



# Micro LED Display Market Trend & Technology Status

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## 1. Overall of wide color gamut display market

- > History of wide color gamut display market
- > Wide color gamut display market forecast

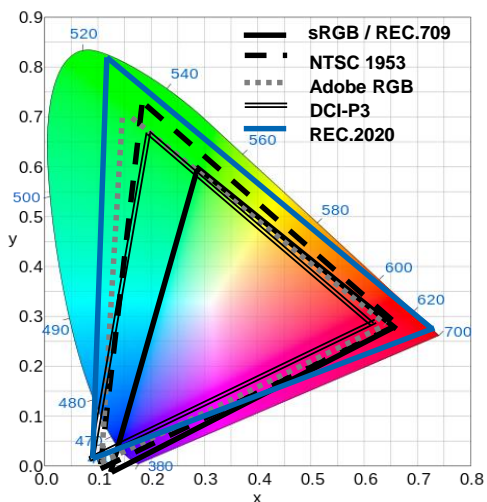
## 2. In-depth analysis for micro LED display industry

- > Micro LED display focus on the large display market
- > Why are set brands interesting in the micro LED display
- > Micro LED display manufacturing process issues
- > What are problems of mass transfer technology
- > Micro LED display market forecast

# History of wide color gamut display market

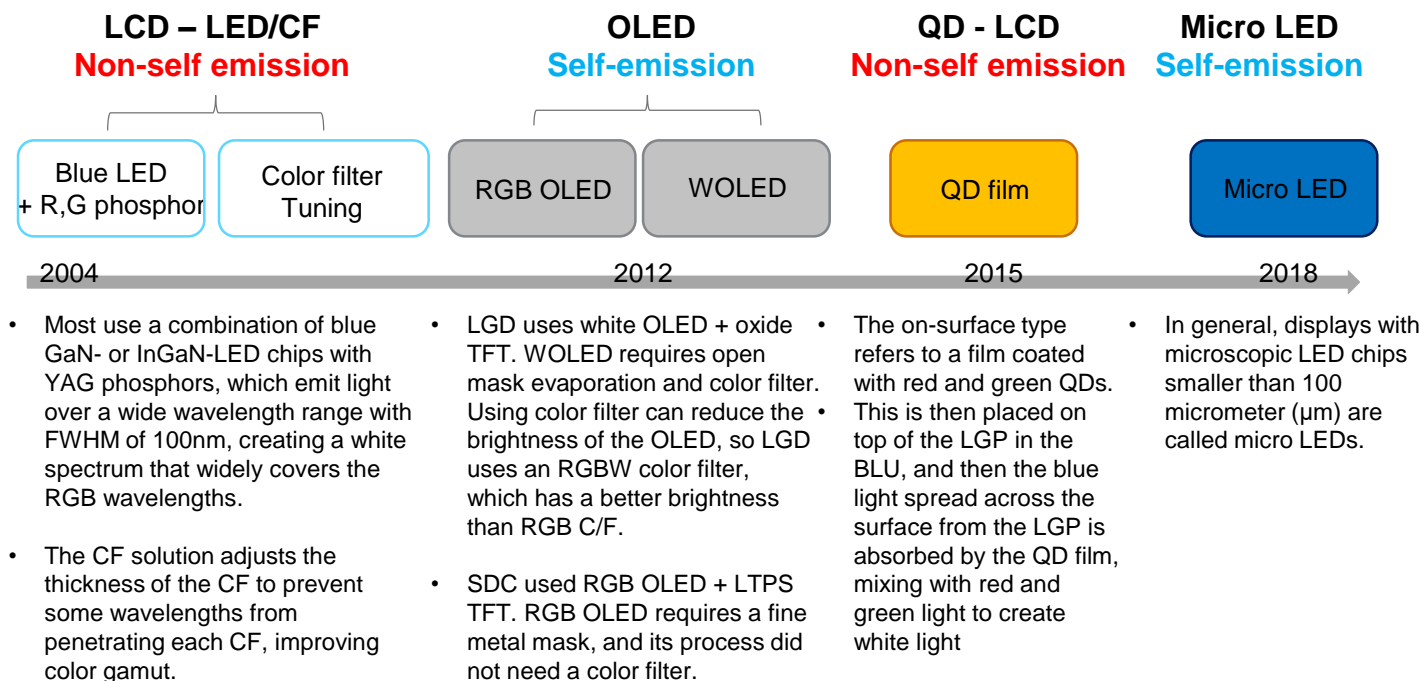
- Color gamut is measured by an area ratio using the International Commission on Illumination's (CIE) XY chromaticity coordinates.
- The REC. 2020 with the widest color space has 34% more space than the NTSC 1953. The standard broadcasting signal recommended by ITU is shining a light on WCG display, which is getting much attention.
- In 2018, WCG display market still represents a small share of the display market

## Definition of Wide color gamut

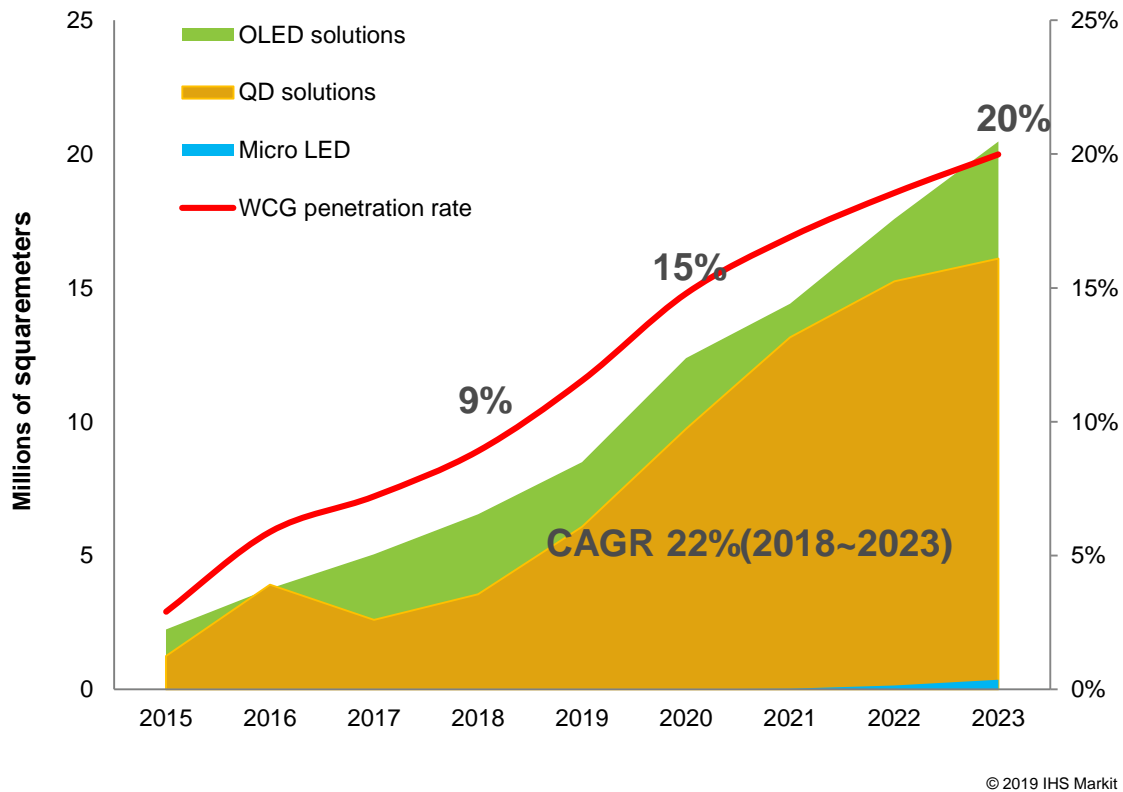


Color gamut rate by Technology at NTSC	
TVs	Color gamut (NTSC %)
CRT	78% ~ 82%
PDP	90% ~ 95%
<b>OLED</b>	<b>100%↑</b>
LCD (WCG CCFL)	85% ~ 95%
LCD (White LED)	68% ~ 78%
<b>LCD (C/F improvement + LED)</b>	<b>90%</b>
<b>LCD (RGB LED)</b>	<b>90% ~ 95%</b>
<b>LCD (Quantum dot film)</b>	<b>100%</b>
<b>QD color filter + Blue OLED</b>	<b>100%↑</b>
<b>Mini/Micro LED(R,G,B)</b>	<b>100%↑</b>

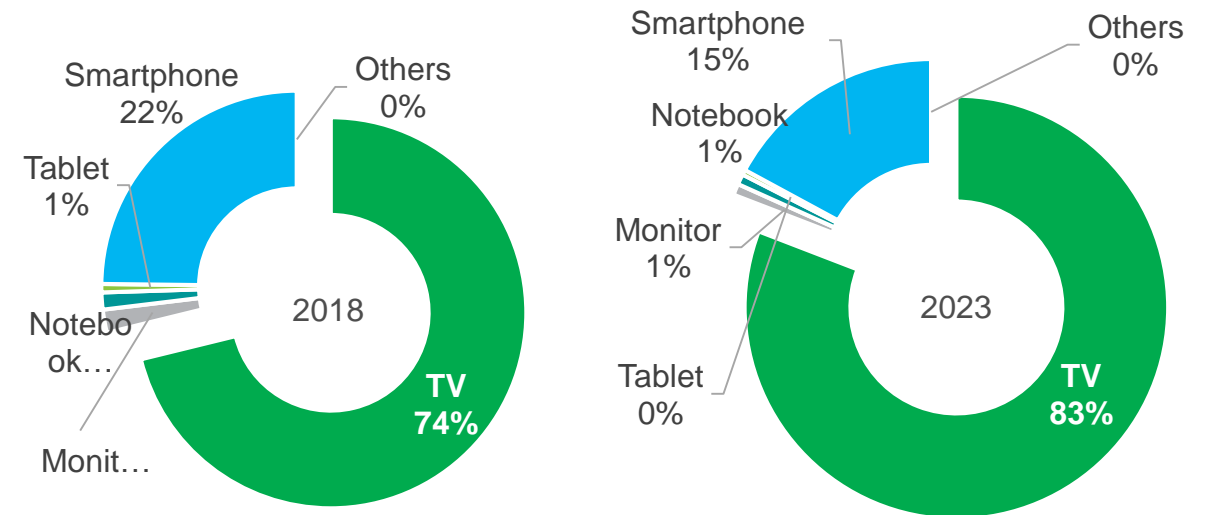
## Major technology of Wide color gamut display market by time



# All of WCG display must be growing with together









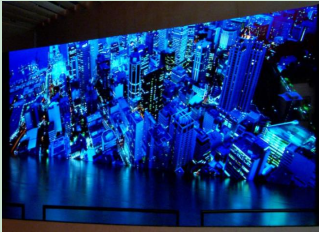


- Various WCG solution will be driving market growth in each target display market.
  - > OLED Solution : High-end TV & smartphone
  - > QD solution : Mid-High end TV
  - > Micro LED : Small & Ultra Large size display



# Micro LED display focusing on large display market

Divider slide subtitle

# Display set brands leads the mini/micro LED display technology and product

Issues for Micro LED display industry					
Major application for Micro LED display by companies	<p><b>Google / glo</b></p>  <p><b>ITRI</b></p> 	<p><b>APPLE(LUXVUE)+TSMC</b></p>  <p><b>Plessey</b></p> 	<p><b>SONY(2012)</b></p>  <p><b>Samsung (2018)</b></p> 	<p><b>SONY(2016)</b></p>  <p><b>LG(2018)</b></p> 	<p><b>Samsung (2019)</b></p> 
	Expected target market	Smartphone, Smartwatch AR, HUD etc.	Signage, TV, etc.		
	Display size	≤6 inch - Small display	Large display		
	LED chip size	<10μm	50~150μm		
	Market entrance level	Need to new LED chip technology and cost competing with OLED cost	Current LED chip technology, cost issues more free than small size display		

# Micro(Mini) LED display , Ultra large size display more competing than small size

Year	2012	2016	2018		2019			
TV brand	Sony		Samsung Electronics	LG Electronics	Samsung Electronics		TCL	Hisense
Items	TV	TV	Signage	Signage	TV	Signage	Signage	Signage
Size	55"	396"	146"	173"	75"	219"	118"	145"
Resolution	1920x1080	7680x2160	3840x2160	3840x2160	3840x2160	5760x2160	3840x2160	3840x2160

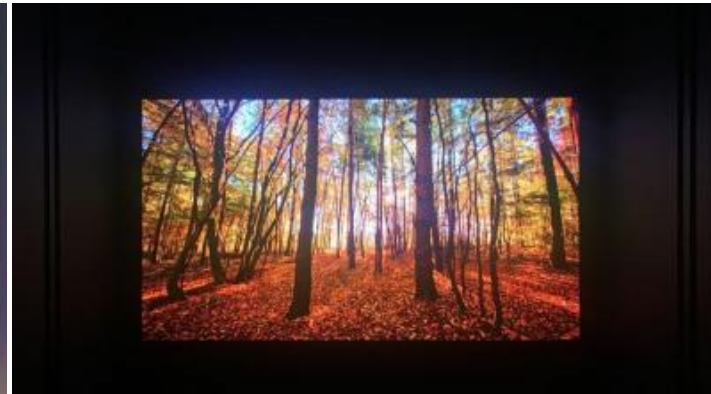
Sony- 396"



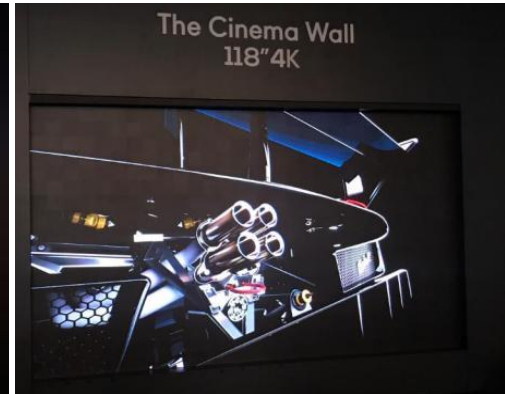
Samsung - 146", 219"



LG - 173"

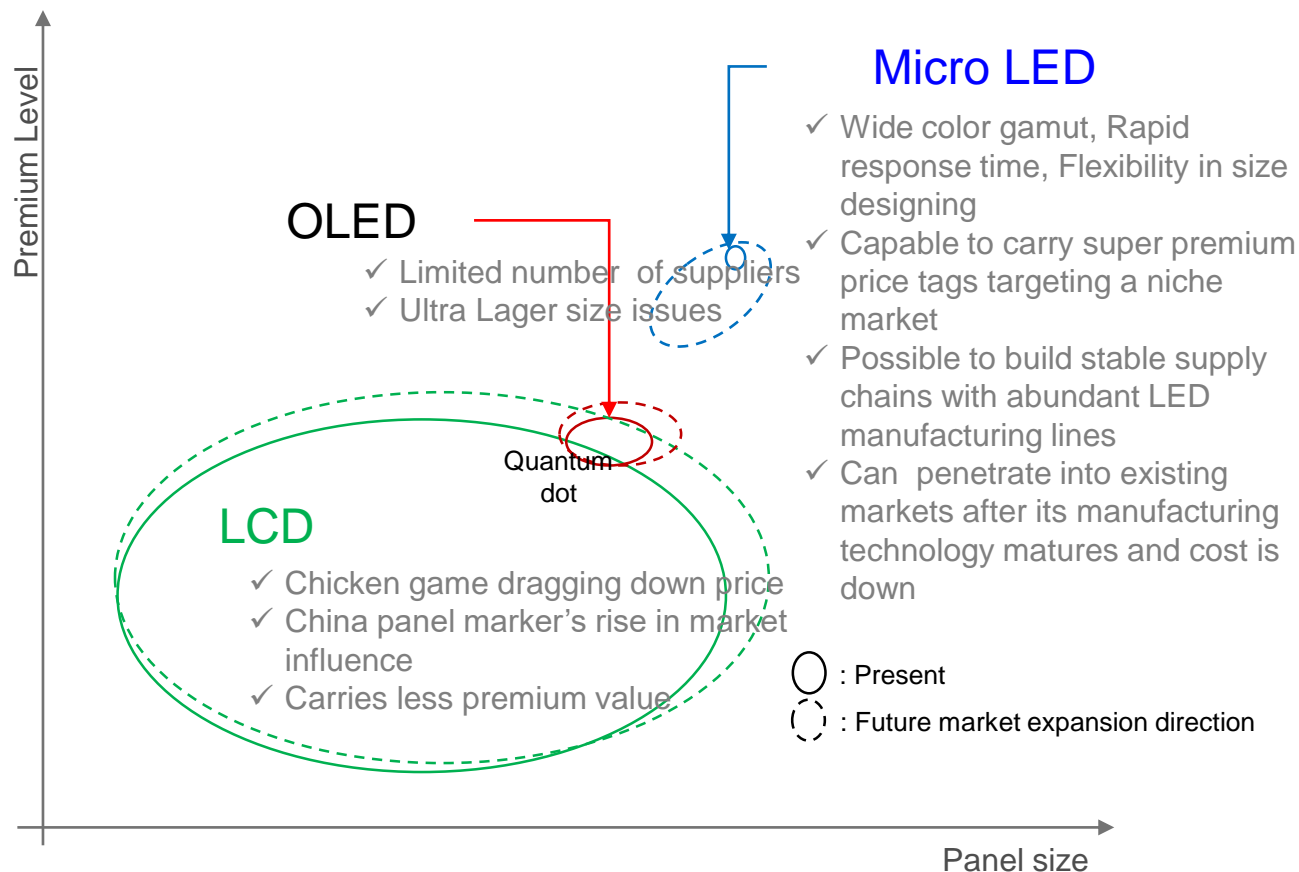


TCL - 118"

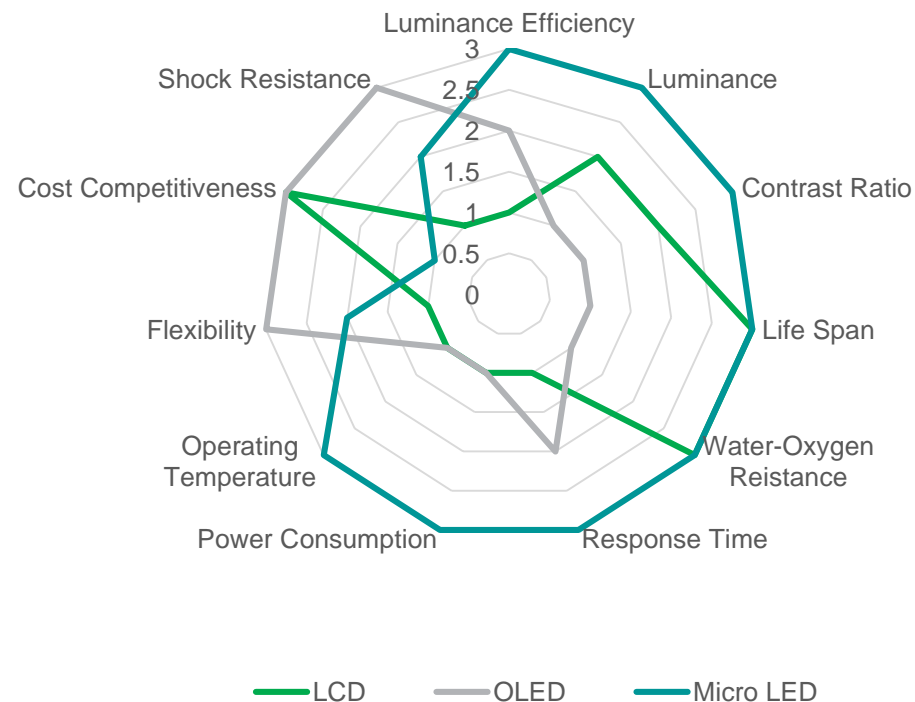


# Why are set brands interesting in the micro LED display

## Position of Micro LED display forecast in the display industry



## Property comparison of LCD and OLED with Micro LED





# Real micro LED TV released the 2019 CES by Samsung electronics

- 75 inch



Module spec.(e)



	Items	TV(e)
Display	Size	75"
	Resolution	3840x2160
	Pixel Per Inch	58.74
Module	Resolution	480xRGBx270
	Number	64_(8X8)_9.38"
	Backplane	LTPS
LED	Pixel Pitch	432.4µm
	Chip Size	34x85µm
	Supplier	Playnitride

- 146, 219 inch



Module spec.(e)



	Items	Signage	
Display	Size	146"	219"
	Resolution	3840x2160	5760x2160
	Pixel Per Inch	30.18	58.74
Module	Resolution	240xRGBx240	240xRGBx240
	Number	16X6_15.9"	18X9_15.9"
	Backplane	PCB	
LED	Pixel Pitch	847µm	
	Chip Size	125x225µm	
	Supplier	SanAn	

# Micro LED display technology issues and market forecast

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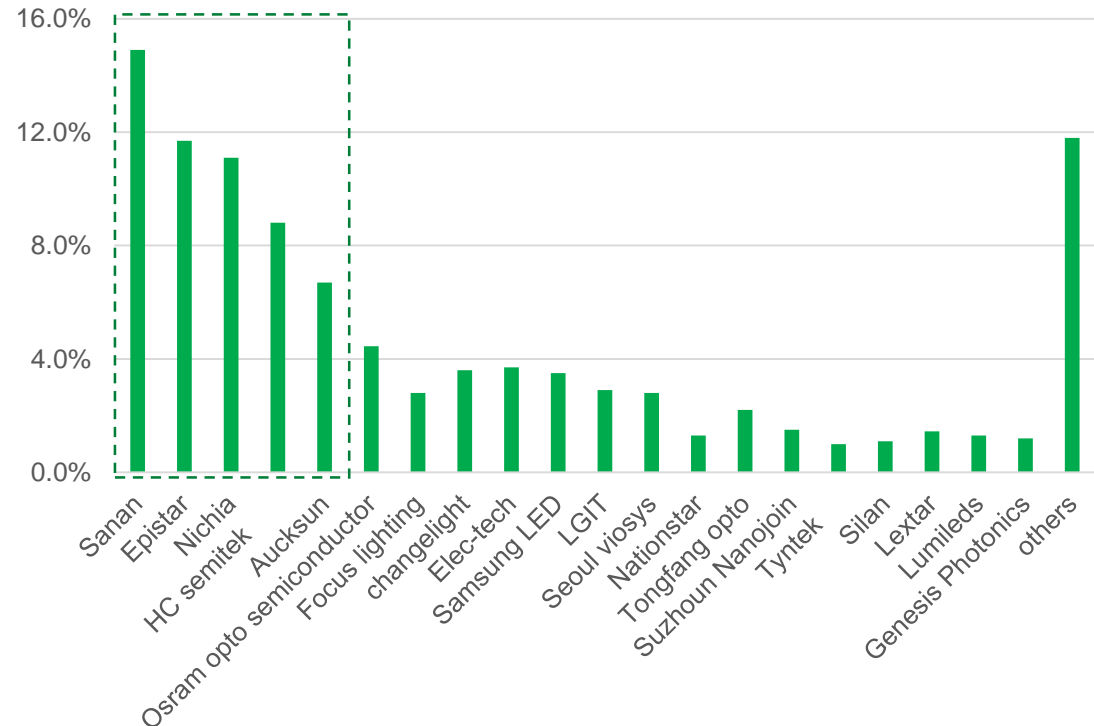
# Actively cooperating with LED chip manufacturers and display set brands

- The existing dominant LED makers are most likely to remain at their position in the micro LED market.
- Display set makers are cooperating with leading LED chip makers and building the supply chain for micro LED display.

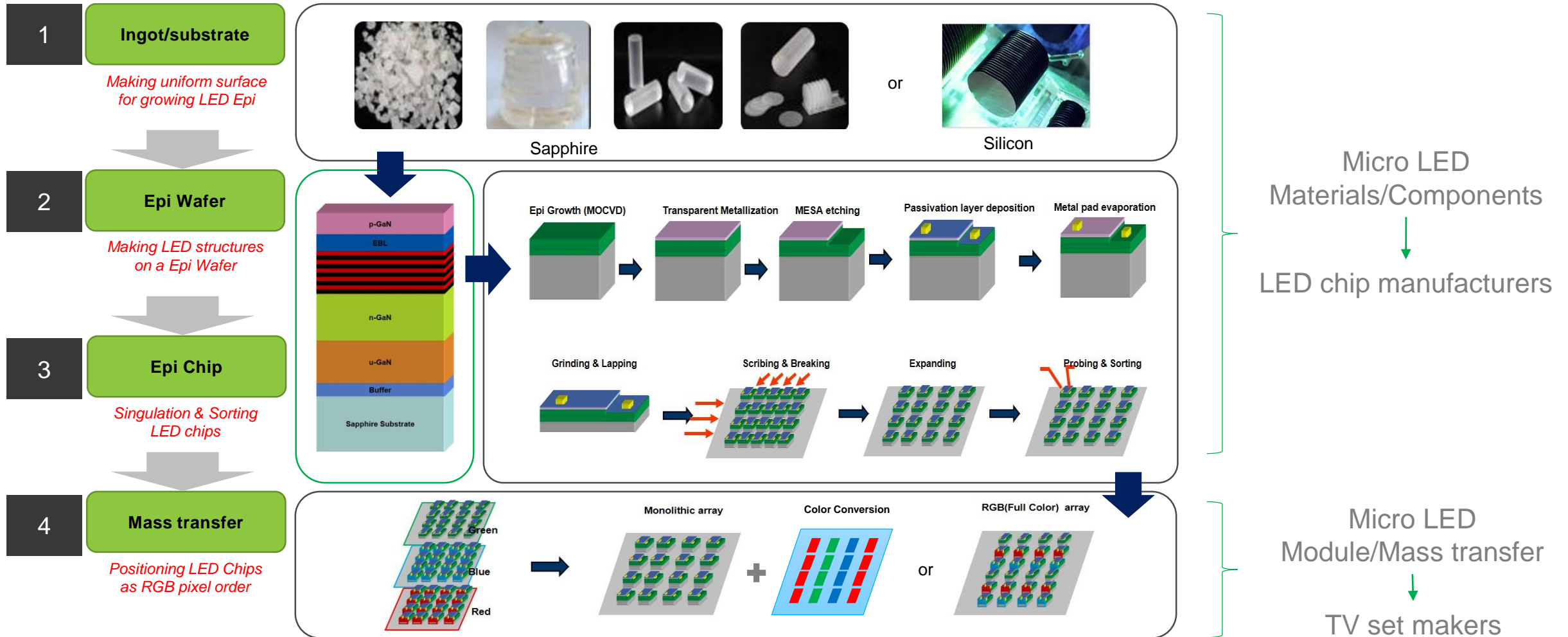
Compare with Mini and Micro LED

	Mini RGB	Micro RGB
Chip size	100~250um	<100um
Chip structure	Flip(with/without sapphire)	Flip, vertical, 3D without sapphire
Transfer technology	Die(Chip) bonding/ Mass transfer	Mass transfer
BLU type	Self emitting	Self emitting
Thickness	<5mm	<1mm
Power	Normal	Low
Cost	High	Ultra High
Technology level	Order production	Under development

LED manufacturer capacity share

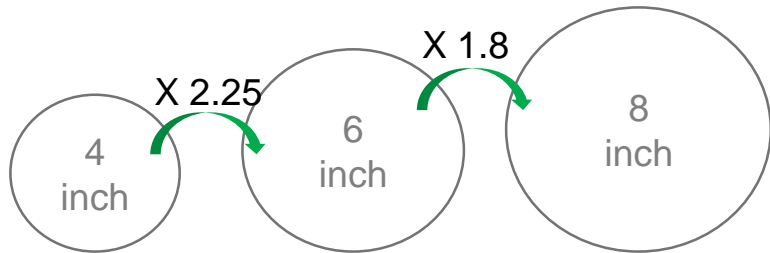


# Micro LED display is not impossible, it's just difficult

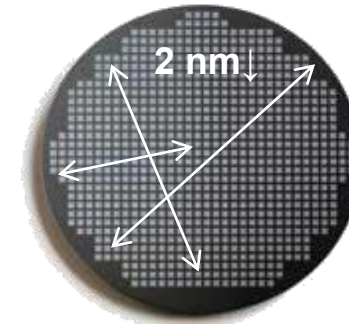


# Cost reduction of micro LED chips is big issues to enter display market

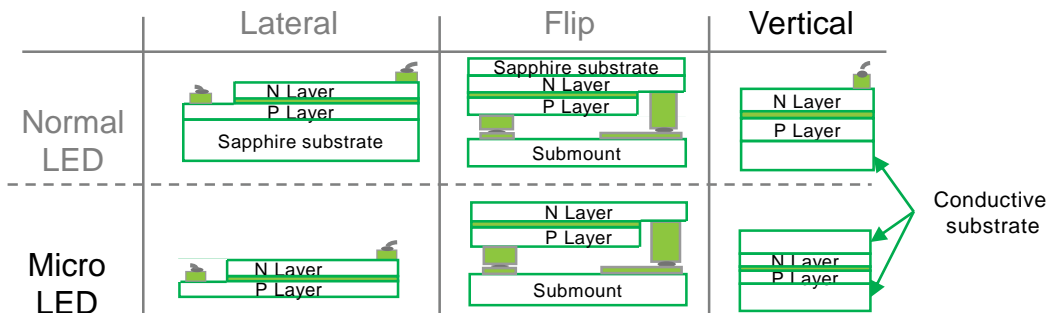
- Large-size substrate to increase productivity per substrate
  - > 4 → 6 → 8 inch (Major substrate : Sapphire)



- Epi wafer wavelength uniformity : 5nm → 2nm
  - > Need to precise control for temperatures on MOCVD process

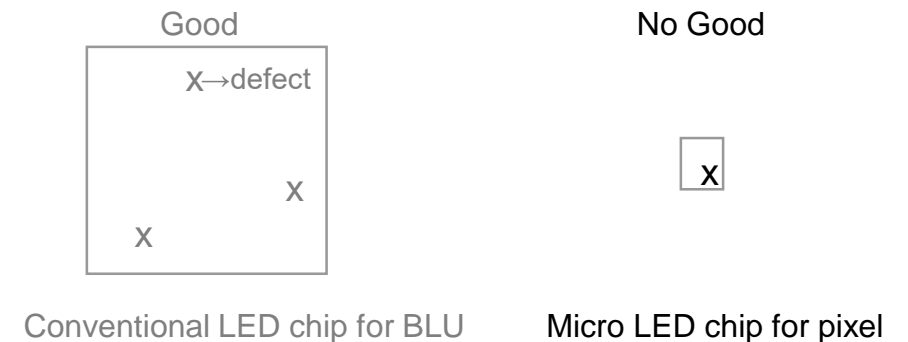


> Micro LED chip structure : Vertical type is best



Ex) Length : 1/2 → Area 1/4 → **Cost 1/4**

> Reduce to defect : 100 class clean room



# Too many mass transfer technology introduced, but it is just concept of technology

Die bonder (1 by 1)

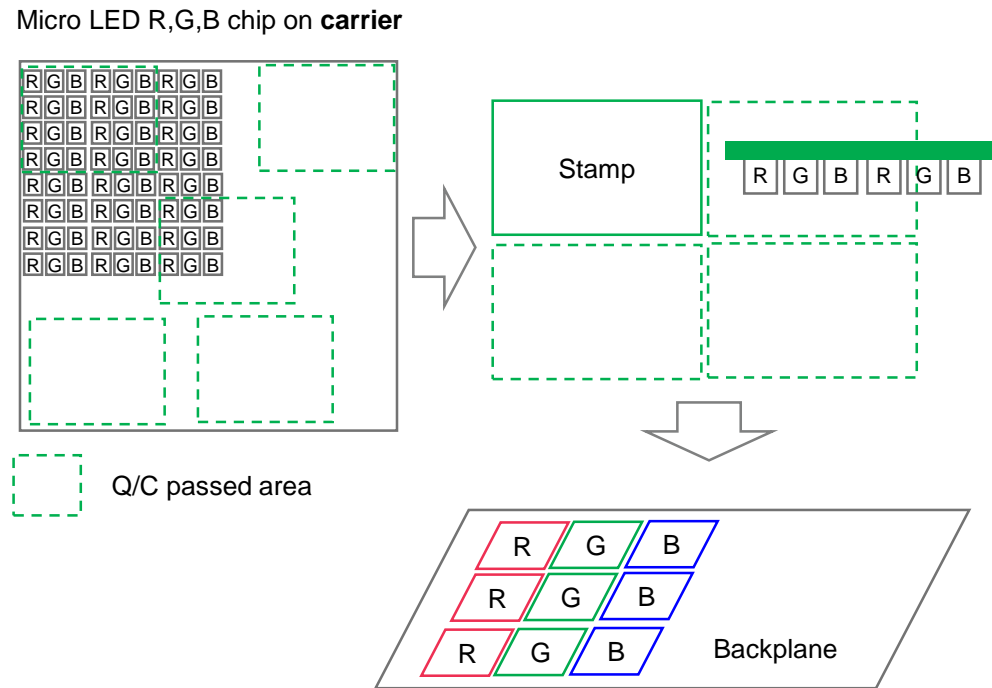
Resolution- Subpixel number	Die bonding (18,000 UPH)
4K - 24.8 million	2 month
8K - 100 million	7 month

Mass transfer technology by companies

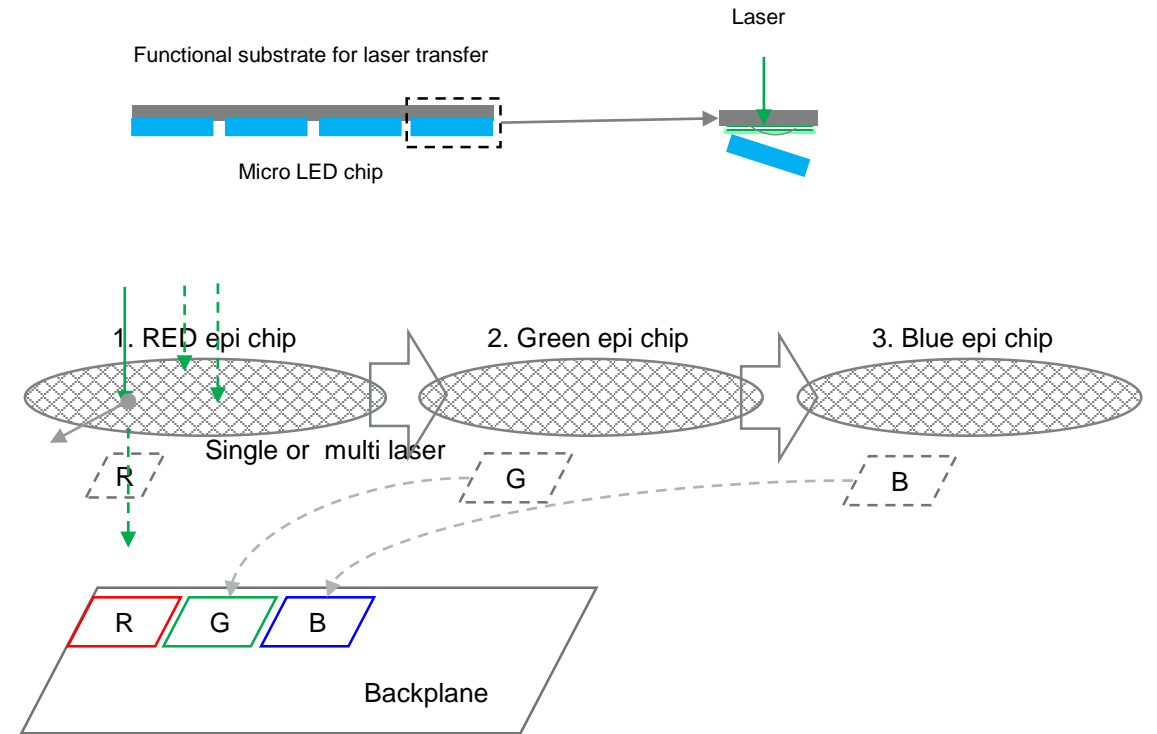
Mass transfer technology	Owner	By control method	Remarks
Electrostatic	Apple(Luxvue)	Electrostatic force	R&D stage (Patent)
Electromagnetic	Playnitride	Electromagnetic force	
Elastomer stamp(PDMS)	X-celeprint	Van der Waals force	
Laser assisted(LLO)	Sony, QMAT...	Laser	
Pressure dependent adhesion	KIMM	Mechanical deformation	
Monolithic	LETI	Directing bonding to CMOS	
Fluidic assembly	Foxconn(eLux)	Fluidic drag force	
Solid printing	VueReal	Printing	
Stretchable transfer	Playnitride	Stretchable film	

# Speed and accuracy are key function for mass transfer technology

- Stamp method



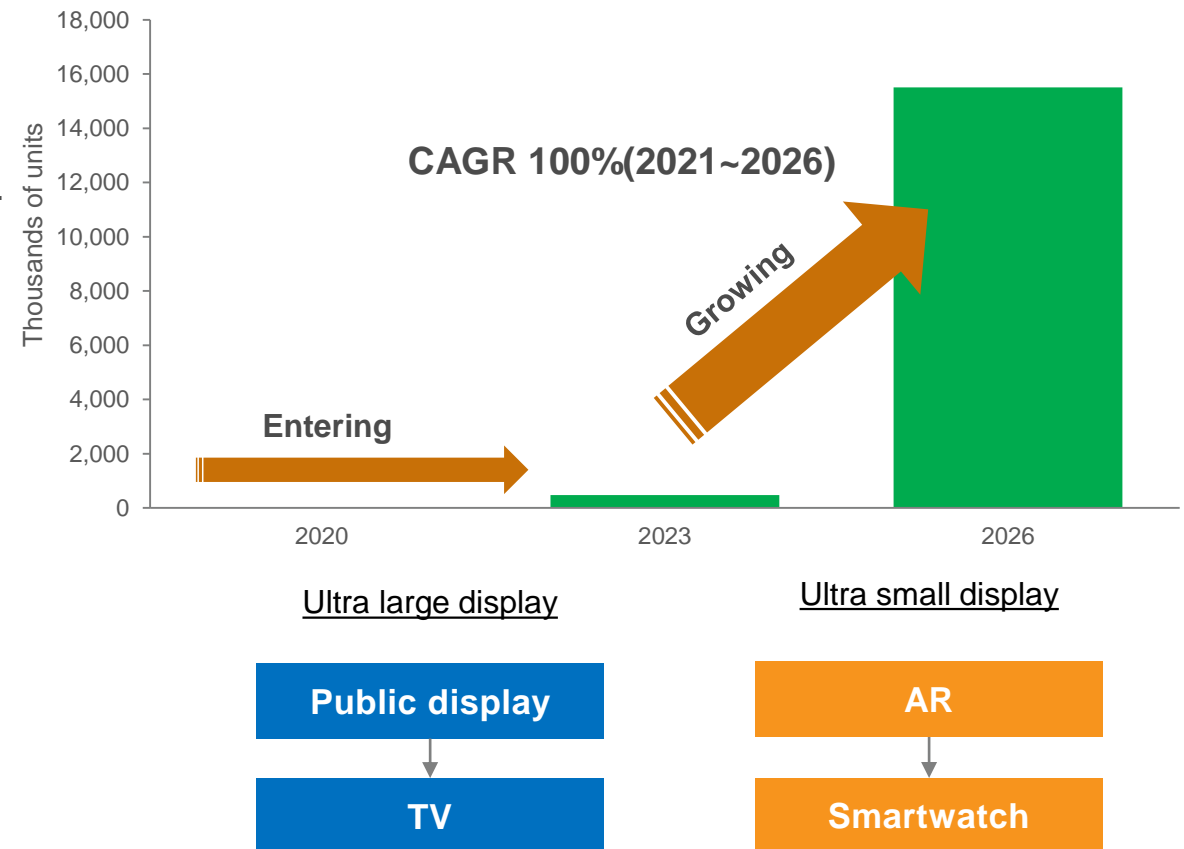
- Laser method



# Micro LED display to grow high CAGR in near future

- Currently, Infancy stage in term of manufacturing process, supply chain, and marketing strategy
- The market will likely start off on a small scale, focusing on limited amounts, and then slowly increase.
- Large display will be the key growth engine for micro LED displays.
- From 2021 to 2026, CAGR will be expected the 100%.

Micro LED display market forecast





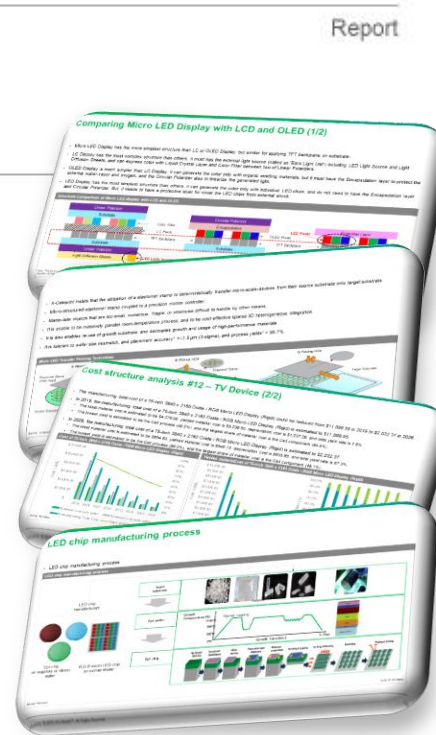
# Report introduction : Micro LED Display Technology & Market – 2019

## TECHNOLOGY

Displays

### Micro LED Display Technology & Market – 2019

7<sup>th</sup> June 2019



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1. Executive Summary
2. Market Issues
3. Market Forecast
4. Technology Issues
5. Cost Estimation
6. Display Developers Trend
7. LED, Equipment, Component Trend

- 180 Slides in Power-point

Detailed Database in Excel

1. Micro LED Display Market Forecast
2. Micro LED Wafer Market Forecast
3. Micro LED Cost Estimation

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## 2.0 MICRO LED DISPLAY MARKET ISSUES

Appearance of Micro LED Displays

TV set shipment has been gradually falling

TV set with OLED & QD LCD is still limitedly increasing

Full screen smartphone needs the sensor-integrated display

Real full-screen smartphones will be realized in a few years

LED Manufacturers are looking for new demand

Definition of Micro LED & Micro LED Display

SWOT analysis of Micro LED Display market

## 3.0 MICRO LED DISPLAY MARKET FORECAST

Summary of Micro LED Display market forecast

Micro LED Display shipment forecast

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Cost structure analysis #7~8 – Automotive (10-inch RGB LED vs. Color Converted)		
Cost structure analysis #9~10 – Monitor (30-inch LTPS vs. Oxide)		
Cost structure analysis #11~12 – TV (75-inch Modular LTPS vs. Modular Oxide)		
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AU Optronics		
China Star Optoelectronics Technology		
glō		
Hisense		
Jade Bird Display		
LG Electronics		
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		Sony
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		eLux
		EPISTAR
		Industrial Technology Research Institute
		Jasper Display Corp.
		Korea Institute of Machinery and Material
		Lumens
		Playnitride
		Sanan Optoelectronics
		Toray Engineering
		X-Celeprint

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