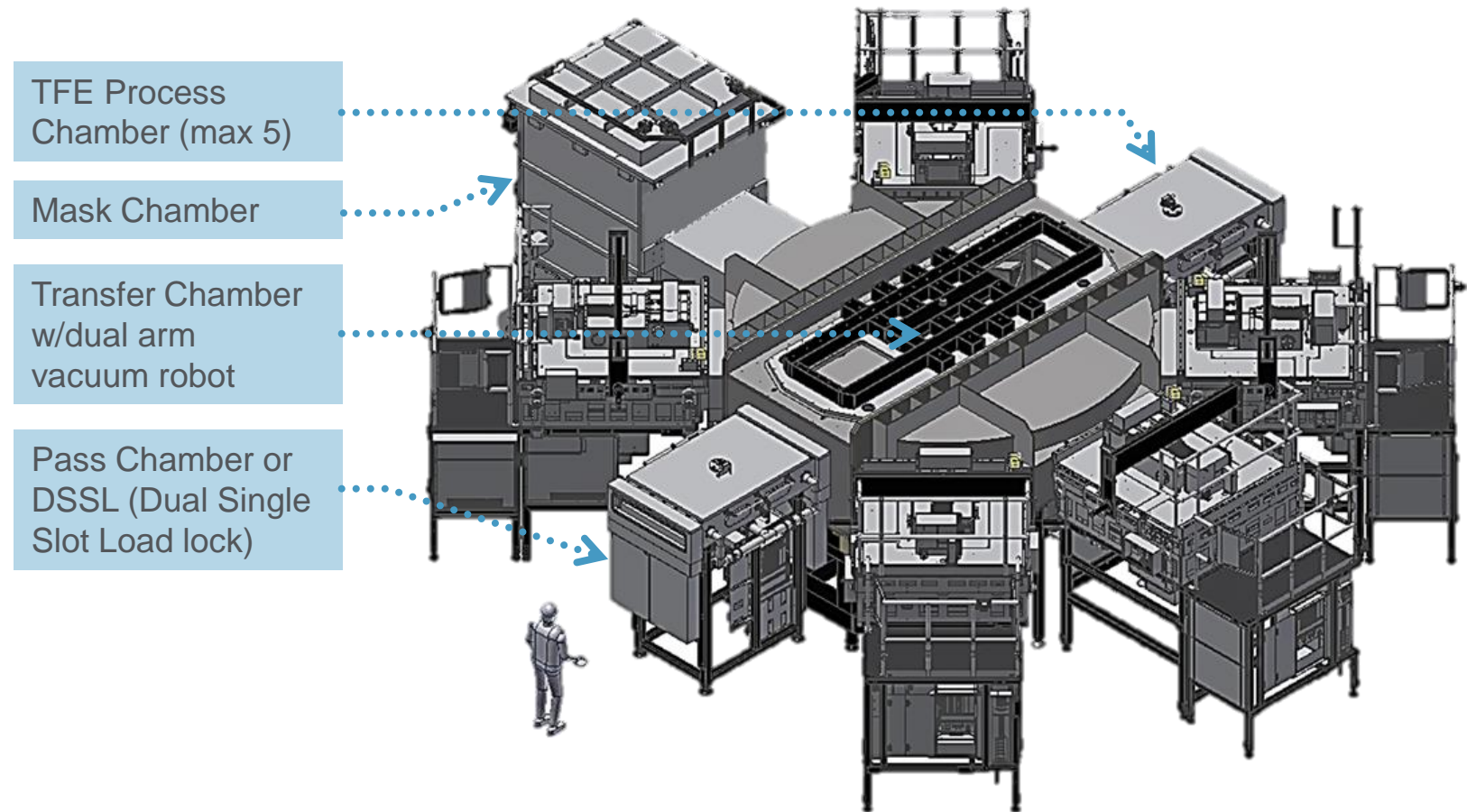
SYSTEM ARCHITECTURE

Single substrate operation system at cluster tool

- ▶ Max 5 TFE process chambers
- ▶ Mask chamber
- ▶ Pas chamber or DSSL (Dual Single Slot Load lock)
- ▶ Transfer chamber
- ▶ Dual arm vacuum robot

KEY ADVANTAGES

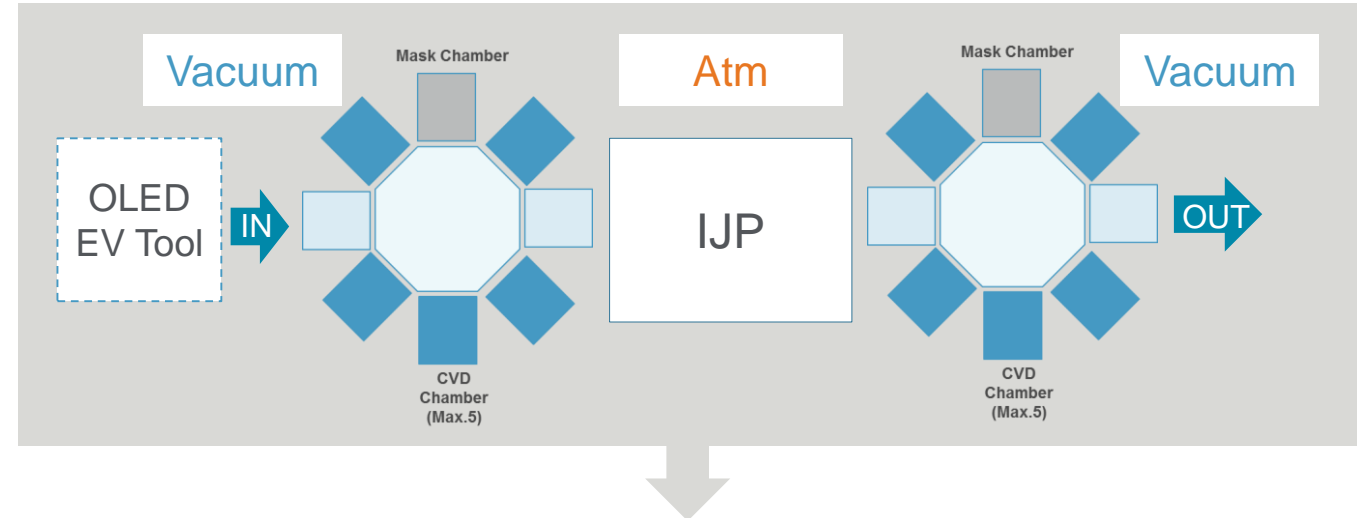
Superior WVTR & uniformity
Particle control
High system reliability



“One Cluster Solution”

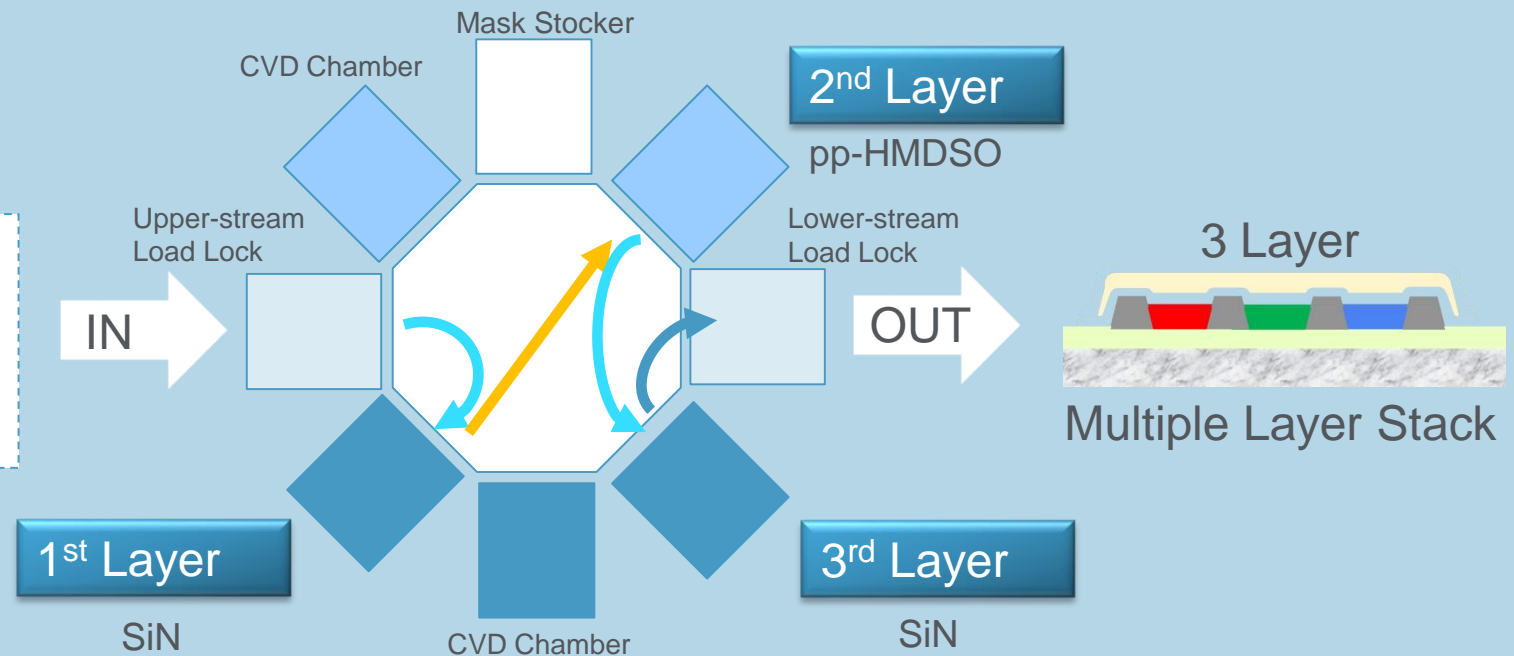
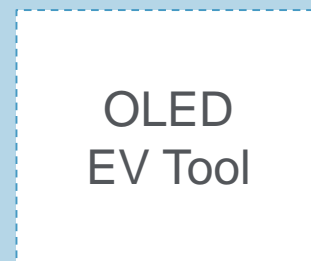
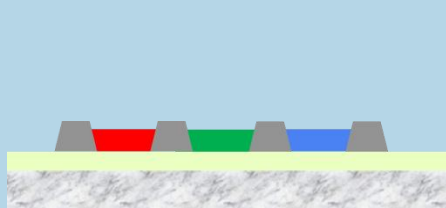
Complete All TFE process in one cluster


- ▶ Vacuum Connection to EV tool
- ▶ Flexible sequence control by MCC software
- ▶ High reliability mainframe and vacuum robot
- ▶ Mask deposition with auto mask exchange and mask stocker



TFE Technology for OLED mass production new concept

All process under vacuum





Displays are the window to the “information universe” and **better displays are constantly in demand**

Many display technology inflections **need materials engineering innovation**

Display industry can leverage **semiconductor methodologies** to enable increasingly complex displays

