# A HI Flexible High Resolution µDisplay Enabled By FlexTrate™

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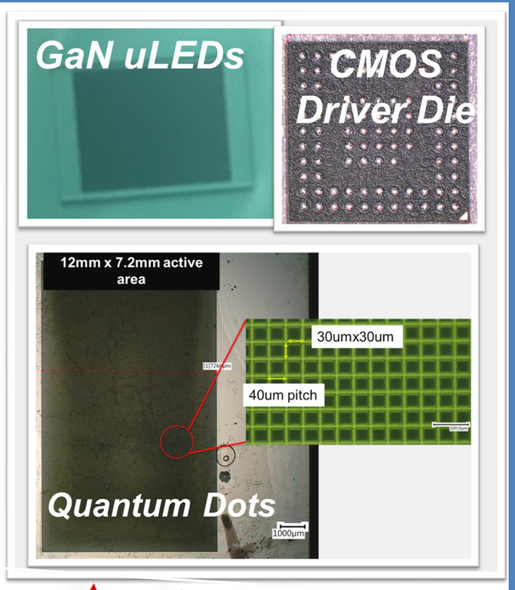
## Introduction and Motivation

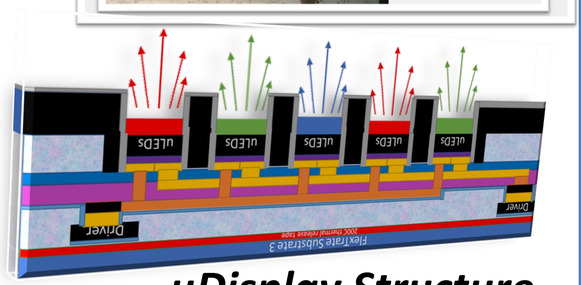
***Novel approach to create Quantum dot-enabled, flexible, uDisplays using FlexTrate™ Featuring:***

- GaN µLEDs: High brightness (>5000nits), high hi resolution (>600PPI in 360x280 resolution)
- High Performance CMOS driver for passive matrix display (TLC6984)
- Quantum Dots to convert monochrome LED to RGB subpixels (<10um thick QD layer)
- FlexTrate™ Platform for Heterogeneous Integration

***Key Benefits:***

- Light weight, High Flexibility
- Long display lifetime (10 years+)
- Substantial increase in manufacturability
- Agnostic to die thickness and material type

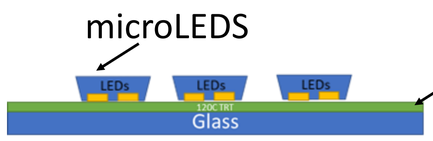


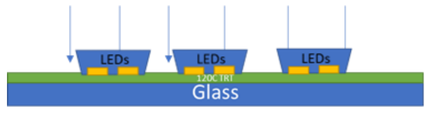

***µDisplay Structure***

## Fabrication Process Flow for µLED Display

***Mass Transfer onto Flexible PDMS substrate***



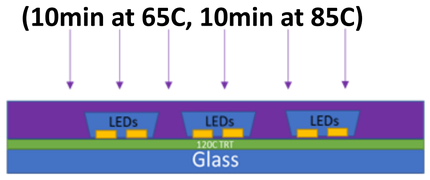

1. LEDs on Thermal release tape (TRT) after Laser Liftoff




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

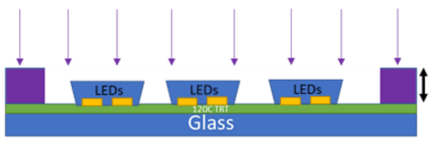

*Su-8 thickness = desired PDMS thickness during step 7*

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



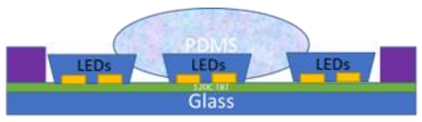

4. Exposure #1 and post-exposure bake


5. Development for 7min

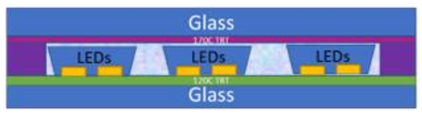



*Su-8 thickness = desired PDMS thickness during step 7*

6. Second exposure at same dose

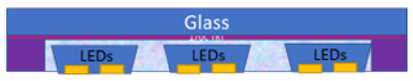



7. PDMS Dispense




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

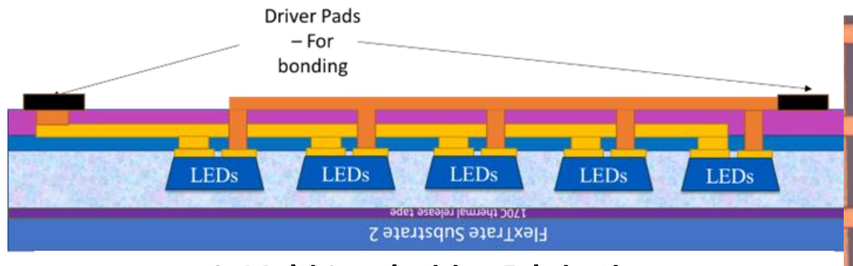
***Initial Mass transfer complete***



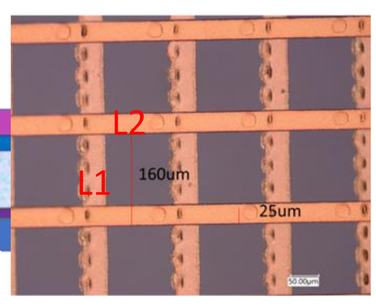

9. Release first glass handler with hotplate (120C)

***High throughput and high yield (>99.99%)***

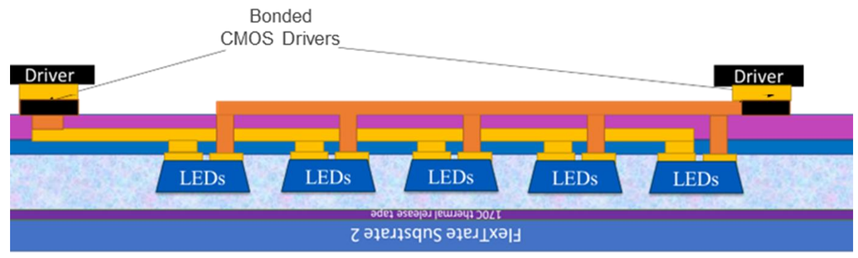
***Wire fabrication and Driver, Quantum Dot Integration***




1. Multi-Level wiring Fabrication

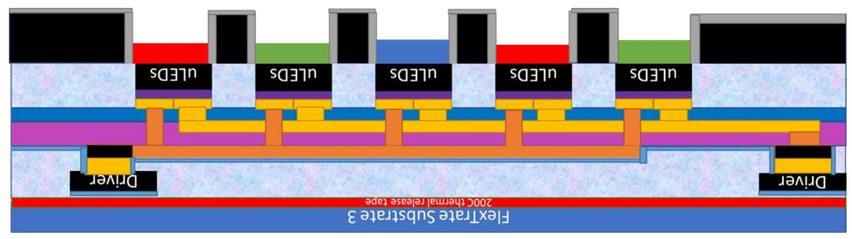



## Bonding of Drivers and Quantum Dot Integration




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***



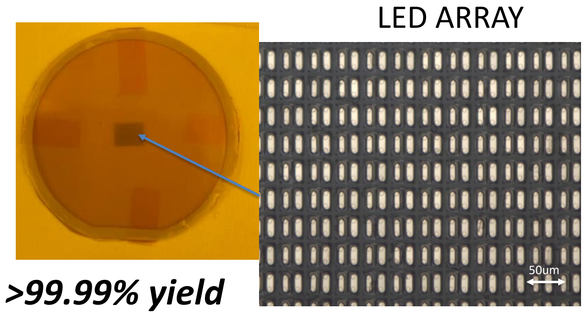

3. Final Structure with Quantum Dot (QD) dispense

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

## Results And Discussion

### Mass transfer results

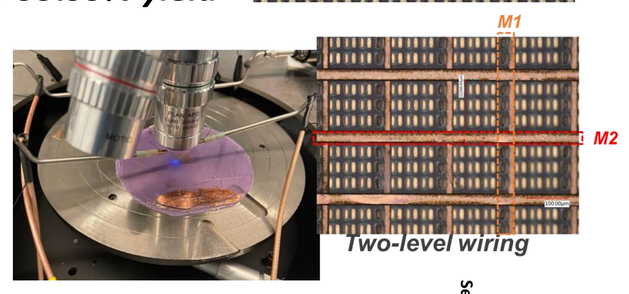
- ~100,000 dies transferred at >99.99% yield
  - 361 x 284 pixels
  - 30µm pixels at 40µm pitch
- High degrees of flexibility <3mm bending radius after molding on flexible substrate



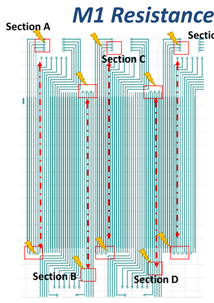

***>99.99% yield***

### Two-level wiring grid design

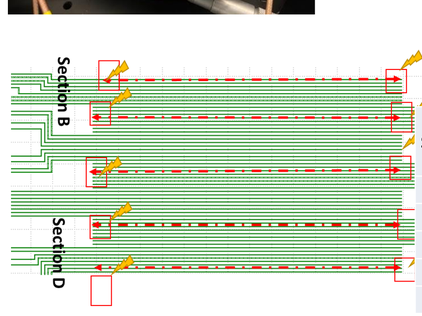
- M1 layer addresses the n-contacts of LEDs while M2 layer addresses the p-contacts
- Individual LEDs turn on at 3.01V
- Process optimization to maintain uniform, low resistance across individual wires




***M1 Resistance Measurements***



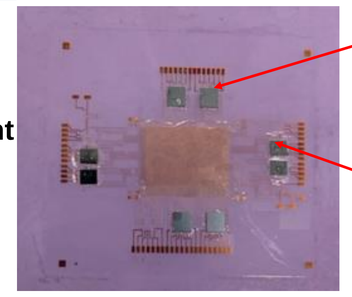

| Section | Average Ω | σ |
|---|---|---|
| A | 6.2 | 1.04 |
| B | 4.4 | 2.1 |
| C | 4.1 | 1.78 |
| D | 5.6 | 2.2 |
| E | 6.3 | 2.54 |

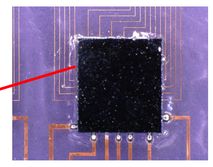



| Section | Average Ω | σ |
|---|---|---|
| A | 13.2 | 1.6 |
| B | 10.1 | 3.1 |
| C | 14.6 | 2.87 |
| D | 12.02 | 3.04 |
| E | 12.2 | 1.79 |

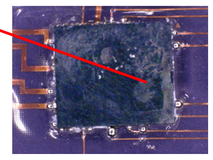
### Driver integration

- 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.***

***2023 UCLA CHIPS Workshop***
***Poster Session***

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