# MICROLED TECHNOLOGY AT CEA-LETI

March 2023

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# CEA-LETI AT A GLANCE

## “3rd Innovative Public Research Organization Worldwide” 2012-2020

Derwent™
A Clarivate Analytics company

Since **1967**

**1 870** people

**Patents:**
- > 3 200 in portfolio
- **40% under license agreement**

**Startups:**
- 72 created for 20 years (75% in activity)
- 3 500 jobs created

**Cleanrooms:**
- 500 state-of-the-art equipment in 200 & 300 mm
- 11 000 m² cleanroom

**Budget:**
- 315 M€
- 85% from R&D contracts

**CREATE INNOVATION & FAST TRANSFER TO INDUSTRY**

**RELIABILITY, ROBUSTNESS AND YIELD IS IN OUR DNA**

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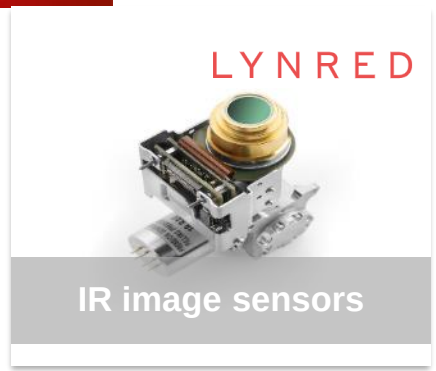
# EXAMPLES OF CEA-LETI'S INNOVATIONS AVAILABLE ON THE MARKET

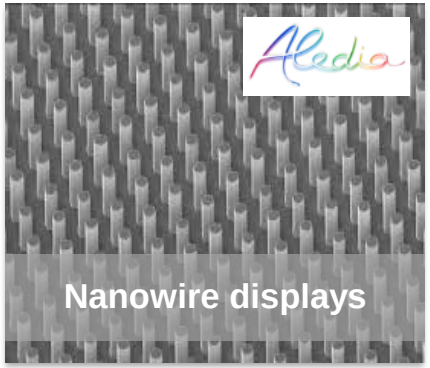



IR image sensors

Thermal image sensors

CMOS image sensors

SOI substrates




Nanowire displays

Gas analyzers

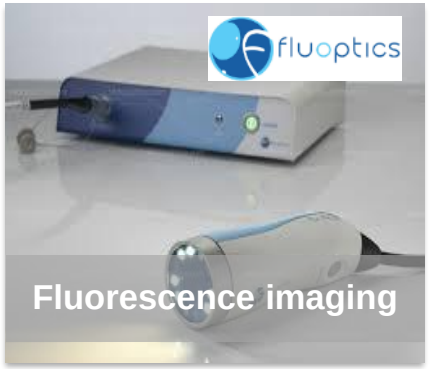
OLED displays

PACS camera

Gas sensors

X-Ray Imaging

LiFi




Fluorescence imaging

leti
cea tech

**700** state-of-the-art tools
**11,000 m²** of cleanroom space

# Main Technological Baselines

| | | |
|---|---|---|
| 300 mm | 1 | NW GAA / BEYOND CMOS |
| 200 mm, 300 mm | 2 | EMBEDDED MEMORIES |
| 200 mm, 300 mm | 3 | RF (active and passive devices) |
| 200 mm, 300 mm | 4 | Si PHOTONICS |
| 200 mm, 300 mm | 5 | µLED DISPLAY |
| 300 mm | 6 | IMAGERS |
| 200 mm | 7 | MEMS |
| 200 mm, 300 mm | 8 | POWER (Si, GaN, SiC) |
| 200 mm, 300 mm | 9 | 3D |
| 200 mm, 300 mm | 10 | SUBSTRATES |
| 200 mm | 11 | II-VI and III-V |

## World-class facilities

## for your future business needs

# DISPLAY ACTIVITIES (DEPARTMENT OF OPTICS AND PHOTONICS)

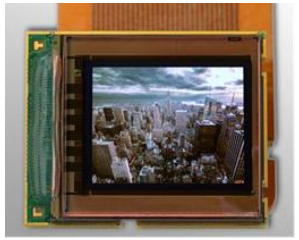
Associative image

## LCD

*Microdisplays*

## GaN MicroLED

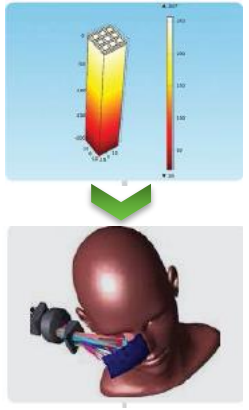
*Microdisplays*
*'Big' displays*
*Optical Communications*



w/ microOLED

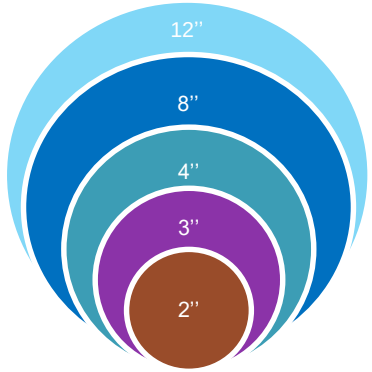
## OLED

*Microdisplays*
*Health*
*Optical Communications*



## Complete Process

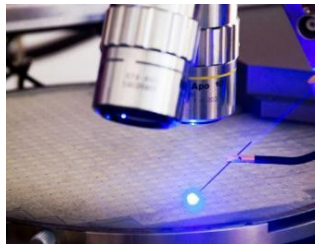
*Simulations*
*Design*
*Epitaxy*
*Wafer process*
*Packaging*
*System level*




## Integration Technologies

*Chip to chip*
*Chip to wafer*
*Wafer to Wafer*
*Integration on ASIC:*

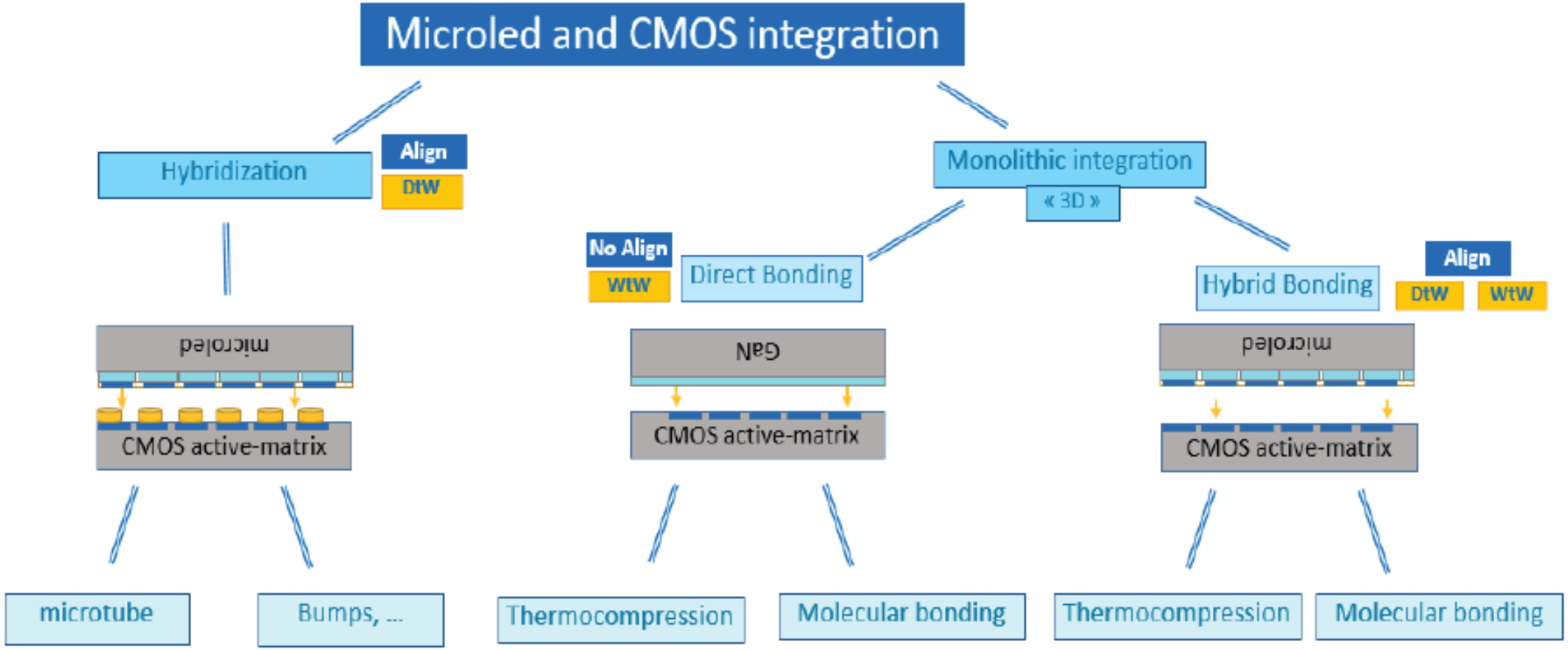
- *micro-tubes*
- *hybrid bonding*
- *metal/metal bonding*



## Full Carac. Set-up

*Material*
*Fine Characterization*
*On wafer*
*Packaged*

# MICROLED / CMOS INTEGRATION OPTIONS




F.Templier, C. Dubarry, Proceedings of the International Display Workshops, VOL.29, 2022

**Experience in all types of bonding**

**For MicroLEDs applications; but also for other applications like sensors**

# CEA-LETI DEMONSTRATORS

## Microtubes: 10 microns

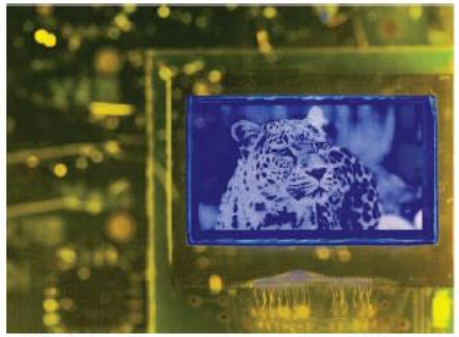


Fig. 3 WVGA, 10µm.-pitch, microLED prototype made with microtube technology [3].

## Direct Metal Bonding: <5 microns

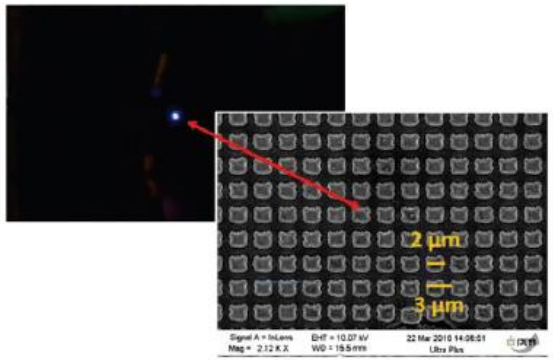



Fig. 5 (right) Scanning Electron Microscope image of a 2-µm size, 3-µm pitch blue microLED array and (left) one of the microLEDs switched on [9].

## Hybrid Bonding: <5 microns

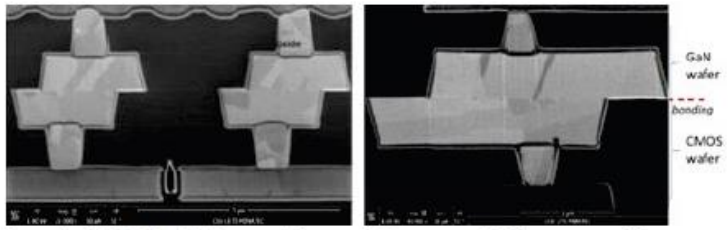



Fig. 4: FIB-SEM X-section of Copper /silicon oxide hybrid bonding area for 3 and 5 µm pitch

**Decades of experience in microLED**

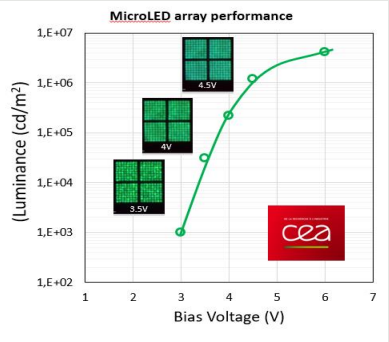
**CMOS / GaN integration, microLED pixel structurisation and performance improvement**

F.Templier, C. Dubarry, Proceedings of the International Display Workshops, VOL.29, 2022

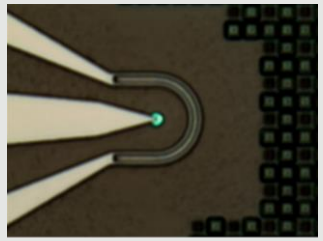
# OTHER RESULTS AND POTENTIAL COLLABORATION OPPORTUNITIES

## 1 000 0000 cd/m2!

- **Proof of concept on passive backplane**
- **11.4 mm x 16.6 mm**
- **1750 × 1200 pixels @ 9.5 µm pitch**
- **Going down towards 1 µm possible**

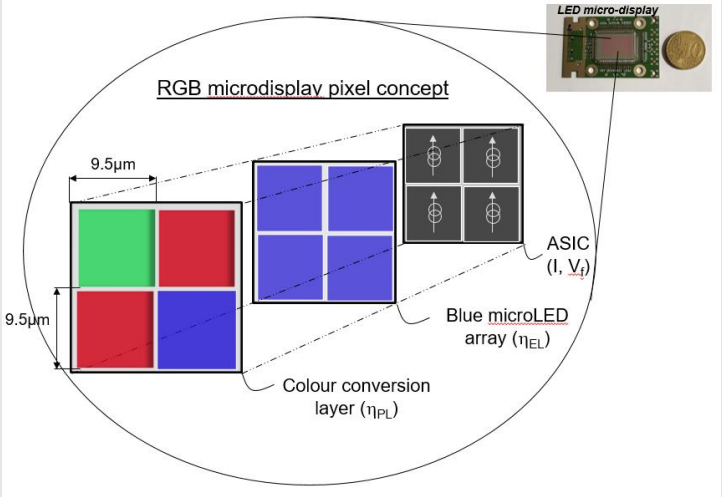



Clean Sky 2 JU H2020 HILICO project



LED d= 1.25µm

## RGB design
## Colour conversion

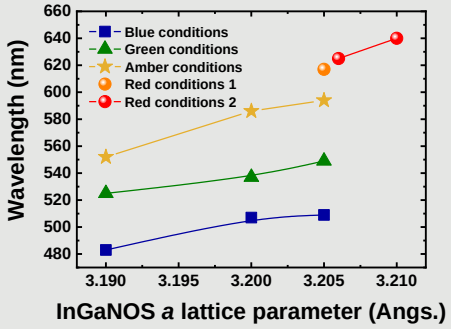


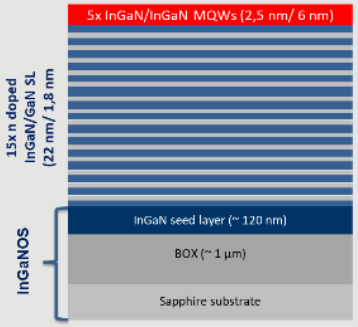

Clean Sky 2 JU H2020 HILICO project

E. Quesnel et al., J Soc Inf Display. 2020;1–14.

## InGaN RED/native colour

- **Partially relaxed InGaN pseudo-substrate (InGaNOS from Soitec)**
- **Improve the In incorporation rate, with an increasing effect as the a lattice parameter increases.**
- **10 µm circular micro-LED**




Exemplary condition

A. Even *et al.*, *Appl. Phys. Lett.* 110, 262103 (2017)
A. Dussaigne and D. Sotta, Compound Semiconductor, July 2017
A. Dussaigne *et al.*, Appl. Phys. Express 14, 092011 (2021)

**Work on µLED, colour conversion, ASIC and their integration**

**Work on red InGan/Native RGB**

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