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KOREA**

High-Resolution OLED Display Driver IC Testing: Trends and Challenges

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Agenda

- ❑ Introduction
- ❑ Display Technologies and Trends
- ❑ OLED Advantages, Disadvantages, and Challenges
- ❑ OLED DDIC Test Key Concepts
- ❑ Addressing Technical and Economic Challenges of OLED DDIC Test



Cohu Introduction

The Evolution of Cohu – 50+ Years of Expertise



Global Technology and Market Leader

 **~\$814M**
LTM Revenue ⁽¹⁾

 **3,000+**
Employees

 **23,700+**
Equipment Installed Base

SEMICON® KOREA

Cohu

Market and Technology Leadership

Strong position in each business vertical



#3

Semi Tester⁽¹⁾

High fidelity measurement instruments
Compact, low-power systems → Scalability



#1

Test Interface



#1

Services⁽²⁾

Global footprint
Data analytics



#2

Inspection & Metrology

Thermal and Vision Inspection
Technologies enabling higher yield



#1

Test Automation

(1) Leading supplier of RF Front-End test equipment; company estimates

(2) Service business of Cohu systems



Display Technologies and Trends

OLED Advantages and Disadvantages

Mass Market Flat Panel Displays – Technologies and Applications

Smartphone



Smart Watch, Wearables



Tablet, Laptop



TV, Monitor



OLED



LED/
miniLED/
microLED



LCD (Active
TFT/ LTPS)

Automotive



Outdoor/Video Wall



AR/VR



Modern Flat Panel Display Technologies

❑ LCD (Liquid Crystal Display)

- Tiny rod-shaped molecules change orientation in the presence of electric current
- Angle of the tiny rod-shaped determine amount of light passing through
- Electrode pair for each color dot is controlling the liquid crystal angle
- White LED backlight, Combination of 3 color filter provide actual color

❑ QLED (Quantum Dot LCD with LED Backlight)

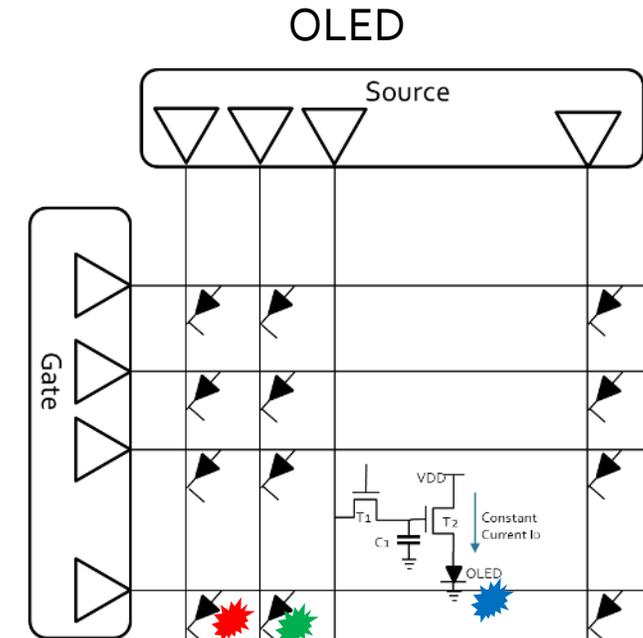
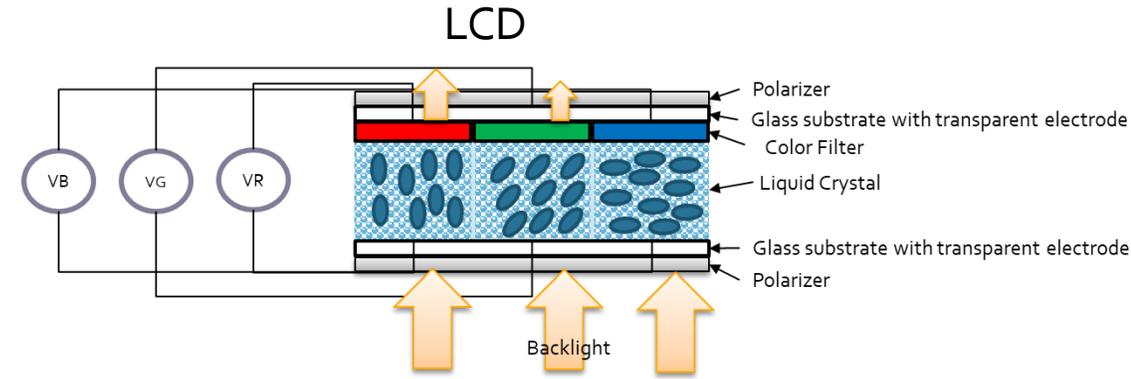
- Tiny crystals emit color when you shine blue or ultraviolet light on them
- Use a blue LED backlight instead of white
- Emerging OLED backlight, transition from miniLED

❑ OLED (Organic Light Emitting Diode)

- Using organic carbon-based compounds, OLEDs are mass fabricated on plastic sheets
- OLEDs emit light in response to an electric current; no backlight
- Current flow through transistor is control by capacitor voltage
- RGB OLED vs White OLED with Color Filter (cost down)

❑ MiniLED, MicroLED, and More

- MiniLED – Tiny discrete LEDs, used for backlighting of LCD panel or to make large scale display pixels
- MicroLED – Microscopic discrete LEDs to create the entire display pixels
- MicroOLED – Tiny High PPI OLED for VR
- Liquid Crystal on Silicon – Tiny High PPI LCD for AR/VR



OLED Display Trends

Benefits over LCD

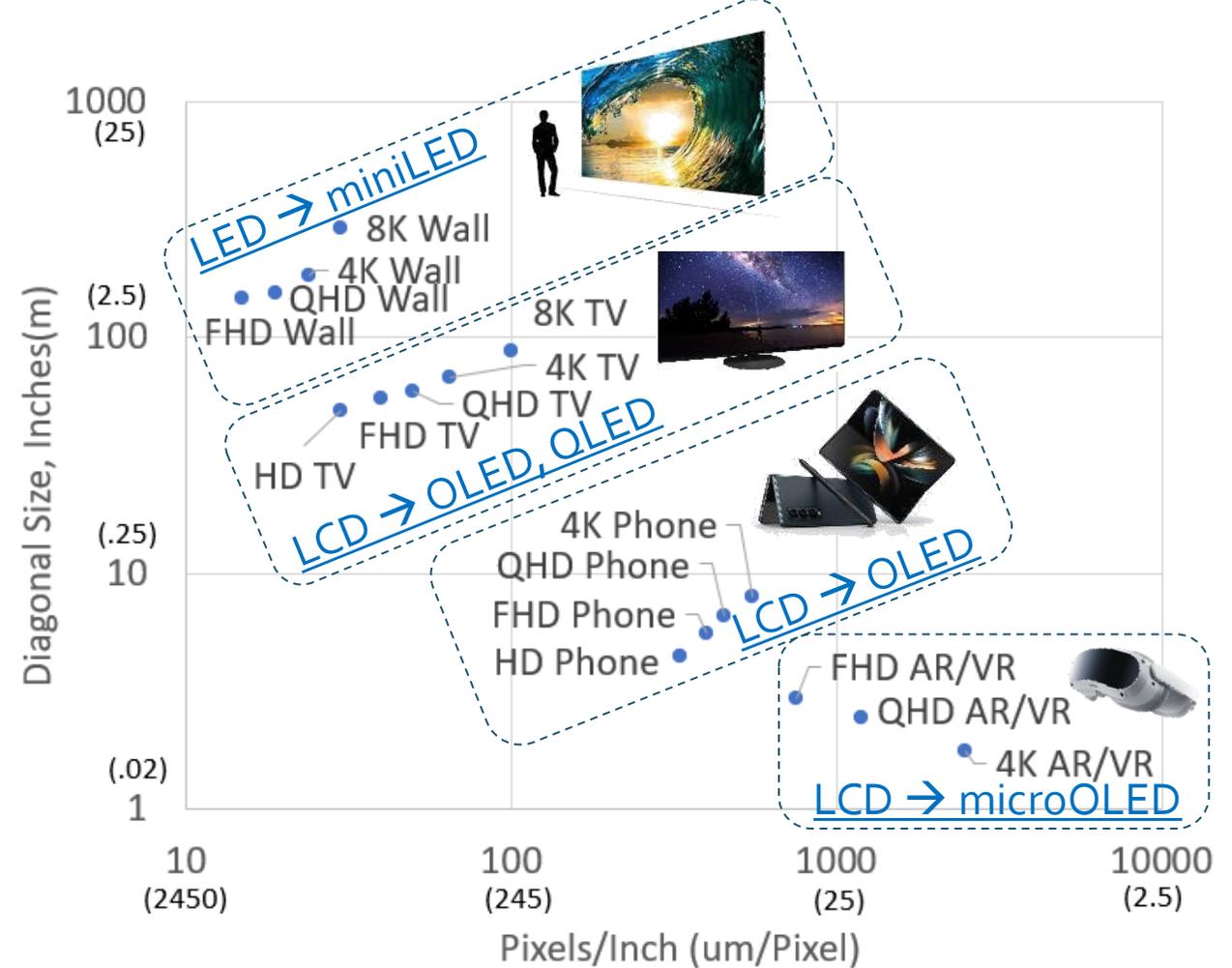
- Self-light emission → Wide viewing angle, improved contrast and color gamut, lower power, faster response time
- Eliminates use of backlight module → Ultra-thin design
- Flexible → Innovative form factors

Disadvantages

- OLED display has a higher cost than TFT-LC mainly due to yield issues
- Long-term reliability concerns

OLED becoming dominant in high-end phones and TV, smartwatch, AR/VR

Emerging in high-end automotive



OLED Enabling Re-Diversification of Mobile Form Factor

Samsung Display Investor Presentation 2022





OLED DDIC Test Key Concepts

Addressing Technical and Economic Challenges

Mobile DDIC Structure and Test Requirements

Highly Integrated IC

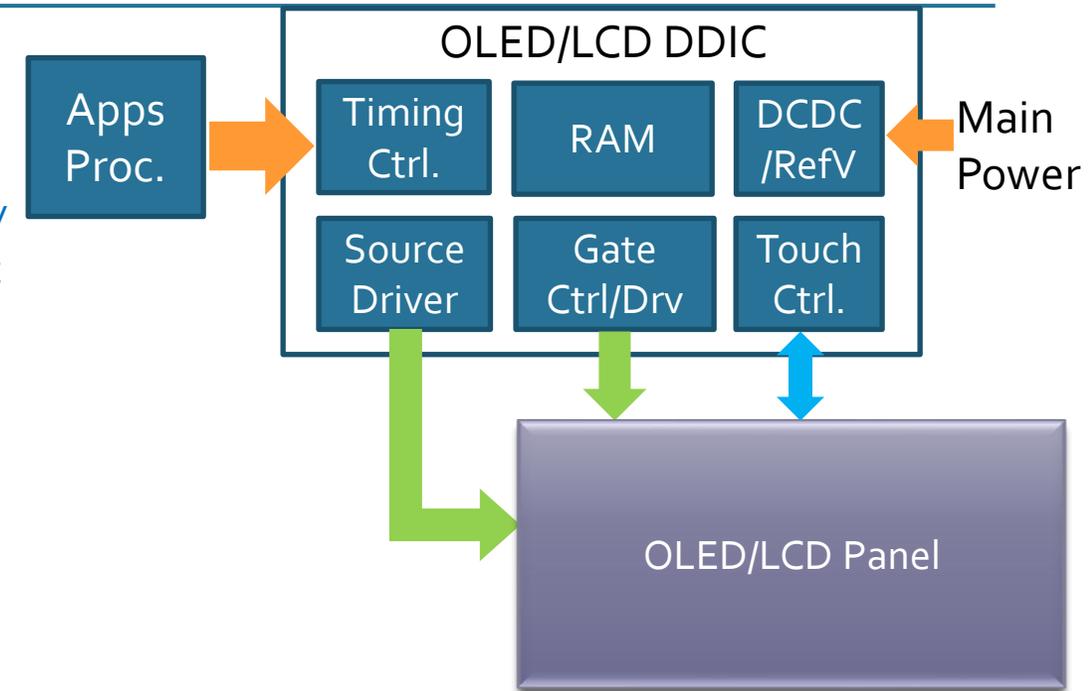
- High Speed Digital Receiver: MIPI D-Phy/C-Phy, with HS/LP modes, Speeds increasing to 6Gsym/s+ → High speed digital instrument
- Timing Controller (TCON), Scaler, RAM → Full digital test capability
- DC-DC, LDO, Gamma Reference Supplies → Full analog/power test capability
- Source and Gate Drivers → Specialized high channel count DDIC instrument with high voltage digitizer/comparator/TMU
- Touch Sensor Integration → Additional mixed-signal instrumentation requirements

Usually Chip-on-Glass (COG) or Chip-on-Plastic (COP)

- Requires known-good die → comprehensive testing at probe, incl. full mixed-signal, power/trim, high-speed digital
- Chip-on-Film (COF) sometimes used bezelless display
→ Requires expertise in test cell integration with probers and COF handler

Ultra-High Pin-Counts and Multi-Site Cost Down

- Basic HD Mobile device: 720 columns * R/G/B = 2160 channels
- Higher resolution devices have even more channels
→ Requires high density, scalable, cost-effective test solution



TV/Monitor Panel DDIC

❑ Separate IC for TCON, DC-DC, Gamma VRef, Gate Driver, Source Driver

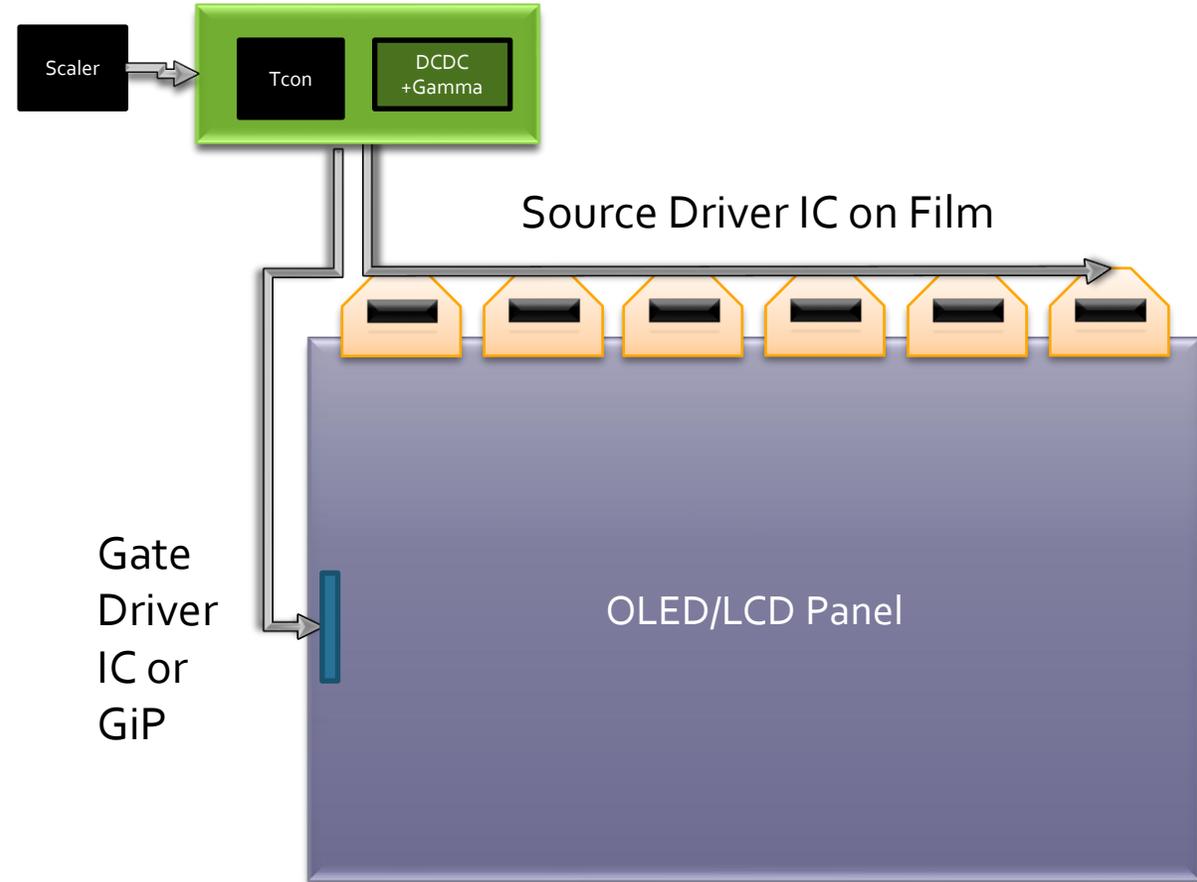
- Multiple Source Driver ICs used to achieve higher resolution and drive large panel
- HDR Wide Color Gamut driving higher resolution Source Drivers
- Higher Brightness OLED driving higher Source drive current
- High Speed SerDes Interface: 3-4Gsym/s, moving to 6Gsym/s+

❑ Source Driver ICs are usually on COF packages.

- Fold and hide on the backside of the panel
- Also provides another layer of fanout of IC signals to larger pitch I/O on panel

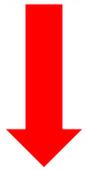
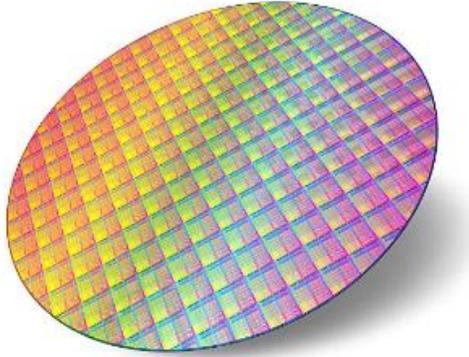
❑ Key Test Challenges/Requirements

- Specialized DDIC instrument
 - High voltage digitizer, comparator, TMU; Enhanced accuracy for HDR and higher load capability for brighter OLEDs
- High Speed Digital SerDes Instrument
- COF Package extremely sensitive to leakage <<10nA
- Probe and COF Test Cell Integration Expertise

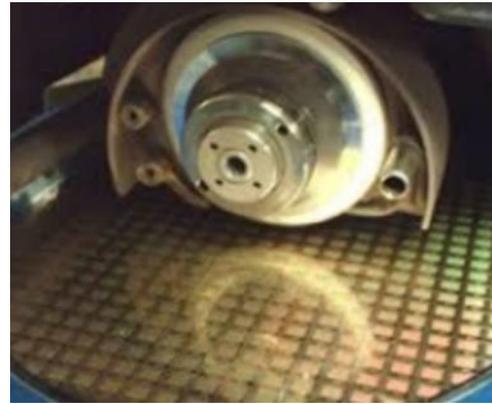
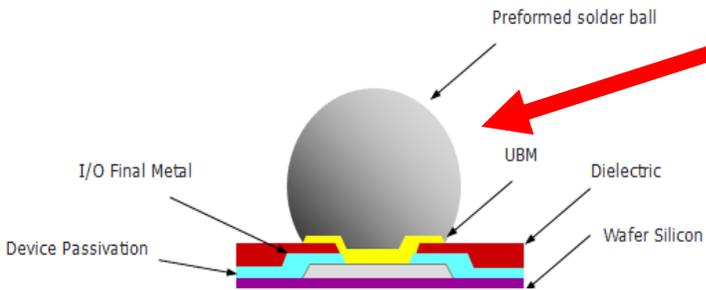


Chip On Glass/Chip On Plastic (COG, COP)

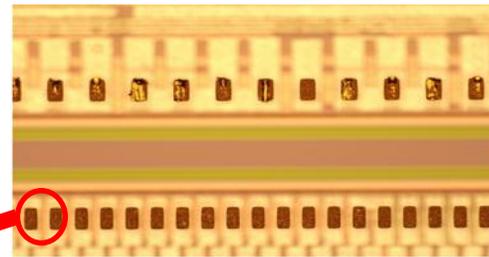
Wafer



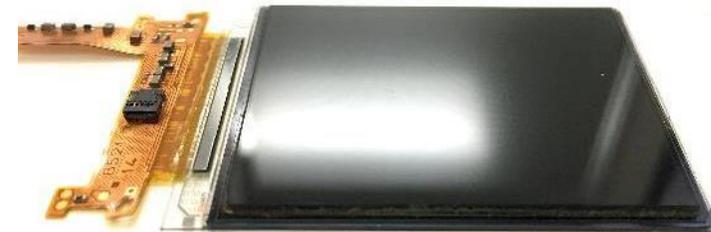
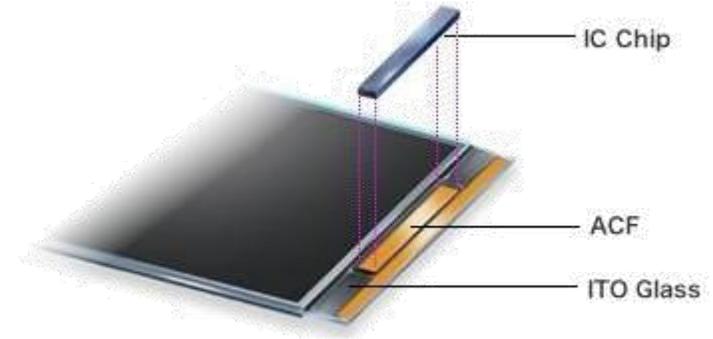
Gold Bumping



Wafer dicing

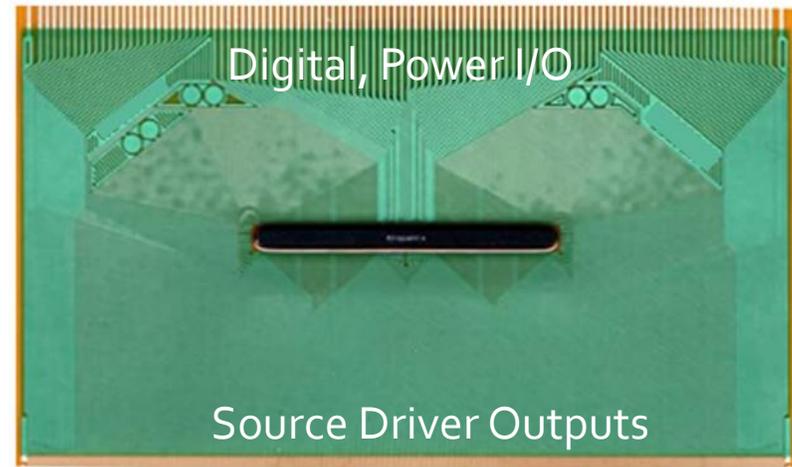
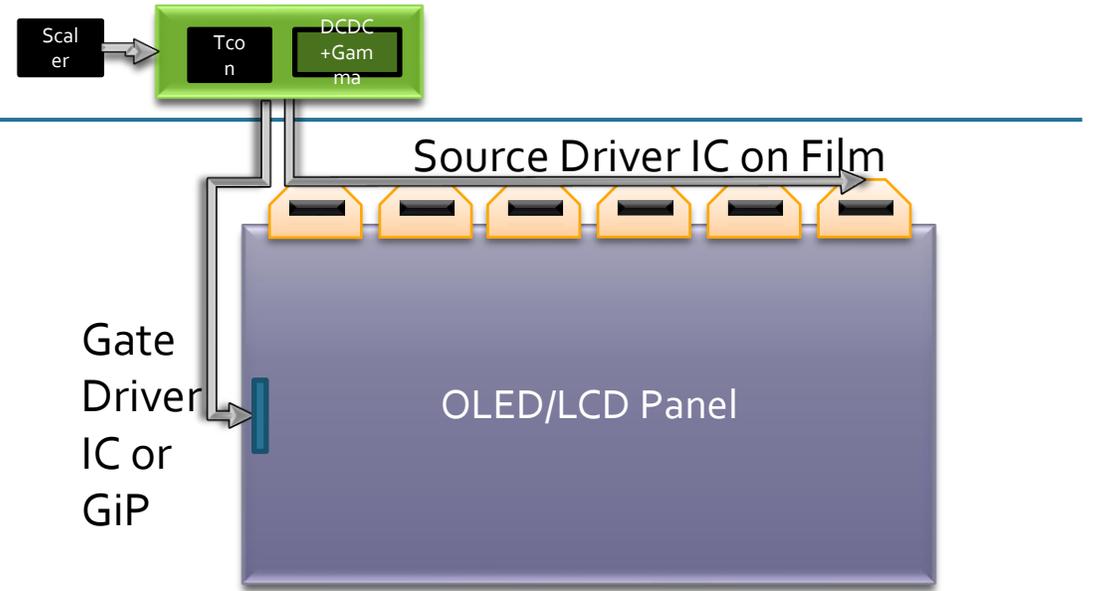
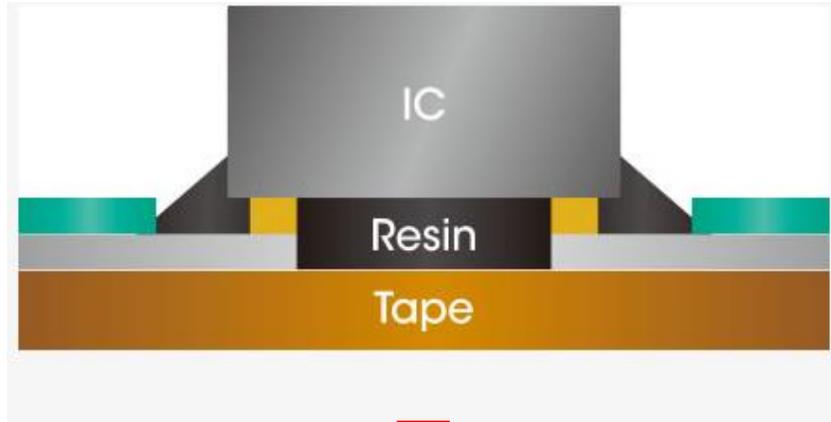


Wafer gold bumping



Final Product

Chip On Film DDIC (COF)



OLED DDIC – Addressing Economic Challenges

*OLED becoming dominant in high end phones and TV, smart watch, AR/VR...
...BUT, significant cost gap versus LCD persists*

❑ Essential Elements for Cost Reduction and Risk Management

- Complex IC with extreme pin count requires aggressive multi-site strategy → Need scalable test system that can meet multi-site requirements
- Increasing integration and modularization, such as OLED TDDI and AR/VR micro-display → Need flexible system that can handle full range of DDIC, analog/power, digital, mixed-signal, even wireless requirements
- Automotive OLED driving need for high reliability and tri-temp test → Test partner must have extensive experience with tri-temp and data analytics for automotive
- Continual focus on test time reduction → High throughput tester architecture and optimized test IP
- Fast-moving display market landscape requires continual focus on fast time to market → Structured approach to getting DDIC to market quickly to maximize profit

Cohu Diamondx Tester – Key Benefits



40 Slot



20 Slot



5 Slot

❑ Low Cost

- Air-Cooled, Small Footprint
- Scalable Infrastructure, from Zero Footprint to Massive Multi-Site
- Leading-Edge Throughput and Multi-site Efficiency

❑ Wide Range of Capability

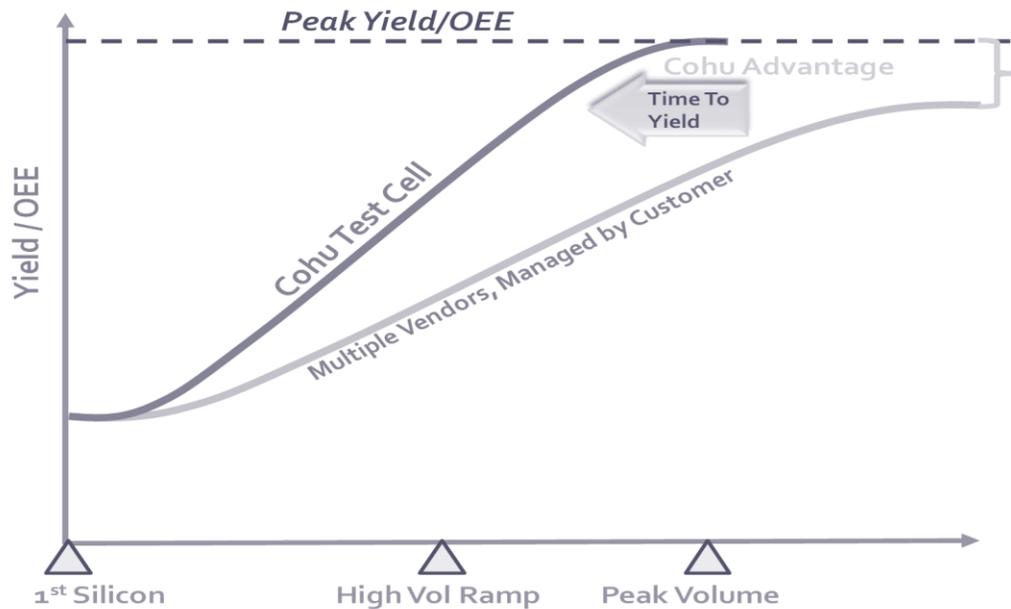
- Display Driver IC
- Wireless: 5G, Wi-Fi 6/7, PA/FEM, IoT
- PMIC, BMU, Automotive
- Logic: MCU, TCON, AP, DTV
- SiP/MCM, Sensor, MEMS

❑ Fastest Time To Market

- Flexible Test IP and Powerful Debug Tools

Accelerating Time To Yield And Test Cell Productivity

Cohu one-stop-shop for leading-edge solutions in test & inspection



Test Cell Solutions

Semi Test

Test Contactor

Test Handler

Total Integration

Grazzi OBRIGADO PALDIES SHUKRIYA SHUKRIYA
KIITOS SPASIBO SHUKRIYA Go raibh maith agaibh Cảm ơn
SALAMAT XIEXIE DEKUJI ASANTE EFHARISTO DANKE Hsieh hsieh

NA GODE
DO JEH

GRATIAS TIBI

THANK YOU

Blagodarya

DANKE JE
Gamsahabnida
Dhanyavaad
Khub-kun

NGIYABONGA

MERCI
GRACIAS
Tusen takk
Köszönöm

DANK U
FALEMINDERIT

HVALA MAHALO
TERIMA KASIH
GRAZIE
DZIEKUJE
Doumo Arigatou