A HI Flexible High Resolution µDisplay Enabled By FlexTrate™

Henry Sun[1], Lisong Xu[2], Kai Ding[2], Mingwei Zhu[2], and Subramanian S. Iyer[1]
[1]UCLA CHIPS, [2]Applied Materials Inc
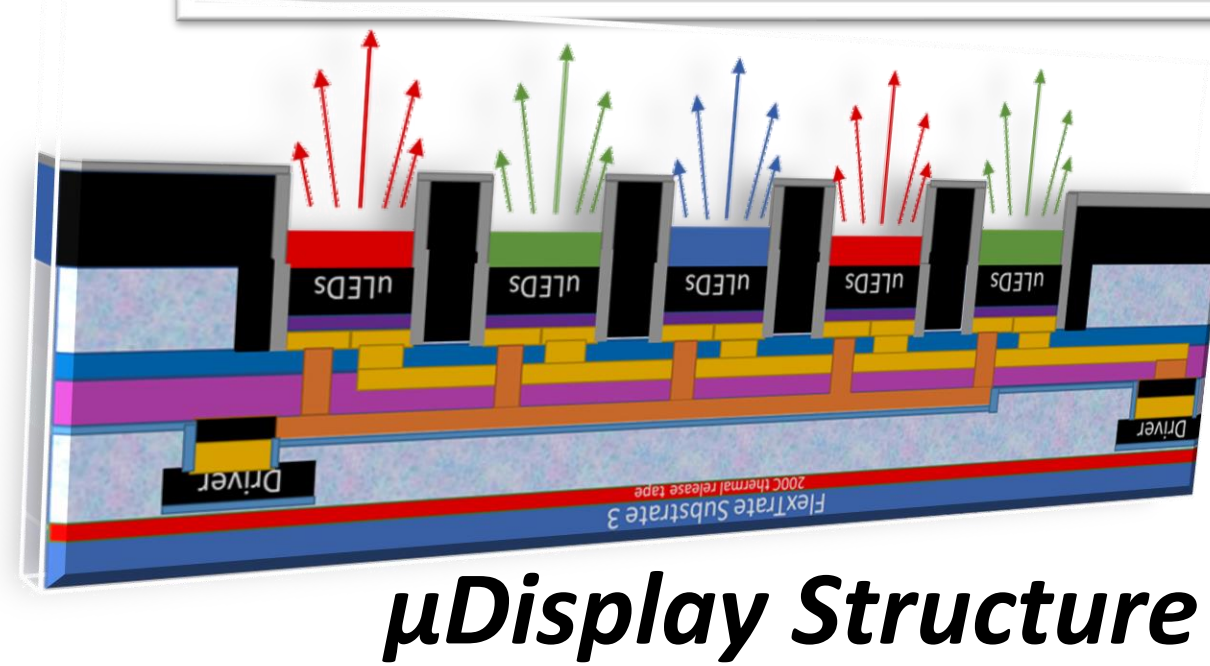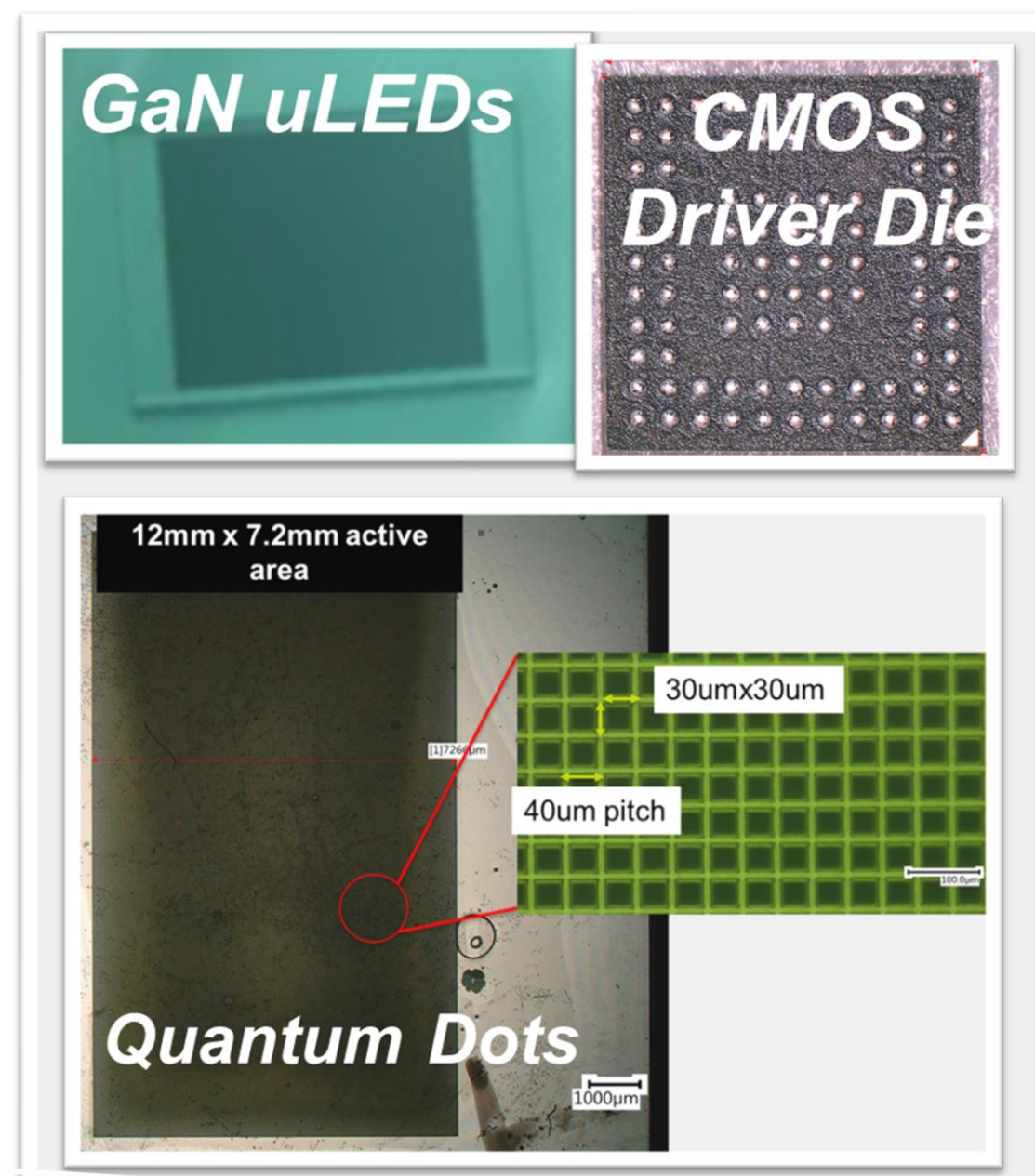#### Hsunhenry@ucla.edu

Introduction and Motivation

Novel approach to create Quantum dot-enabled, flexible, uDisplays using FlexTrate™ Featuring:

o GaN µLEDs: High brightness (>5000nits), high hi resolution (>600PPI in 360x280 resolution)

o High Performance CMOS driver for passive matrix display (TLC6984)

o Quantum Dots to convert monochrome LED to RGB subpixels (<10um thick QD layer)

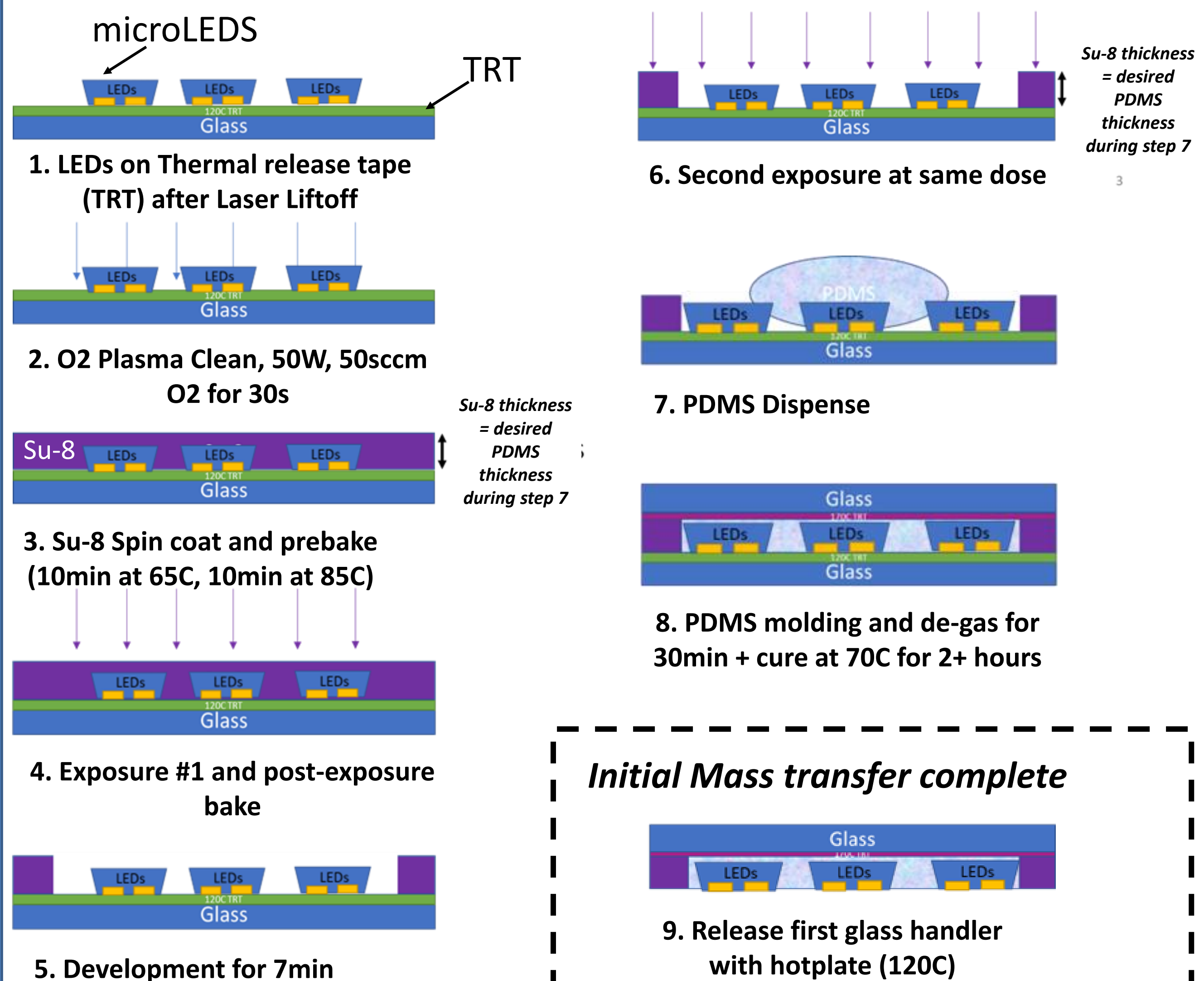o FlexTrate™ Platform for Heterogeneous Integration

Key Benefits:

o Light weight, High Flexibility

o Long display lifetime (10 years+)

o Substantial increase in manufacturability

o Agnostic to die thickness and material type

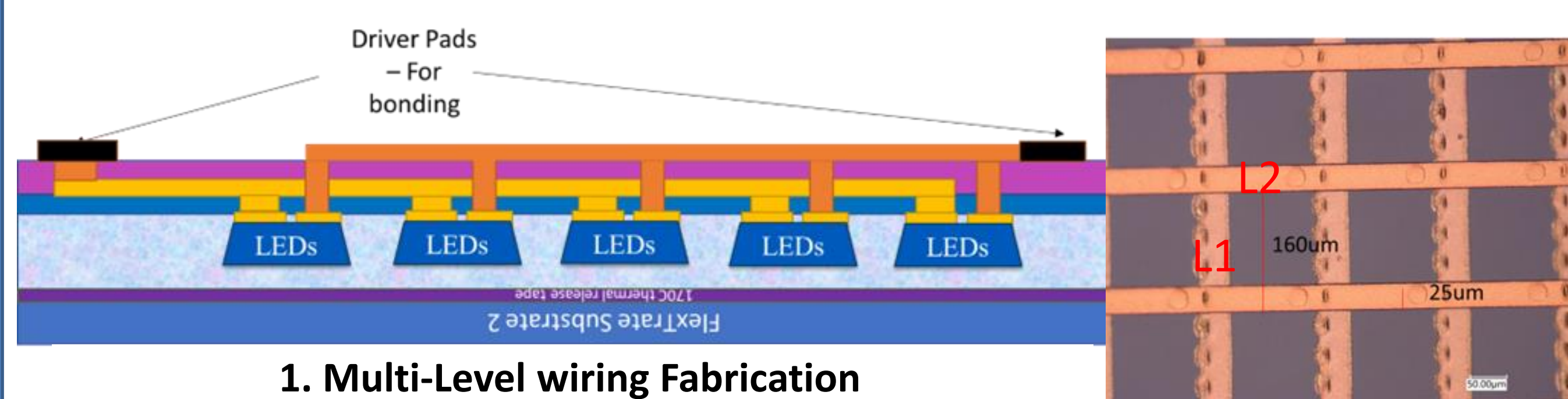**GaN uLEDs** / **CMOS Driver Die**

12mm x 7.2mm active area — 30um x 30um — 40um pitch

Quantum Dots

µDisplay Structure

Fabrication Process Flow for µLED Display

Mass Transfer onto Flexible PDMS substrate

microLEDS / TRT

1. LEDs on Thermal release tape (TRT) after Laser Liftoff

2. O2 Plasma Clean, 50W, 50sccm O2 for 30s

Su-8

3. Su-8 Spin coat and prebake (10min at 65C, 10min at 85C)

Su-8 thickness = desired PDMS thickness during step 7

4. Exposure #1 and post-exposure bake

5. Development for 7min

6. Second exposure at same dose

Su-8 thickness = desired PDMS thickness during step 7

7. PDMS Dispense

8. PDMS molding and de-gas for 30min + cure at 70C for 2+ hours

Initial Mass transfer complete

9. Release first glass handler with hotplate (120C)

High throughput and high yield (>99.99%)

Wire fabrication and Driver, Quantum Dot Integration

Driver Pads – For bonding

L2 / L1 / 160um / 25um

1. Multi-Level wiring Fabrication

Bonding of Drivers and Quantum Dot Integration

Bonded CMOS Drivers / Driver / Driver / LEDs / FlexTrate Substrate 2 / 120C thermal release tape
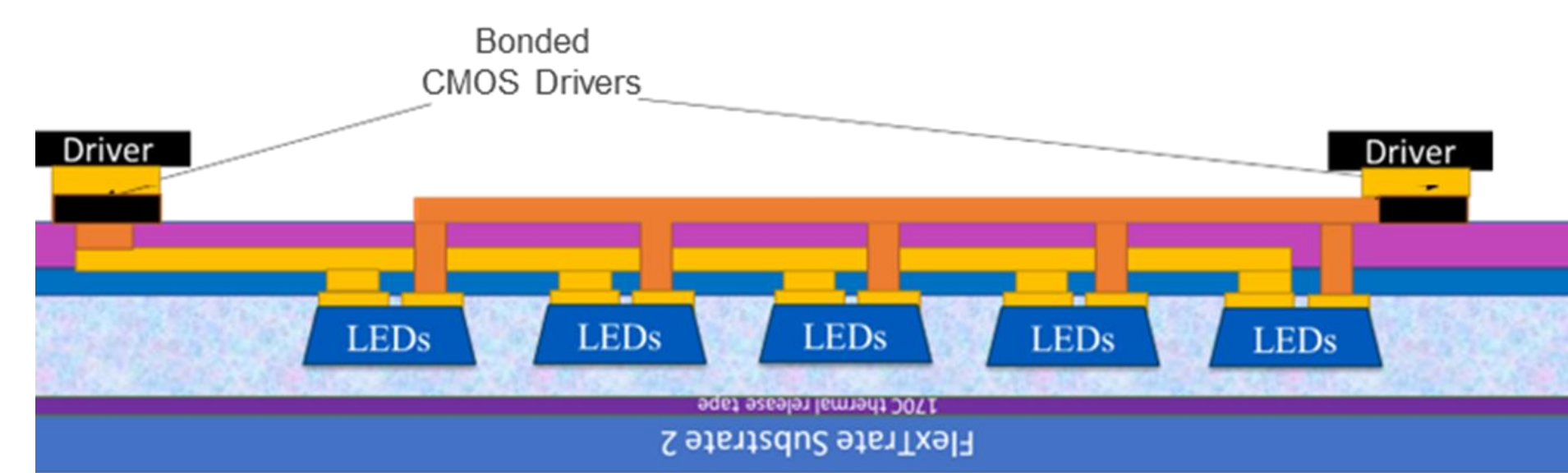
2. Flip-chip bonded driver chips

CMOS drivers and passive components are flip-chip bonded onto the driver pads using K&S APAMA flip-chip bonder

uLEDs / Driver / FlexTrate Substrate 3
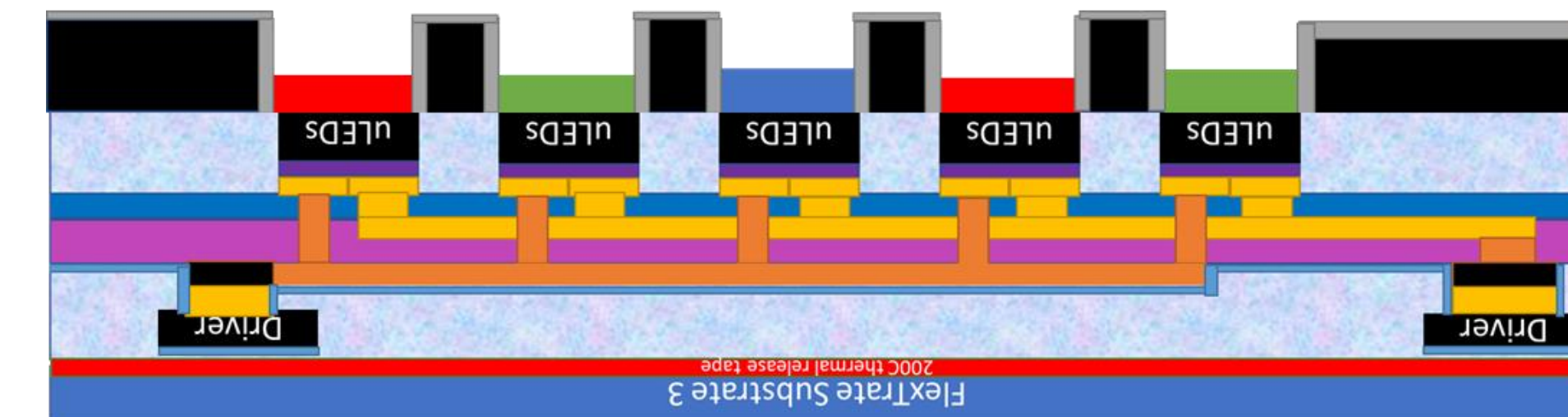
3. Final Structure with Quantum Dot (QD) dispense

Quantum dots are dispensed onto a scaffold structure embedded in PDMS to prevent pixel-pixel optical crosstalk

Results And Discussion

Mass transfer results

o ~100,000 dies transferred at >99.99% yield
  o 361 x 284 pixels
  o 30µm pixels at 40µm pitch
o High degrees of flexibility <3mm bending radius after molding on flexible substrate
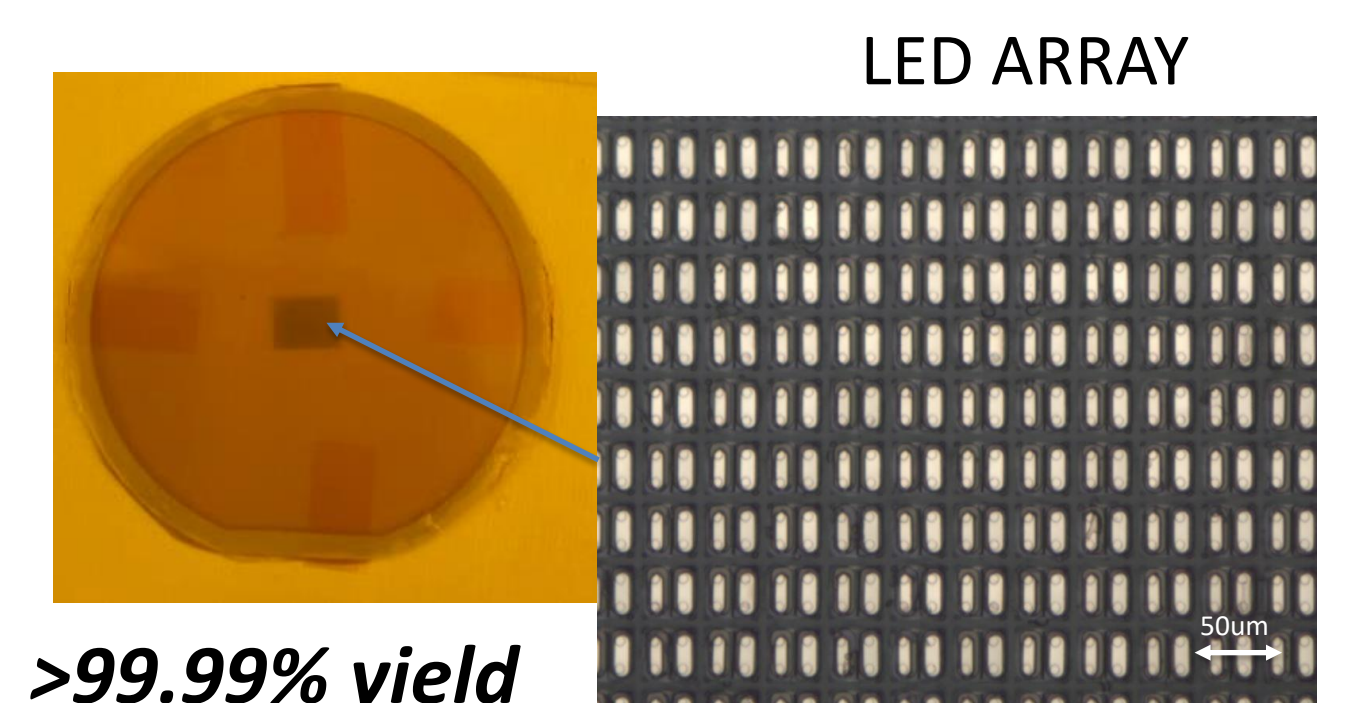
Two-level wiring grid design

o M1 layer addresses the n-contacts of LEDs while M2 layer addresses the p-contacts
o Individual LEDs turn on at 3.01V
o Process optimization to maintain uniform, low resistance across individual wires
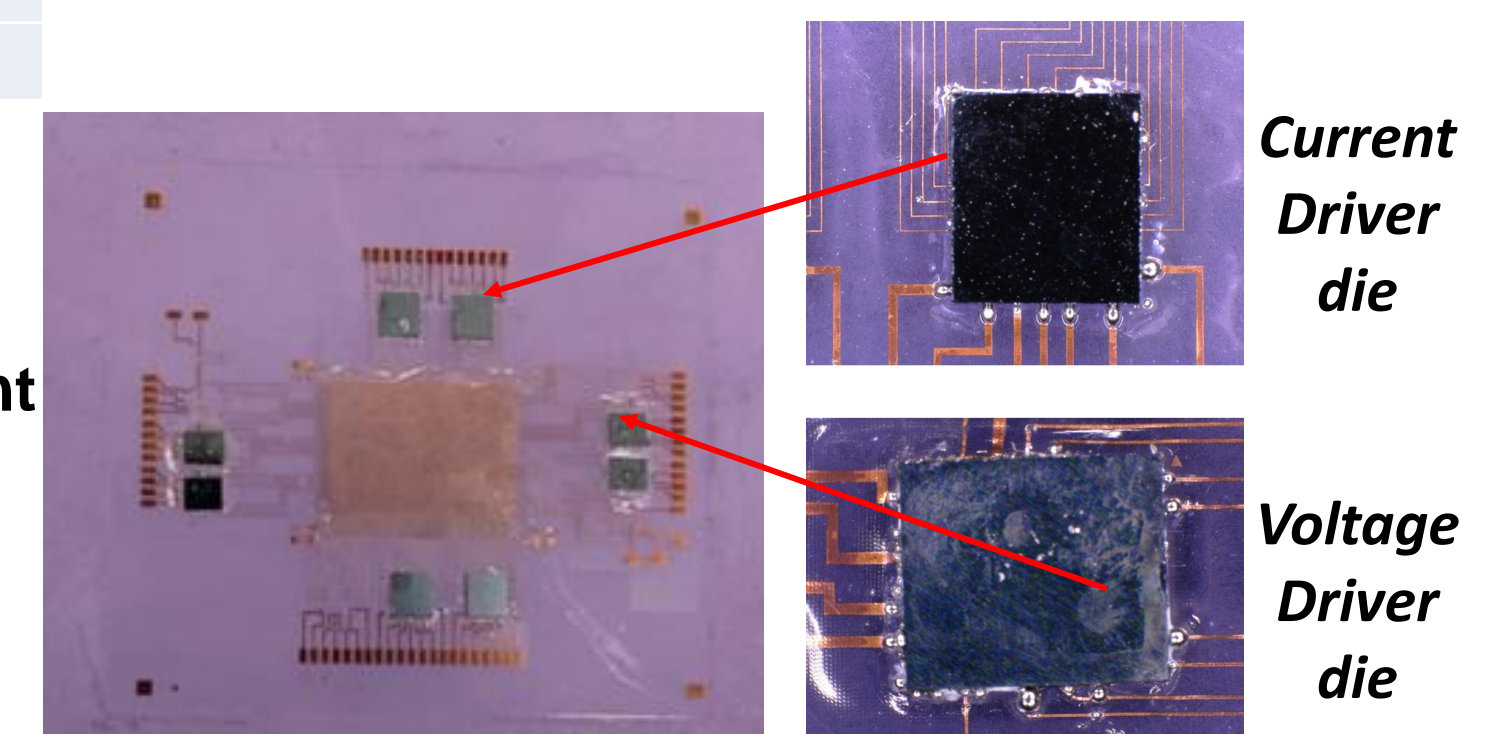
LED ARRAY

>99.99% yield

M1 / M2

Two-level wiring
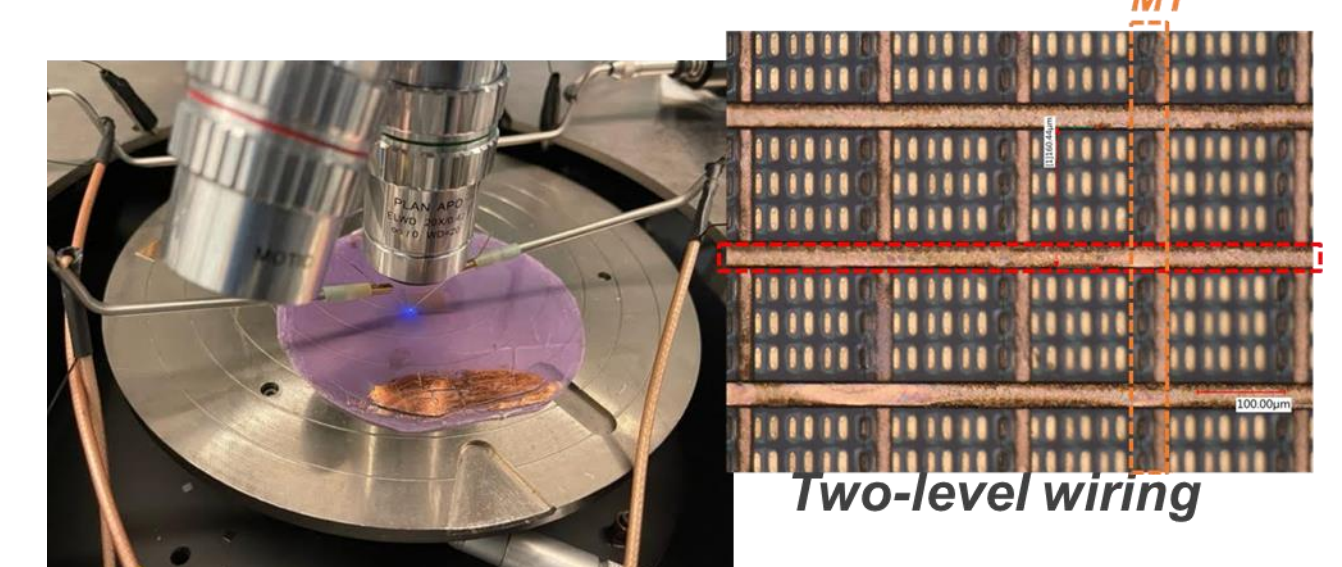
M1 Resistance Measurements

Section	Average Ω	σ
A	6.2	1.04
B	4.4	2.1
C	4.1	1.78
D	5.6	2.2
E	6.3	2.54

Section	Average Ω	σ
A	13.2	1.6
B	10.1	3.1
C	14.6	2.87
D	12.02	3.04
E	12.2	1.79

Driver integration

o Bonding of 2.5mm x 3mm current and 3mm x 3.5mm voltage drivers using flip chip bonder (K&S APAMA) on driver pads

Current Driver die

Voltage Driver die

Conclusion and Acknowledgements

- *Demonstrated a method of fabricating a high performance, flexible uDisplay on FlexTrate™*
- *Demonstrated high yield and throughput during initial transfer step*
- *We thank our partners at Applied Materials and members of the UCLA CHIPS consortium for their generous support on this project.*
- *We also acknowledge the UCLA Nanoelectronics Research Facilities and Integrated Systems Nanofabrication Cleanroom and staff.*

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