The Road to Commercialisation and Mass Production of MicroLEDs Displays for AR

Dr. Tongtong Zhu - CEO & Founder

EPIC Technology Meeting on Photonics for XR at Microsoft

27-28 May 2024

POROTECH

Reality

is beyond imagination

As the Innovation Powerhouse for GaN & MicroLEDs, Porotech is the driving force behind the MicroLED revolution. Our mission is to pave the way for the seamless convergence of visual, spatial computing and AI, bridging the physical and digital worlds to create more intuitive and context-aware interactions and interfaces.
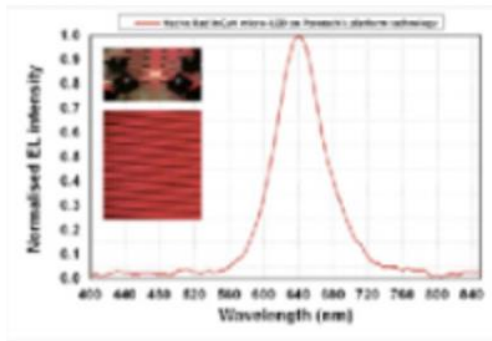
Porotech - Innovation Powerhouse for MicroLEDs

POROTECH

the World's Leading MicroLED Provider

Nov 2020

Highest Efficiency
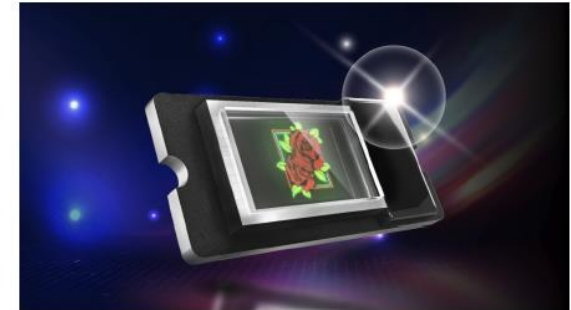
World's 1st
Commercial InGaN Red MicroLED

Nov 2021

Best Prototype
SID Display Week 2022

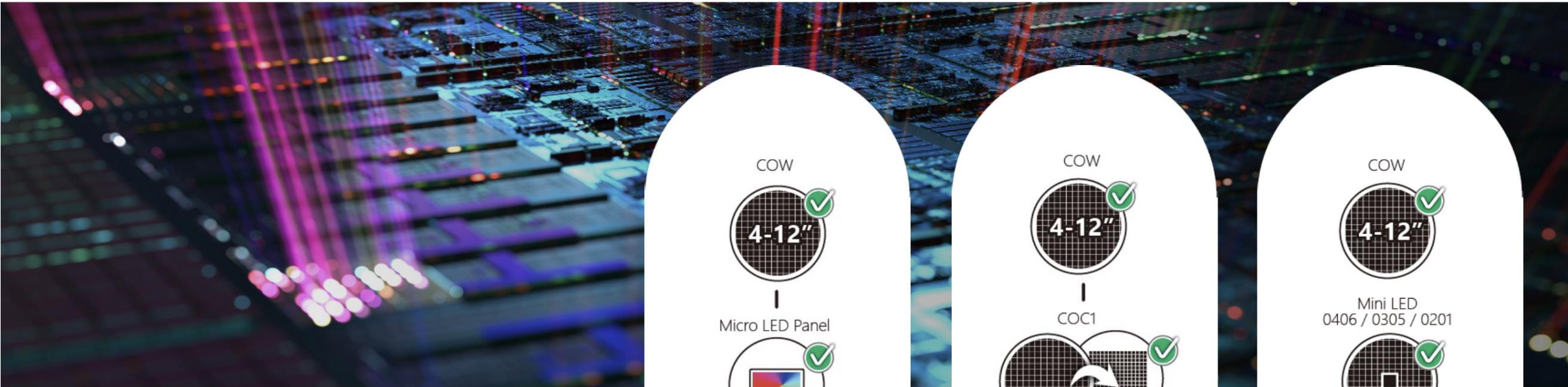**World's 1st**
Monochrome RGB Micro-Displays

May 2023

Best Display Component
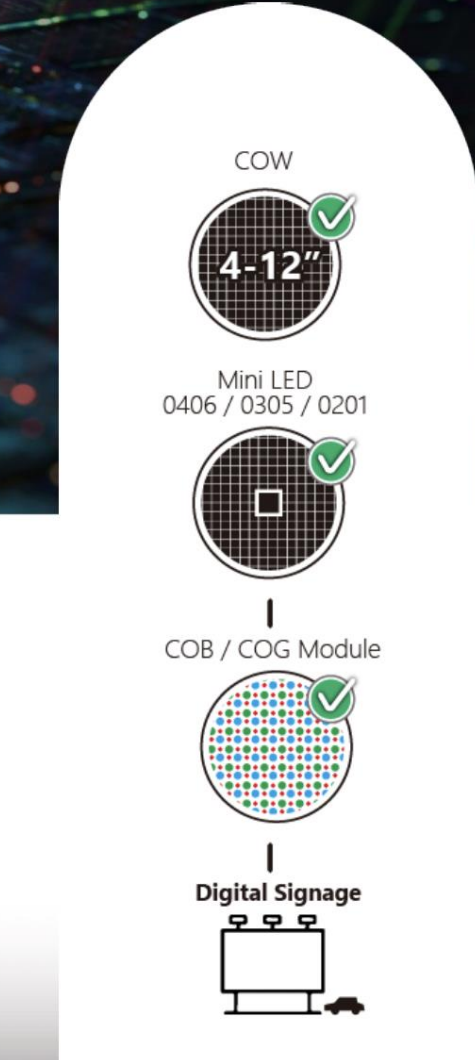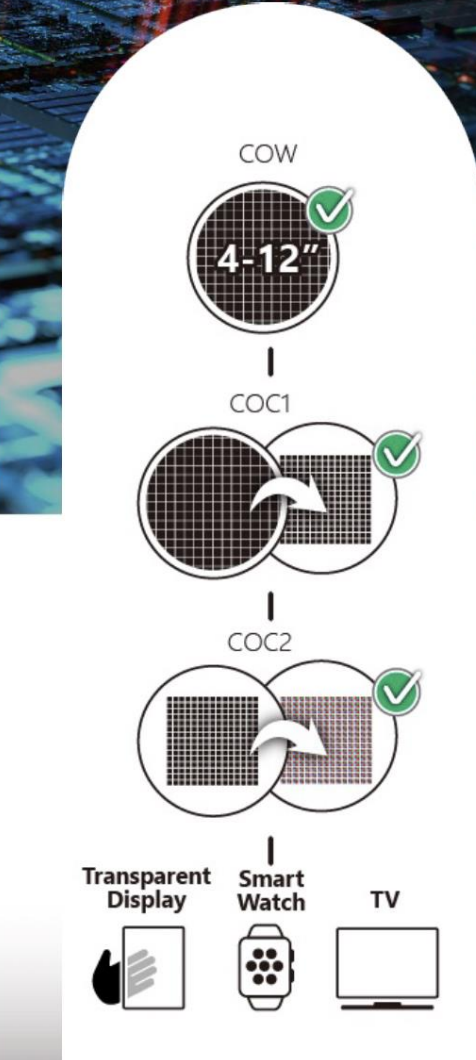SID Display Week 2023

World's 1st
Monolithic Full-colour Micro-Displays

MicroLED - Module Level Benchmarking for AR Glasses

Light source	Micro LED	LCOS	OLED	DLP
Color uniformity	Excellent	Excellent	Excellent	Excellent
Form factor prediction	< 0.5 cc	1.4-0.8 cc	< 0.5 cc	> 8 cc
Brightness	3-4 lm	2.5-3 lm	< 1 lm	>10 lm
WPE (lm/W)	1.4 - 3	> 2	1 - 2	> 10
Color gamut	Excellent	Excellent	Excellent	Excellent

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from
PoroGaN® | DPT®

COW
4-12"

Micro LED Panel

Light Engine

AR Glass   HUD
60 km/h

COW
4-12"

COC1

COC2

Transparent Display   Smart Watch   TV

COW
4-12"

Mini LED
0406 / 0305 / 0201

COB / COG Module

Digital Signage
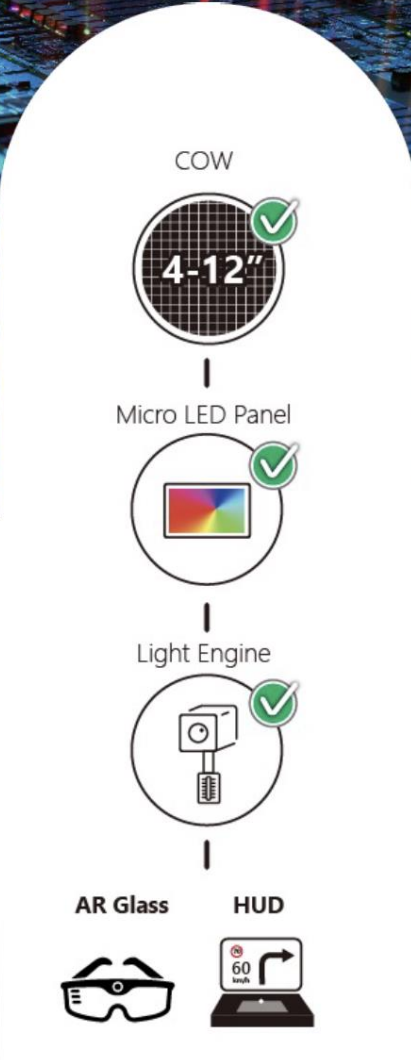
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Porotech MicroLED Display Products & Applications

HUD Head Up Display	**HMD** Head Mounted Display	**Pico Projector**	**AR Glasses**
85 km/h			
1"~0.7"	0.7"~0.5"	0.5"~0.2"	Under 0.2"

AR & AI

Qualcomm XR2

Top-notch MR and VR technologies to unlock a new generation of immersive experiences on thinner, more comfortable headsets.
GPU performance increased by 2.5 X,
AI performance increased by 8 X

Microsoft Game-streaming

The cloud integrates game data across platforms, giving users a seamless and immersive experience without any complicated steps.
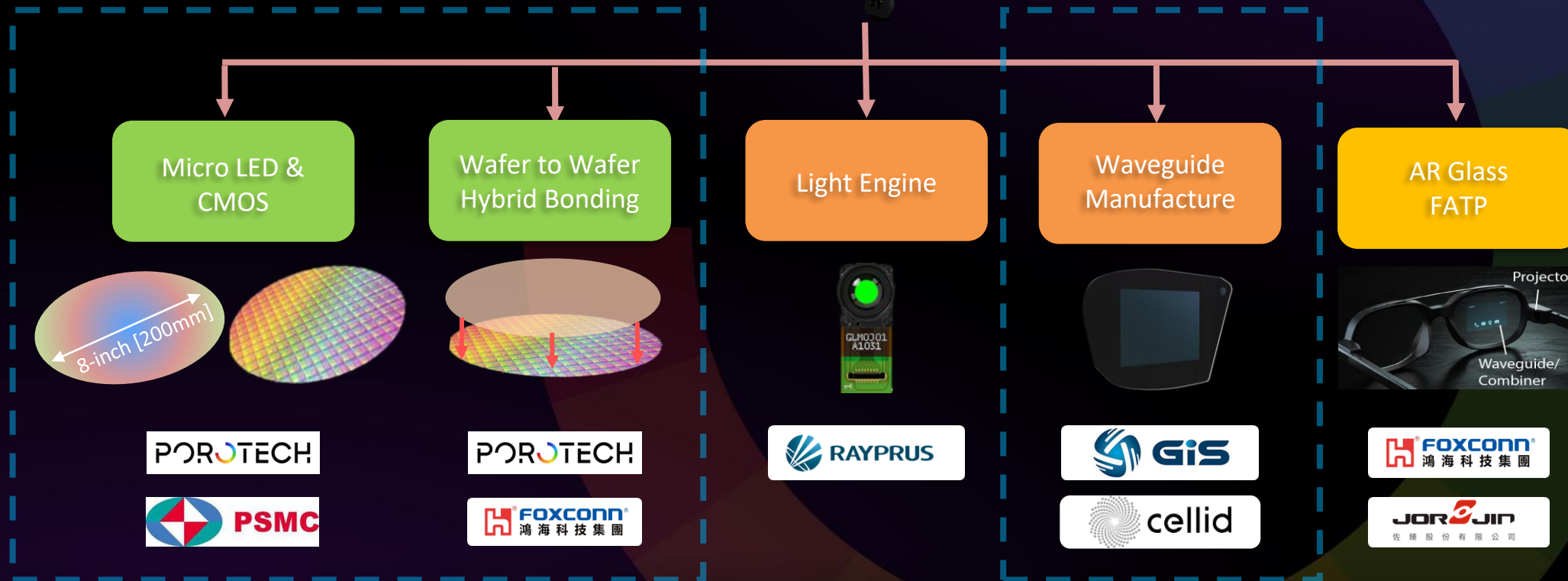
Nvidia Omniverse

The open system and efficient GPU platform integrates various 3D application software, so that the whole world can collaborate simultaneously to create a virtual world in the metaverse.

ChatGPT

Artificial intelligence search engine and human-like dialogue training model help users complete their target tasks more easily.

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Scope of Porotech MicroLED

Micro LED & CMOS	Wafer to Wafer Hybrid Bonding	Light Engine	Waveguide Manufacture	AR Glass FATP

8-inch [200mm]

Projector

Waveguide/Combiner

GLM0J01 A1031

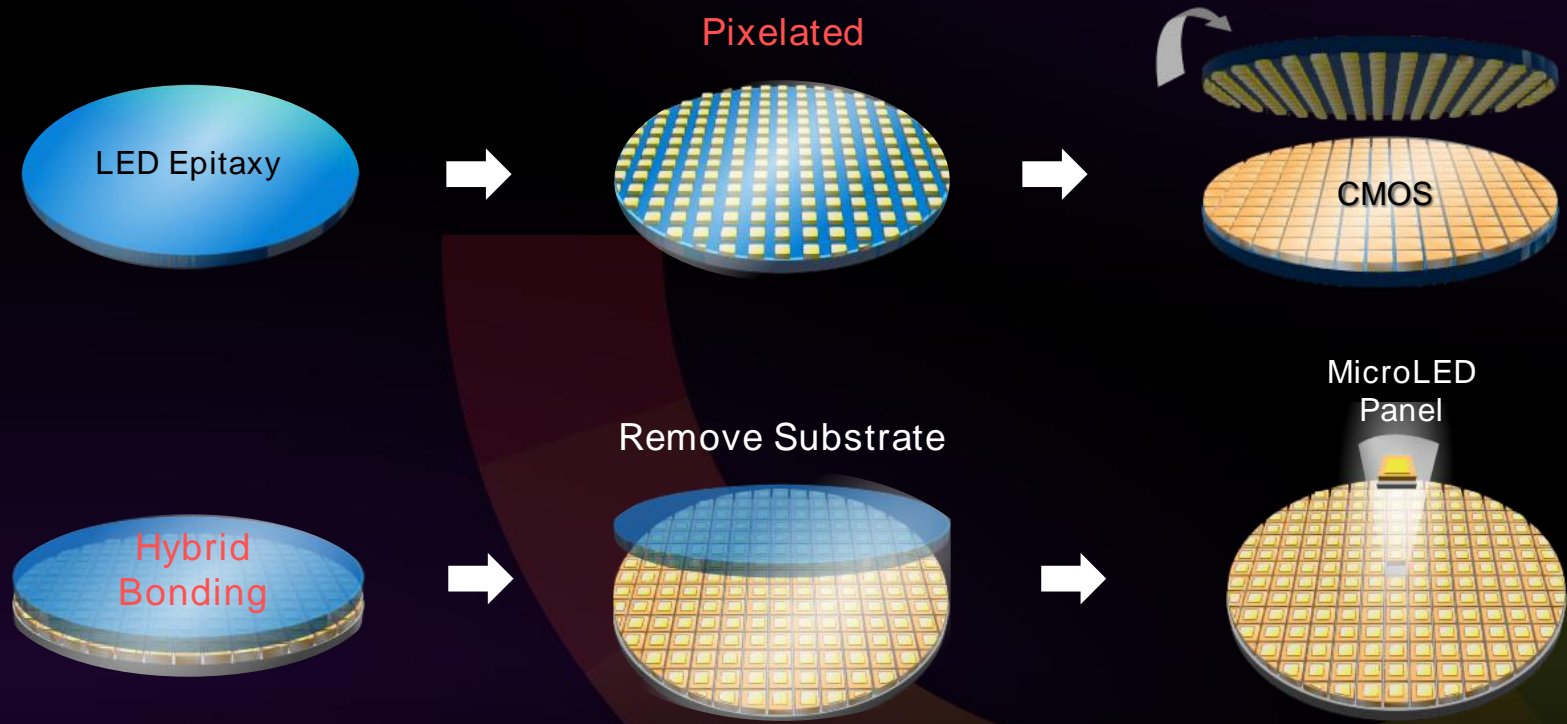| POROTECH	POROTECH	RAYPRUS	GiS	FOXCONN 鴻海科技集團
PSMC	FOXCONN 鴻海科技集團		cellid	JORJIN 佐臻股份有限公司

- **Porotech provides the range of IPs (>140), materials, processes, designs, PDKs, tests & critical tools**
- **Porotech KEY processes for high volume manufacture with high yield**
- **Universal MicroLED production platforms for microdisplays and others applications**
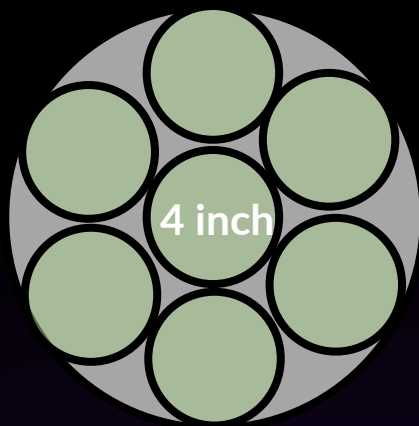
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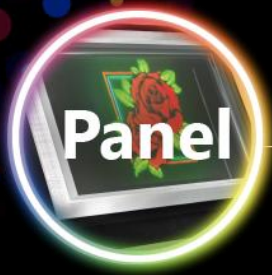
Manufacturing flow

High-yield, low-cost monolithic monochrome/polychrome panel

Pixelated

LED Epitaxy

CMOS

MicroLED Panel

Hybrid Bonding

Remove Substrate

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Product cost & FPY estimate from 8-inch platform

12 inch

4 inch

60% **The other approach**

Process item	Yield prediction
12" mapping to 4"	60%
4" epitaxy	100%
12" CMOS	75%
Micro LED front end process (4-inch LED process)	70%-80%
Eutectic bonding (C2C)	40%
Back end process	85%-90%
COB/flip chip	90%-95%
Panel Sorting (Pixel yield & uniformity)	60%
FPY	< 10%

Process item	Yield prediction
8" mapping to 8"	100%
8" epitaxy	100%
8" CMOS	80%
Micro LED front end process (8-inch semi process)	90%-95%
Hybrid bonding	90%-95%
Back end process	90%-95%
COB/flip chip	>90%
Panel Sorting (Pixel yield & uniformity)	90%
FPY	50%-60%

WtW Hybrid bonding

8 inch

8 inch

100% **Porotech approach**

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Core Technologies & Product Differentiations

- ❑ **PoroGaN®**

- ❑ **PoroGaN® InGaN R/G/B**

- ❑ **Dynamic Pixel Tuning (DPT®) Technology**
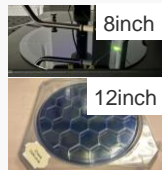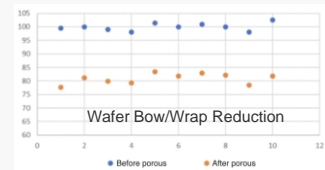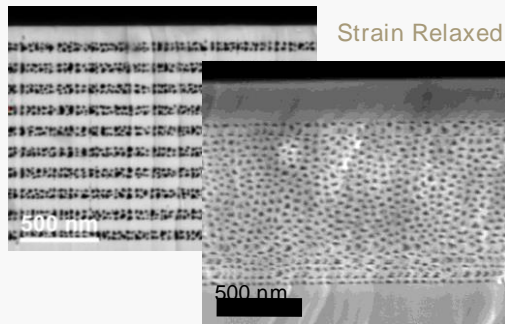
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PoroGaN - Revolutionary Multi-Functional Material Platform

Innovations only Porotech can thrive to empower full-colour & tunable MicroLEDs

1. PoroGaN®

- ✓ High quality materials with tailored properties and functionalities on all sizes & substrates

Optical Mirror/filter

Strain Relaxed

500 nm

500 nm

Wafer Bow/Wrap Reduction

8inch

12inch

Before porous   After porous

2. Native Monochrome Single Colours

- ✓ Highest efficiency, brightness, frequency and colour with a single InGaN material system

PoroGaN Blue LED   PoroGaN Yellow LED

PoroGaN Green LED   PoroGaN Red LED
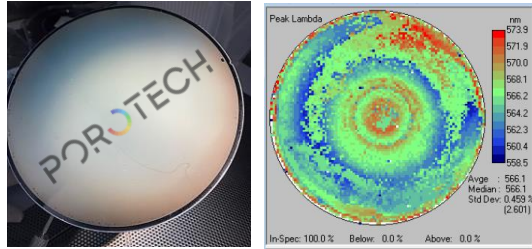
PoroGaN Green LED
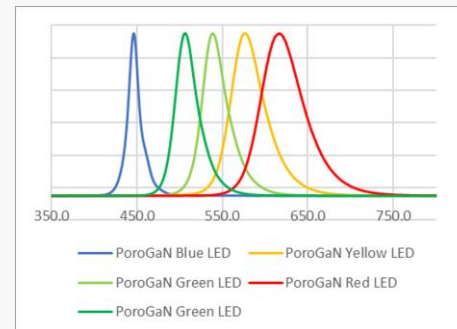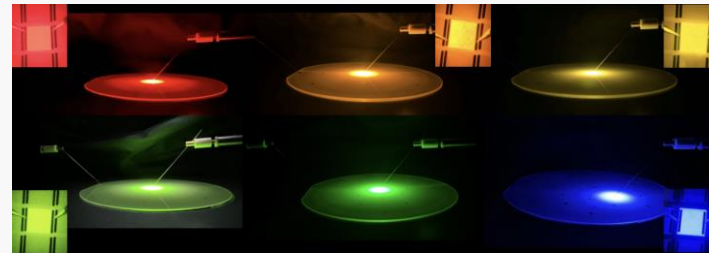
3. DynamicPixelTuning® (DPT)

- ✓ uLED pixel can emit any colour from blue to infrared

- ✓ Dynamically tuned by the choice of material design, pixel architecture and specific driving schemes

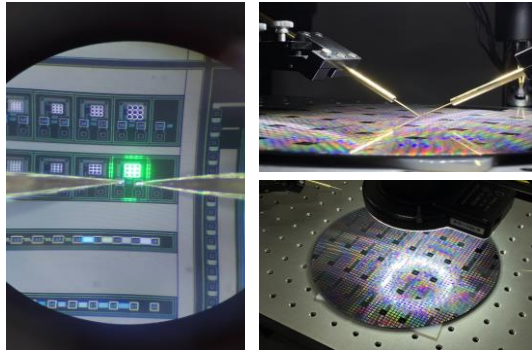- ✓ World's first & only full-colour & dynamically tunable pixel
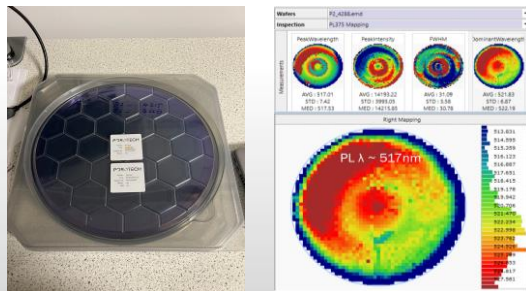

sRGB
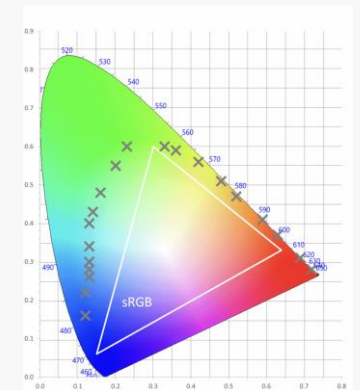
Why Porotech select 8-inch platform

PoroGaN InGaN LED epi on 200mm Silicon

Pixelation ↓   ↑ Epitaxy

PoroGaN InGaN LED epi on 300mm Silicon

But no semi-foundry is ready for uLED pixelation on 300mm

Readiness for MP

	Epitaxy		Pixelation	CMOS	Hybrid bond	Micro Lens	Back-end process
	MOCVD	Testing machine					
8-inch	✅	✅	✅	✅	✅	✅	✅
12-inch	*R&D phase only* ❌	❌	*$$B* ❌	✅	✅	✅	✅

	Substrate Silicon (111)	EQ	CAPA	EQ cost
8-inch	<100 USD/wafer	5 pcs/chamber	10pcs/day	3M
12-inch	>650 USD/wafer	1 pcs/chamber	3 pcs/day	12M

12-inch fab
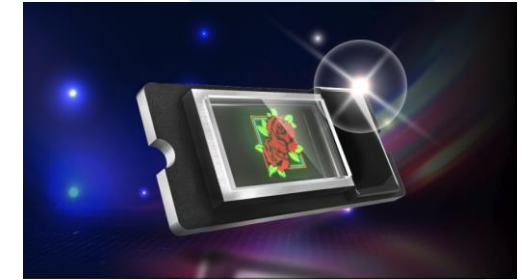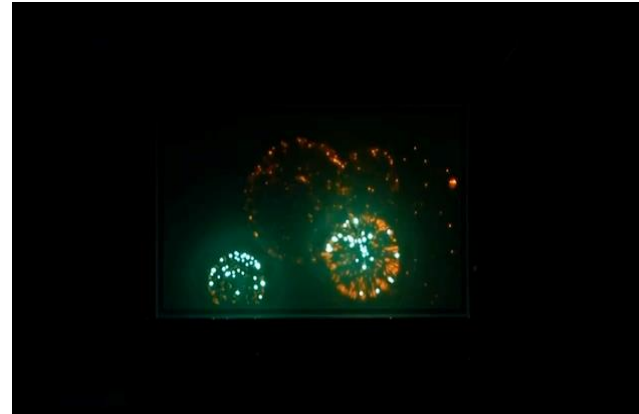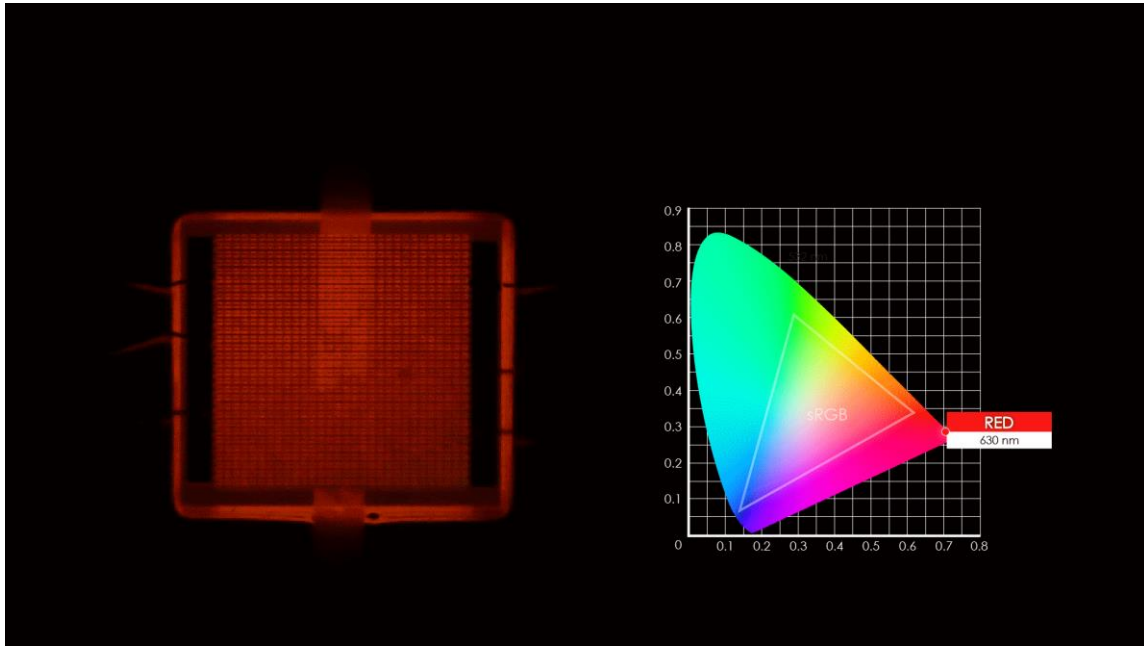
$Billions dollar*

*Osram EUR 600-700m 8-inch fab attempted for MicroLED Apple Watch

DynamicPixelTuning® (DPT®)
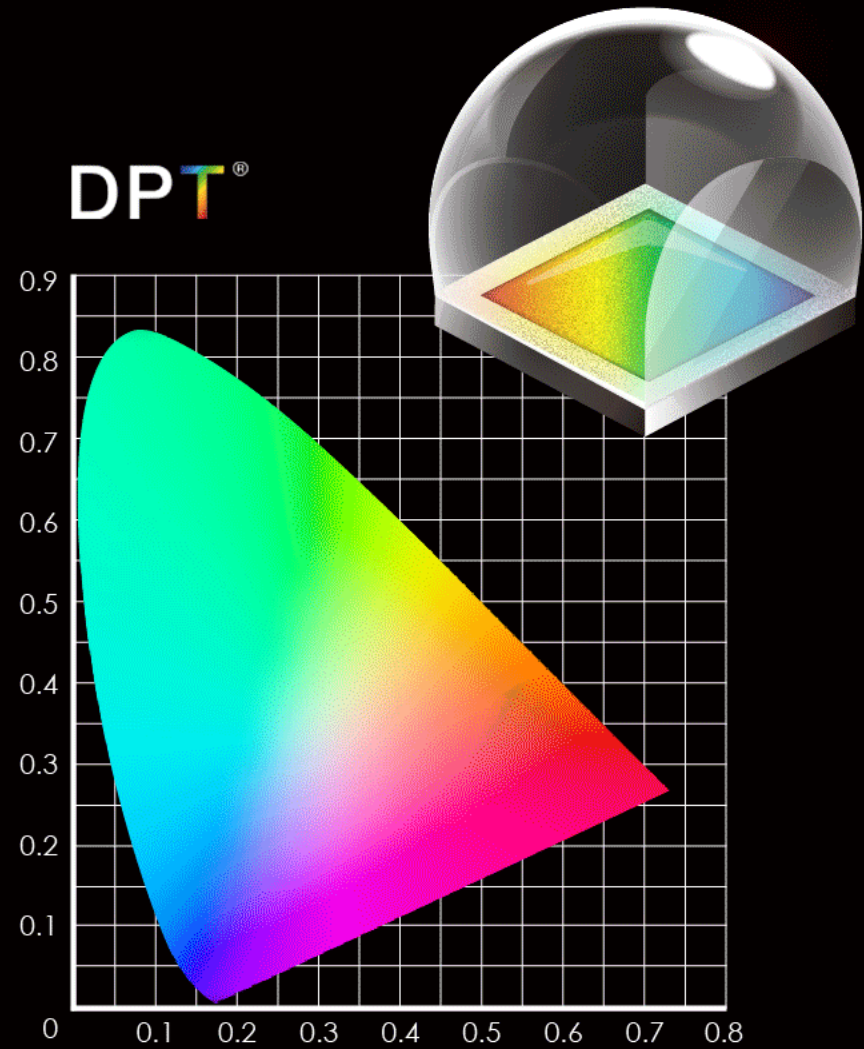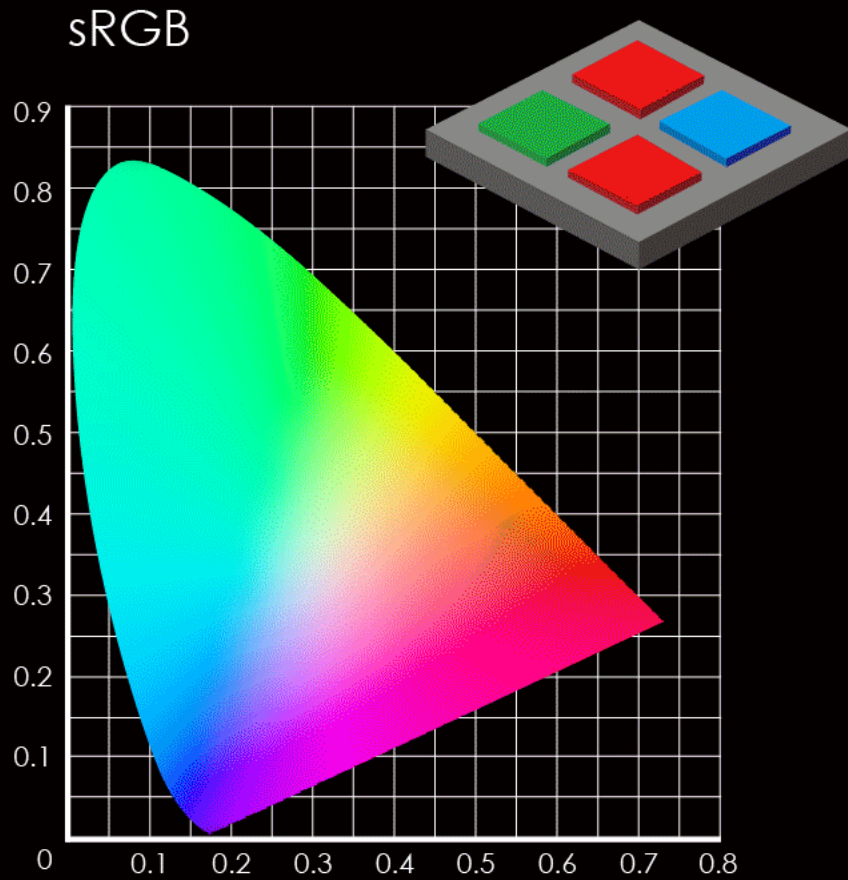
Dynamic Pixel Tuning - Colour Mixing & Display

World's 1st monolithic microdisplay with native colours on a single panel

Best Display Component
SID Display Week 2023

Display Size	0.26" diagonal
Active area	5.76mm x 3.24mm
Grey scale	256 (8-bits)
Resolution	1280 x 720
Pixel pitch	4.5um x 4.5um
Backplane	LCOS voltage
PPI	5600

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Unsung Materials Issue until you've tried it…

PoroGaN® overcomes MicroLED thermal effect for all the applications

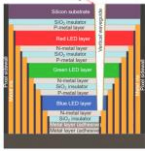| Porotech - InGaN R/G/B	8-inch epi	Temp	Lop loss
B	InGaN	25°C / 85°C	100% / 86%
G	InGaN	25°C / 85°C	100% / 89%
R	InGaN	25°C / 85°C	100% / 87%
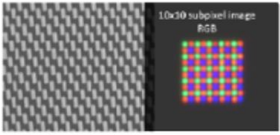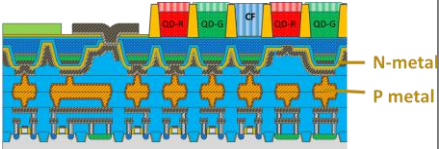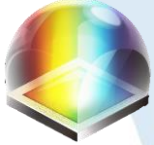
Conventional – InGaN B/G & AlGaInP Red	4-inch epi	Temp	Lop loss
B	InGaN	25°C / 85°C	100% / 90%
G	InGaN	25°C / 85°C	100% / 84%
R	AlInGaP	25°C / 85°C	100% / 48%

Performance

- Brightness degradation (H/C factor) caused by thermal effects due to the (AlInGaP red) material system

- Color drift and reduce the overall light engine brightness output

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Roadmap & Outlook

Porotech - Doing What's Right, Not What's Easy

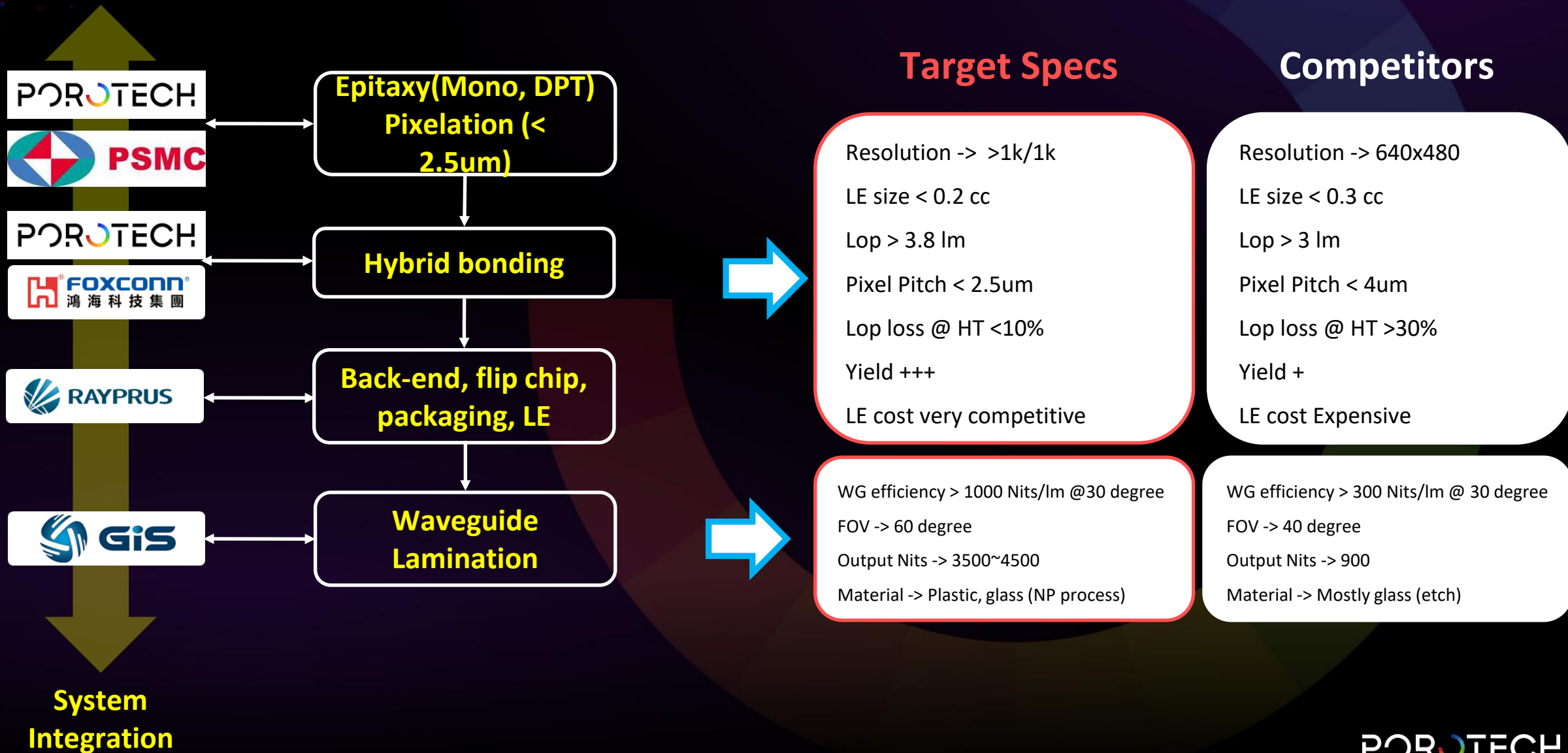| If resolution is 1kx1k	SAG	Vertical Stack	QD	DPT®
Pixel pitch limitation	> 8 um	5-6um	> 4um	2.5um
Panel size	> 0.27-inch	0.27-inch	> 0.16-inch	0.13-inch
Color gamut	Full color	Multi-color	Full color	Full-color
Reliability	Not Known	Poor (AlInGaP)	Poor	Excellent Same as InGaN mono R/G/B
Manufacturability	Impossible	Difficult	Difficult	Simple
Yield	Very Low	Very Low	Low	High
Driving	Quad Pixel	Complex	Quad Pixel	Complex
Test & Repair	Complex	Complex	Complex	Simple
Cost	Very High	Very High	High	Low

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Porotech MicroLED Display & AR Supply Chain Integration & Ecosystem

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PSMC

POROTECH

FOXCONN 鴻海科技集團

RAYPRUS

GiS

System Integration

Epitaxy(Mono, DPT) Pixelation (< 2.5um)

Hybrid bonding

Back-end, flip chip, packaging, LE

Waveguide Lamination

Target Specs

Resolution -> >1k/1k

LE size < 0.2 cc

Lop > 3.8 lm

Pixel Pitch < 2.5um

Lop loss @ HT <10%

Yield +++

LE cost very competitive

WG efficiency > 1000 Nits/lm @30 degree

FOV -> 60 degree

Output Nits -> 3500~4500

Material -> Plastic, glass (NP process)

Competitors

Resolution -> 640x480

LE size < 0.3 cc

Lop > 3 lm

Pixel Pitch < 4um

Lop loss @ HT >30%

Yield +

LE cost Expensive

WG efficiency > 300 Nits/lm @ 30 degree

FOV -> 40 degree

Output Nits -> 900

Material -> Mostly glass (etch)

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Leading the Way for AR Visionaries

Cambridge (UK) • Hsinchu (Taiwan) • Chandler, AZ (USA)

info@porotech.com | www.porotech.com