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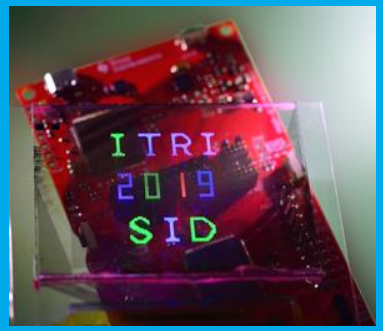
工業技術研究院
Industrial Technology
Research Institute

Micro LED 2.0 – From display to heterogeneous micro assembly system

March, 2021

AR

Transparent



Signage

Flexible

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Outline

- Introduction to micro-LED based display
- ITRI's total solution for micro-LED
- Micro LED 2.0 (our next major developments)
  - Active smart pixel package
  - Micro-LEDs for Augmented Reality (AR) display
  - Micro-sensors for AR Eye Tracking
- Summary

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MicroLED Display, Comparison among technologies

Gaming	AR	Spec. / Technology	LCD	OLED	Micro-LED
	●	Power consumption	X	0.2X	0.1X
	●	Resolution	1000 PPI	2500 PPI (DEMO)	> 5000 PPI
●	●	Brightness (nits)	< 2000	< 1000	> 100 K
●		Contrast	Medium	High	High
		Lifetime (hr)	High	Low	Best
		Environment tolerance	High	Medium	Best
●	●	Frame rate	ms	μs	ns
●	●	View angle (degree)	< 60	> 150	> 150
		Flexibility	Low	High	Medium
		Tech. readiness	High	Medium	Low
		Cost	Low	Medium	Low *

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ITRI's Micro LED Roadmap

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- Signage (PCB display module)

- AR/MR

- Automotive

2009

2014

- Micro-/Mini-LED Transfer
- Optics

2019

- mini-LED: UPH ≥ 200K
- micro-LED: UPH ≥ 2,520K

2022

- Full-color QD
- <10 μm chip
- Eye-tracking

CES2020

2024

- Micro IC + Sensors

Chip → Inspection → Transfer → Inspection → Repair → Module

Equipment (Inspection, Transfer)

Material (Inspection, Repair)

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ITRI has total solution for μLED

- **2 process lines**

Platform for **chip**

Platform for **mass transfer**

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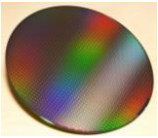

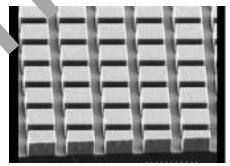

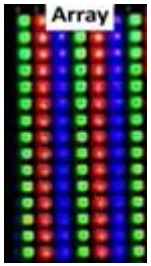

LED on sapphire ⇨ **micro-LED array** ⇨ **micro-LED on backplane**

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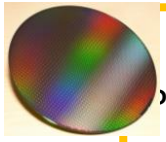
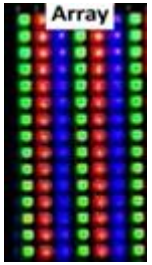
ITRI has total solution for μLED



Platform for chip (class 10)

- Photolithography
- Mapping
- Etching
- Insulator deposition
- Film deposition
- Warpage check

- L-I-V test
- Morphology inspection
- Optical ins
- Plasma etching
- Mass transfer
- Color check



Platform for mass transfer

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Micro LED Industry Chain

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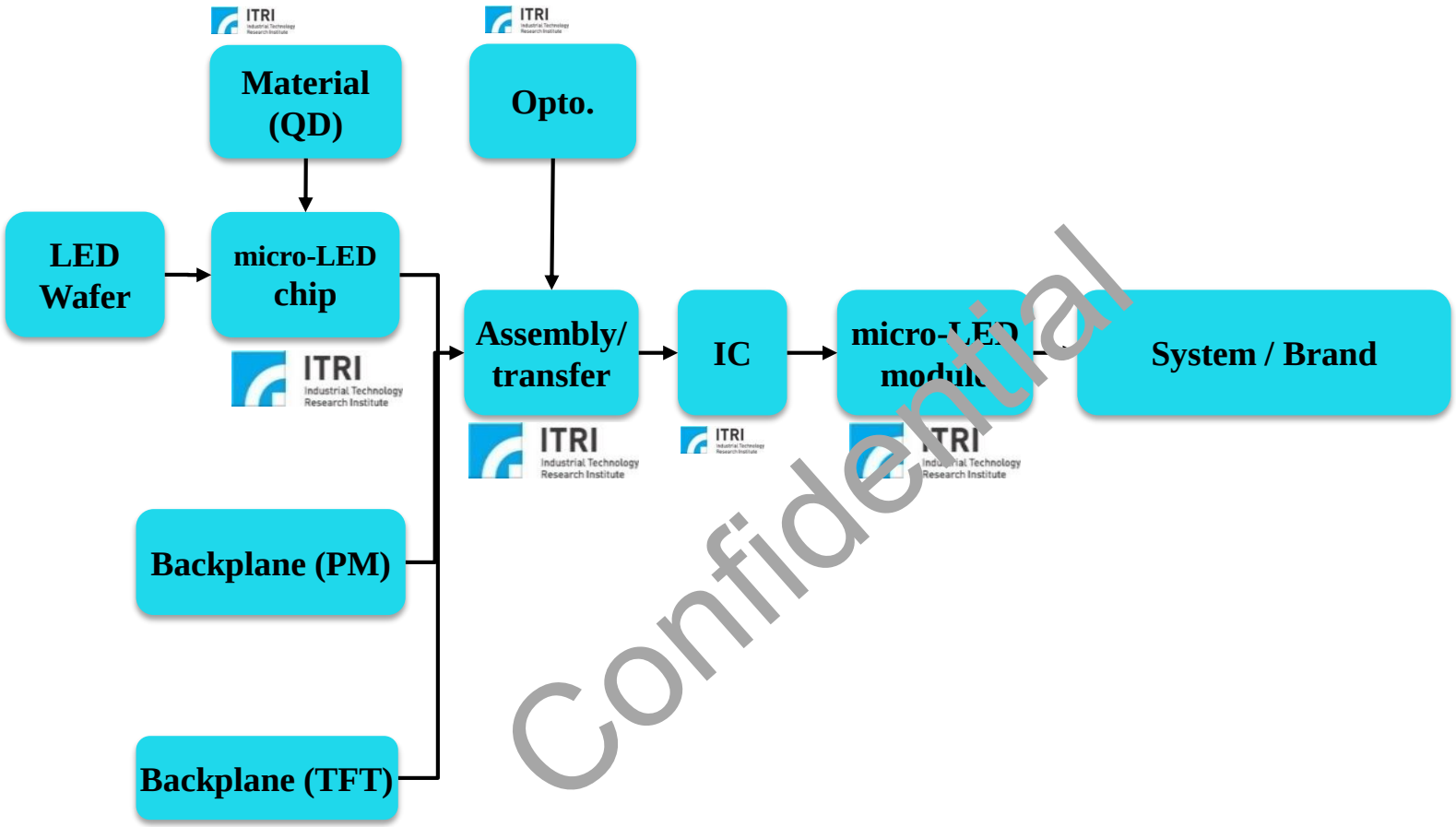

Application

Signage

AR/MR

Automotive

Inspection

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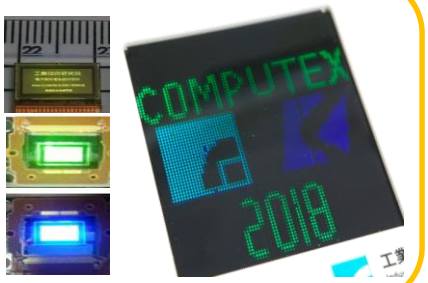
ITRI's progress

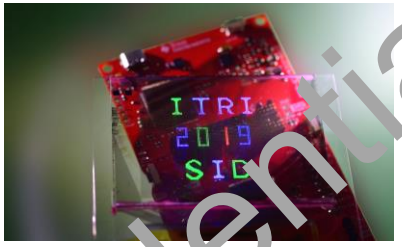
COMPUTEX 2018
micro-display



- Resolution : 960×540 / 80×80
- Pitch : 12.8 µm / 750 µm
- Application: AR / Signage

Blue micro-LED on CMOS

Display Week 2019
Transparent display

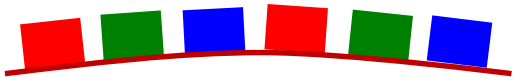


- Resolution : 120×3RGB×120
- Pitch : 375 µm
- Transmittance : > 65 %
- Application : Automobile

R/G/B micro-LED on glass

CES 2020
Fine pitch signage

- Resolution : 480×3RGB×480
- Pitch : 625 µm
- Viewing angle : > 160 deg.
- Application : Signage



R/G/B micro-LED on PCB

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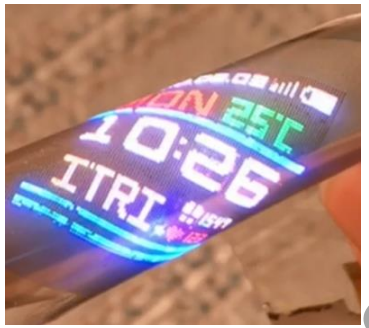
ITRI's progress (cont.)

Display Week 2020

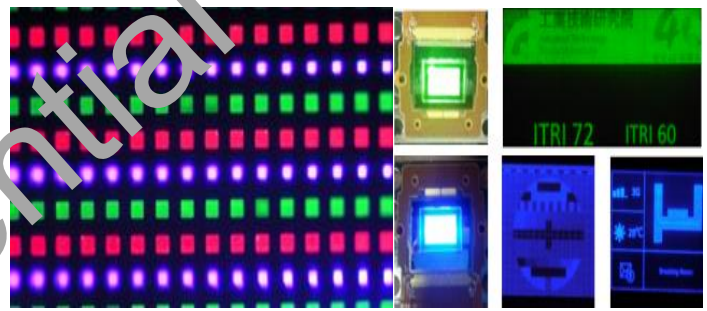
Wearable



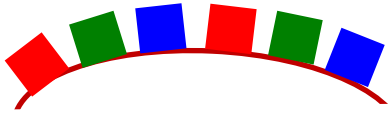
- Resolution : 240×RGB×120
- Pitch : 250 μm
- Transmittance : 30 %
- Application : Flexible / Wearable

2021/Q1

AR Micro-display



- Resolution : 960×RGB×540
- Pitch : 12.8 μm
- Application : AR / MR



R/G/B micro-LED on PI

Blue micro-LED/ QD on CMOS

(cont.)

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- **Micro LED 2.0 (our next major developments)**
  1. **Active smart pixel package**
  2. **Micro-LEDs for Augmented Reality (AR) display**
  3. **Micro-sensors for AR Eye Tracking**
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Micro LED 2.0

Display to more than display-heterogeneous micro assembly system

MicroLED1.0 – Display

Smart pixel
Active driving/
μ-emitting/
μ-sensing

MicroLED2.0 – more than display

supreme quality for displays

- self emissive
- high brightness
- high efficiency
- Color vivid

HMI, display everywhere

- Heterogeneous integration by micro-assembly
- In display hybrid sensing
- Interaction
- AR/MR

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1. Active smart pixel package

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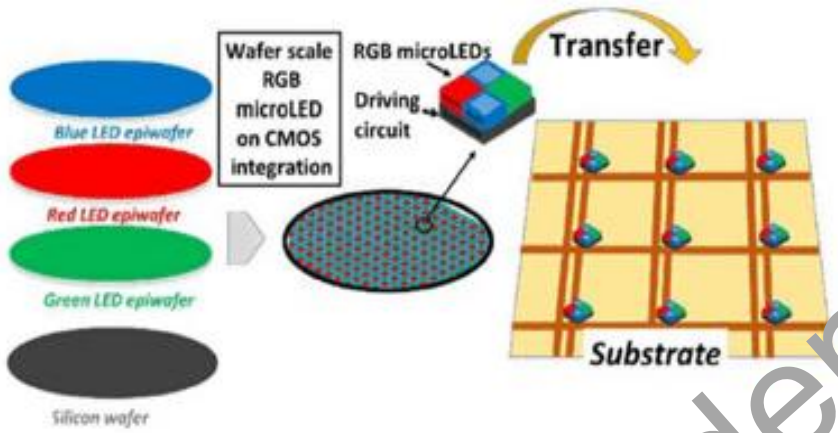
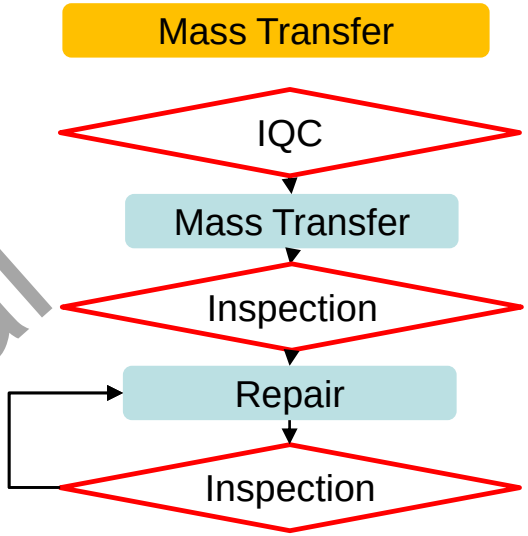
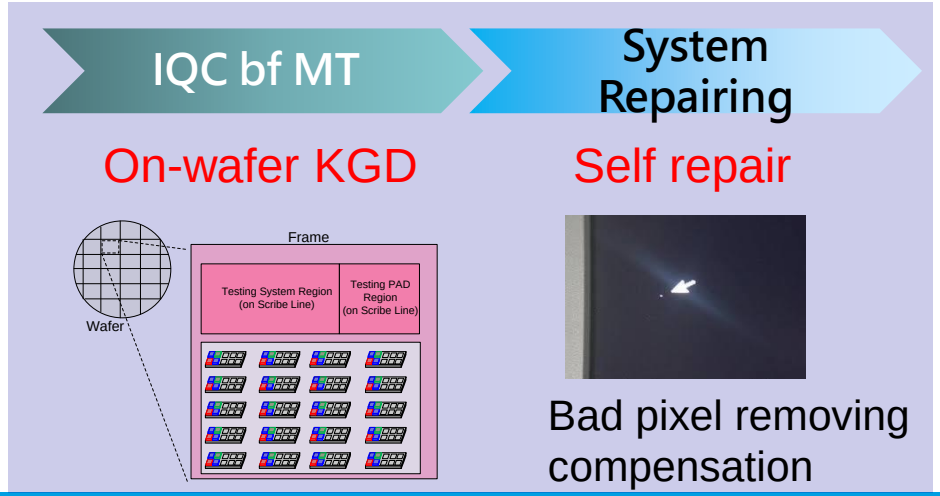
Leti's solution: μ-LED on μ-IC





- "Know Good Dies" test available
- Wafer level fabrication
- 1 transfer instead of 3 or 4
- Addition functions embedded
- Modular pixels

ITRI's total solution (patent pending)



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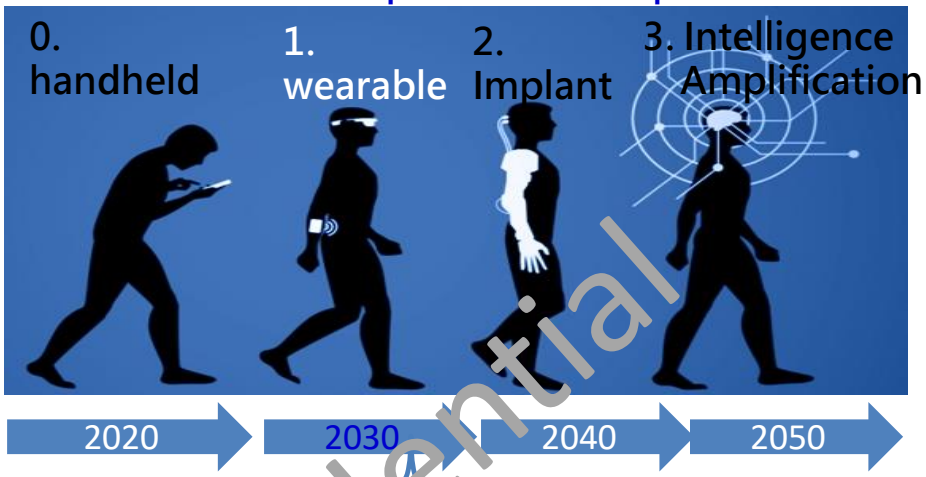
2. Next-gen AR glasses application

- From AR(Augmented Reality) To IA (Intelligence Augmentation)

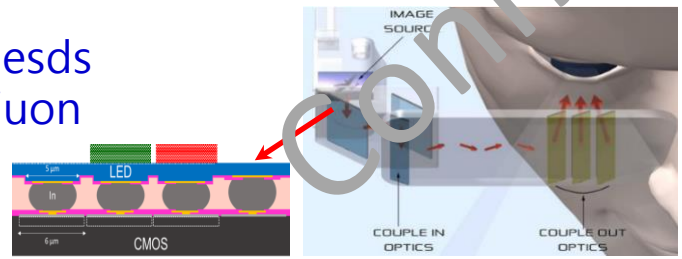
IA development roadmap



High quality (μLED1.0)

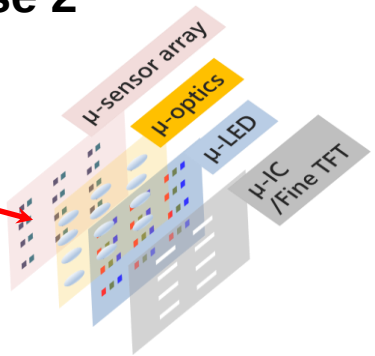
High brightnesds
High resolutiuon
Low power
Color vivid

Phase 1 (now)



- RGB(QD) μLED
- CMOS backplane
- Inspection

Phase 2



- Metalens
- High PPI transparent μLED
- Eye tracking HMI

Multi-functions (μLED2.0)

Display

High immersion, eye HMI

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Phase 1: Micro-Display AR Glass

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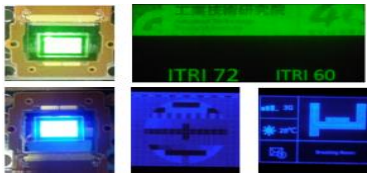
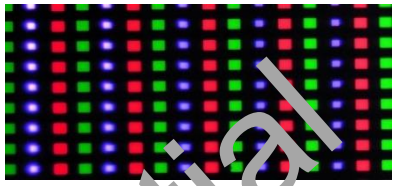
	2013~2020	2021	2023~
Progress	**Mono display**	**Full-color display with color conversion**	**Integrated to AR/MR Glasses**





Core Technology

Micro LED process and Heterogeneous Integration

micro-sensor: eye-tracker

micro-LED

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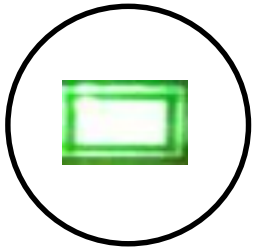
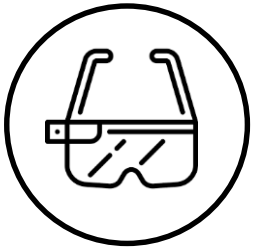


AR Micro-display:

- Resolution: 960×540
- Pixel pitch : 12.8 μm
- Active matrix driving
- CMOS backplane

micro-sensor



AR Micro-display:

- Resolution: 1920×1080×RGB
- Pixel pitch : < 6.4 μm
- Sensing function upon request
- Active matrix driving
- CMOS backplane

Phase 2: Next-gen AR glasses

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Unmet requirements : large FOV, compact and lightweight, HMI

Now

e.g. Microsoft Hololens 2

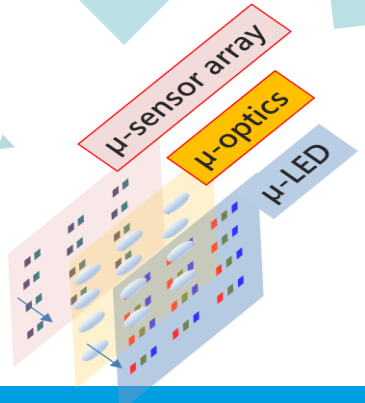
solution

Traditional

Display	Optical system	HMI
• Low resolution • Low brightness <10K nits	• Large engine(>5cc) • Small FOV (~40˚)	• Voice & gesture

solution

µLED display	Metalens	Eye tracking
• High res.(4K) • High brightness >20K nits • Low power consumption	• Small size<1cc) • FOV>80˚ (high immersion)	• Low power consumption • Small size, easy integration



lightweight

High resolution, immersion

Friendly HMI

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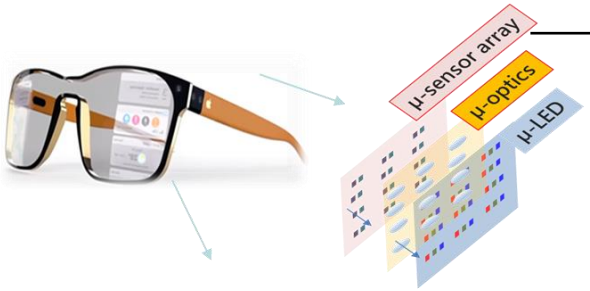
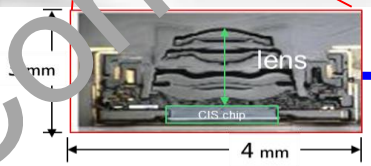
3. Eye-tracking Application



- **As-is（T Company Pro Glasses 3）**
- **To-be（ITRI）**

IR LEDs

Micro-camera (3~5mm)



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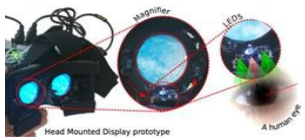
Tech. spec

- **Eye-tracking accuracy ~ 0.5°**
- **System sampling rate ~ 50 Hz**
- **Power consuming**
- **Hard to integrate**

Ref : internet

Eye Tracking, Comparison among technologies

Units	ITRI	ITRI	T Company	N Company
Targets	micro-LED sensor array	lensless camera module	T Company pro glasses 2	VR gaze tracker -2020
Features				
			camera-based	sensor-array-based
Size [mm]			~≧ 5	~≧ 1
Angle [deg]			**0.5**	1
Sampling rate [Hz]			50 or 100	**250**

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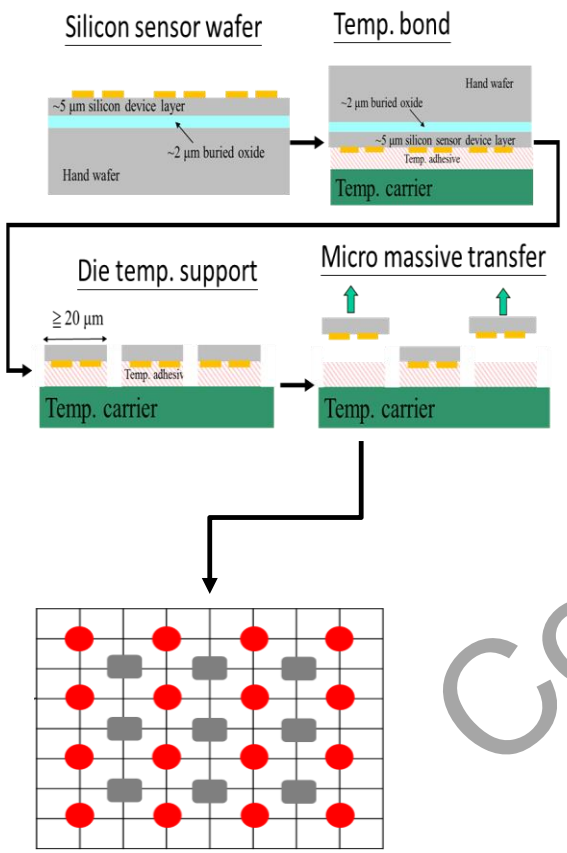
Ref[1]: The concept figure of optical combiner from Digilens.

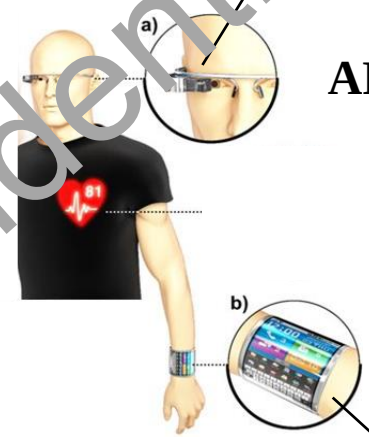
Micro LED as sensor

Heterogeneous micro-assembly



Micro-device Array (Sensors, PV, LEDs, LDs)

Applications

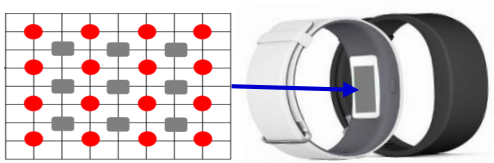


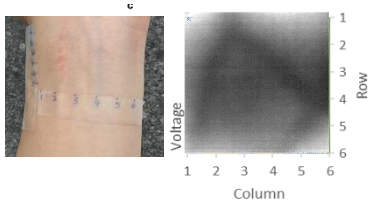
AR-glasses Eye tracking

AR glass

Bands/watches

Bio-sensor & vein IDs





Ref[1]: The concept figure of optical combiner from Digilens.

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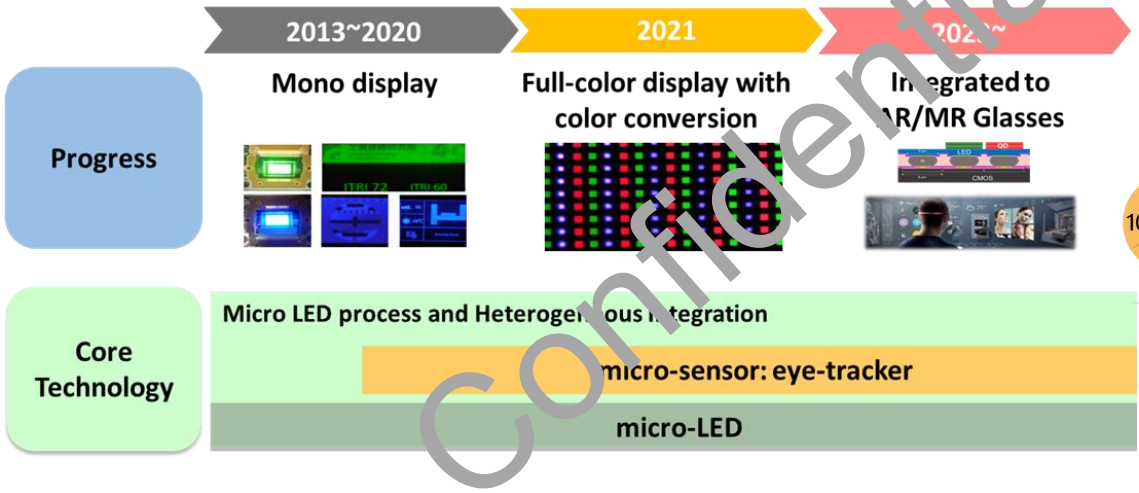
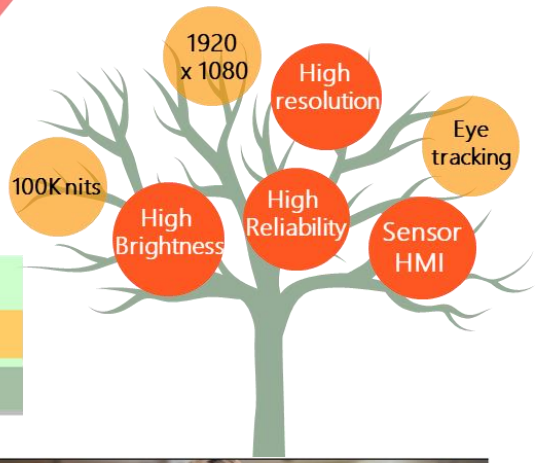
Summary

- **Micro-LED Micro Display (2022 Full-HD AR glass integration)**
  High Brightness/Efficiency MR display : Heterogeneous integration of QD color conversion layer and blue micro-LED onto CMOS Si backplane

- **Micro-LED 2.0 (2021 POC、2022 AR glass integration)**
  HMI for MR glasses : non-camera based, micro-sensor array on glass features ultra-fast, low power consumption and easy integration





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Thanks for your attention