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La Jolla, California

The logo for Total Matrix Addressing (tma). It features the lowercase letters "tma" in a bold, italicized sans-serif font. A red grid pattern is overlaid on the letters, and a small "TM" trademark symbol is at the bottom right.

# Total Matrix Addressing for OLED Displays

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Cambridge Display Technology  
Cambridge  
United Kingdom

- How did we arrive at TMA?
  - OLEDs lifetime is shorter, the higher the peak luminance
    - Even for same average display luminance – MUX ratio dependent
  - CDT investigated whether Multi-line Addressing could be used to reduce peak luminance in PM-OLED Displays
    - Discovered that MLA does not work for OLEDs but
    - CDT developed a new driver technology that does significantly reduce peak luminance in P-OLED displays for same average luminance
      - Net Outcome
        - Longer lived displays **AND**
        - Significant reduction in Power Consumption
  - This is Total Matrix Addressing for PM-OLED Displays

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## Active Matrix

### LTPS

(Low Temperature Poly Silicon)



High current and stability  
Small device



Low yield, scalability  
Non-uniform, immature

### a-Si

(amorphous Silicon)



Mature for LCD, available  
Large scale



Poor current capability,  
Lifetime issues

### PM

(Passive Matrix)



Mature,  
In production



Very limited resolution  
Inefficient, short lived

## Active Matrix

**LTPS**

(Low Temperature  
Poly Silicon)

**a-Si**

(amorphous Silicon)

## Passive Matrix

**PM**

(Passive Matrix)

**MLA**

(Multi-Line Addressing)

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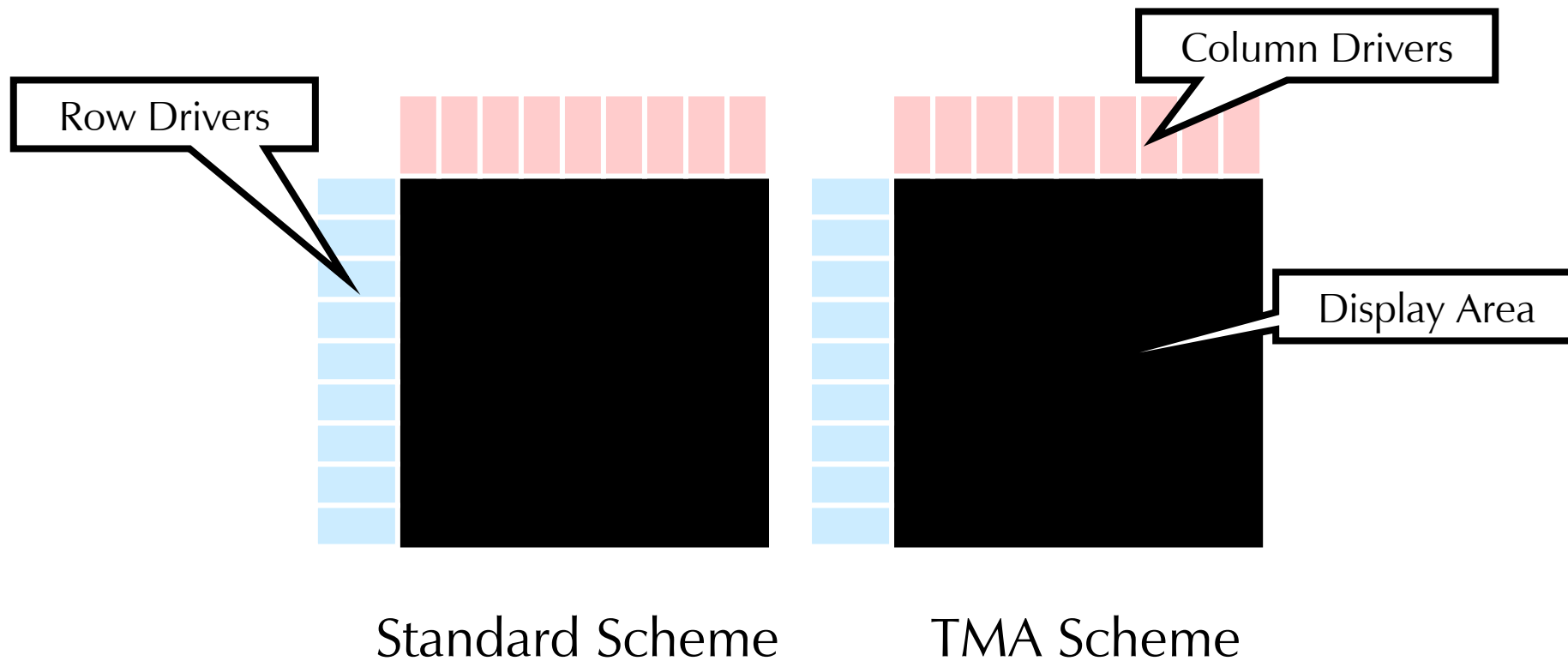
## MLA

(Multi-Line Addressing)

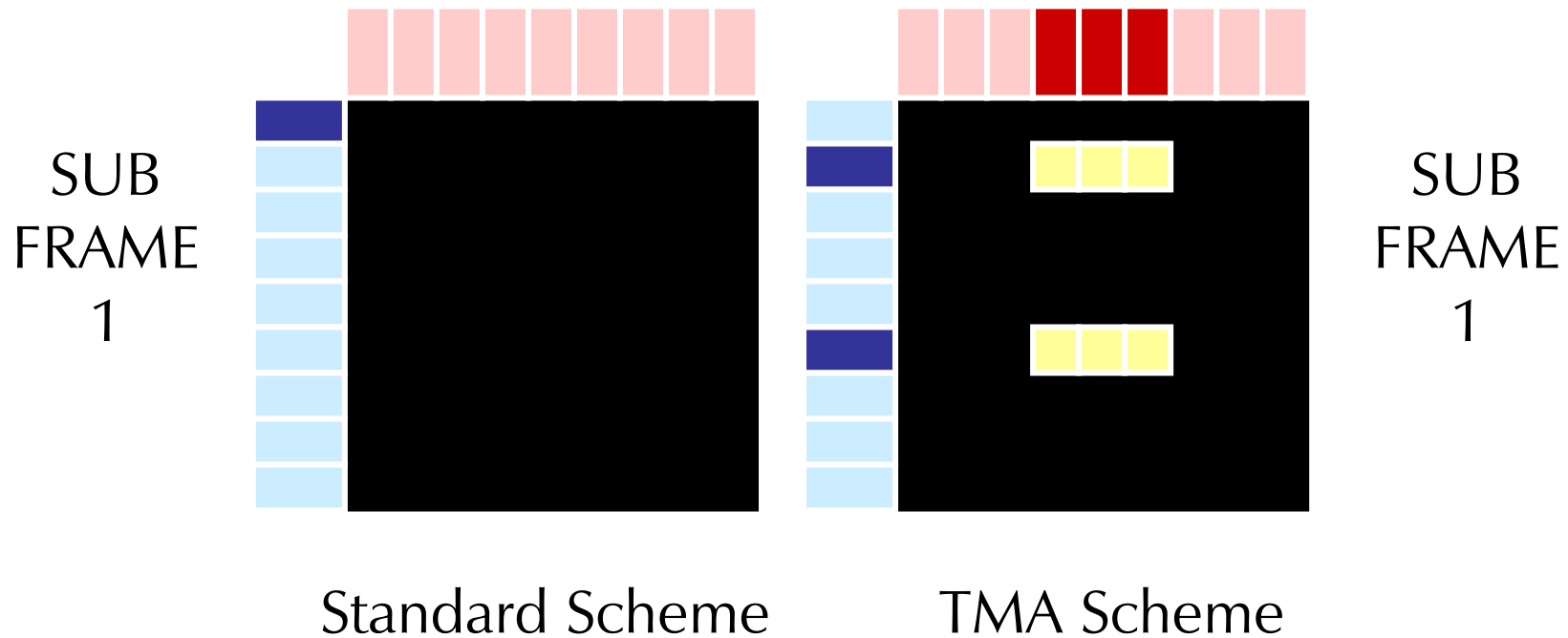
- Substantially improved performance
- Extended the application space
  - Bigger panels
  - Colour PMLCD
- Driving 4, 8 or 16 lines simultaneously
- Works by adding and subtracting from the displayed signal
- **OLED must be additive**
  - **MLA does not work for OLED**

- Total Matrix Addressing (TMA) reduces the effective multiplex rate by driving lines with common information components simultaneously.
- TMA allows the driving of multiple rows and columns simultaneously, substantially reducing peak luminance requirements.

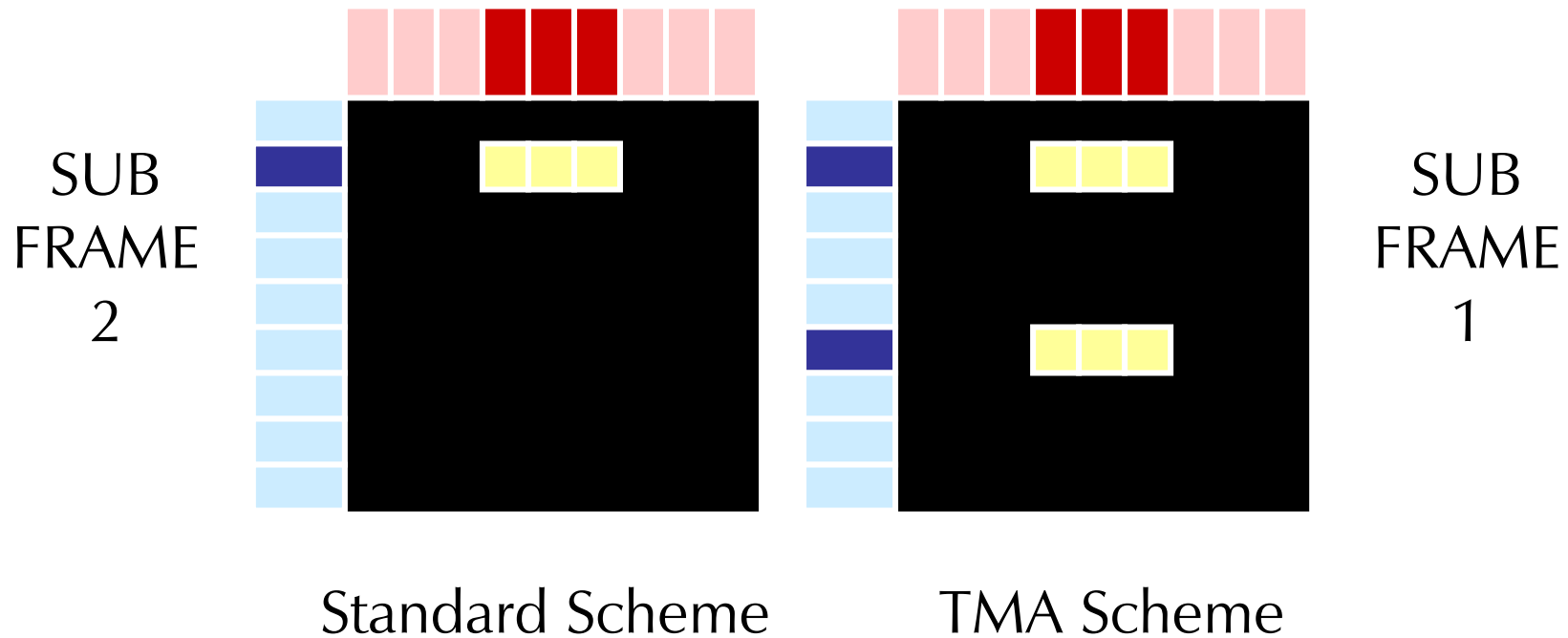
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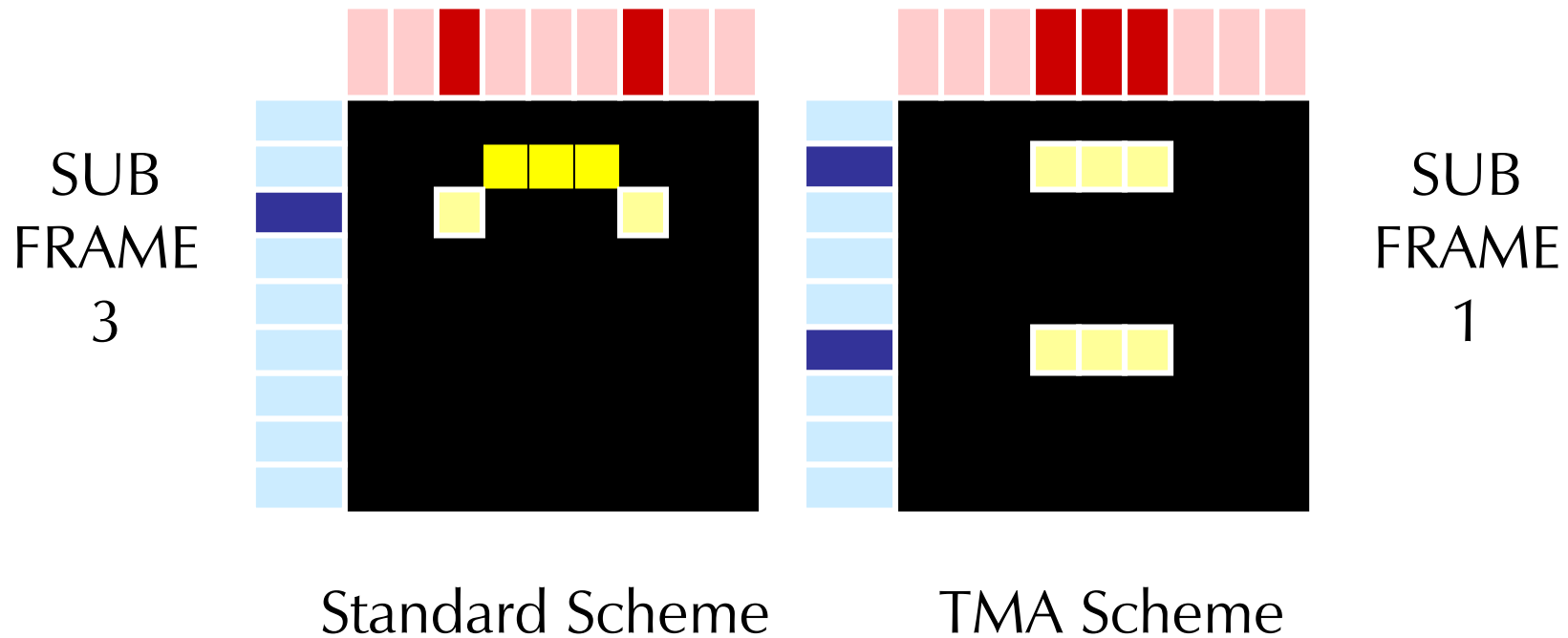
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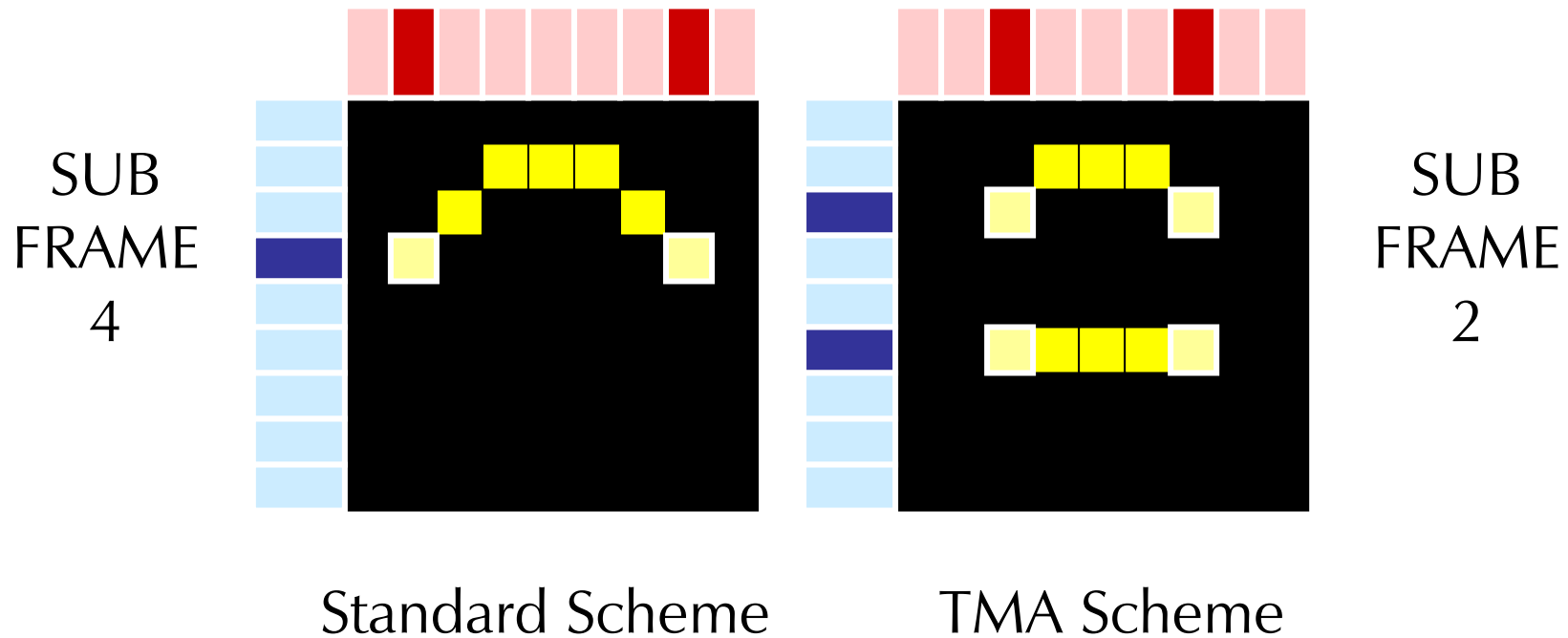
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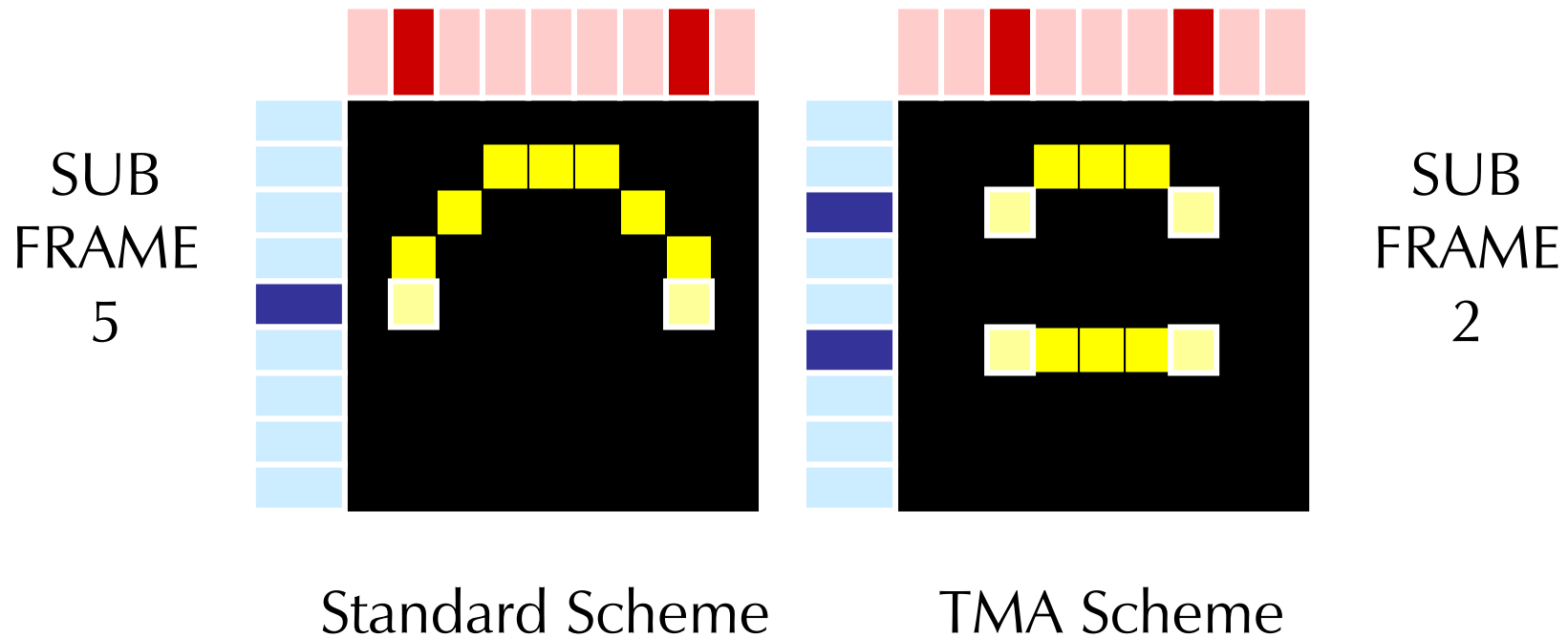
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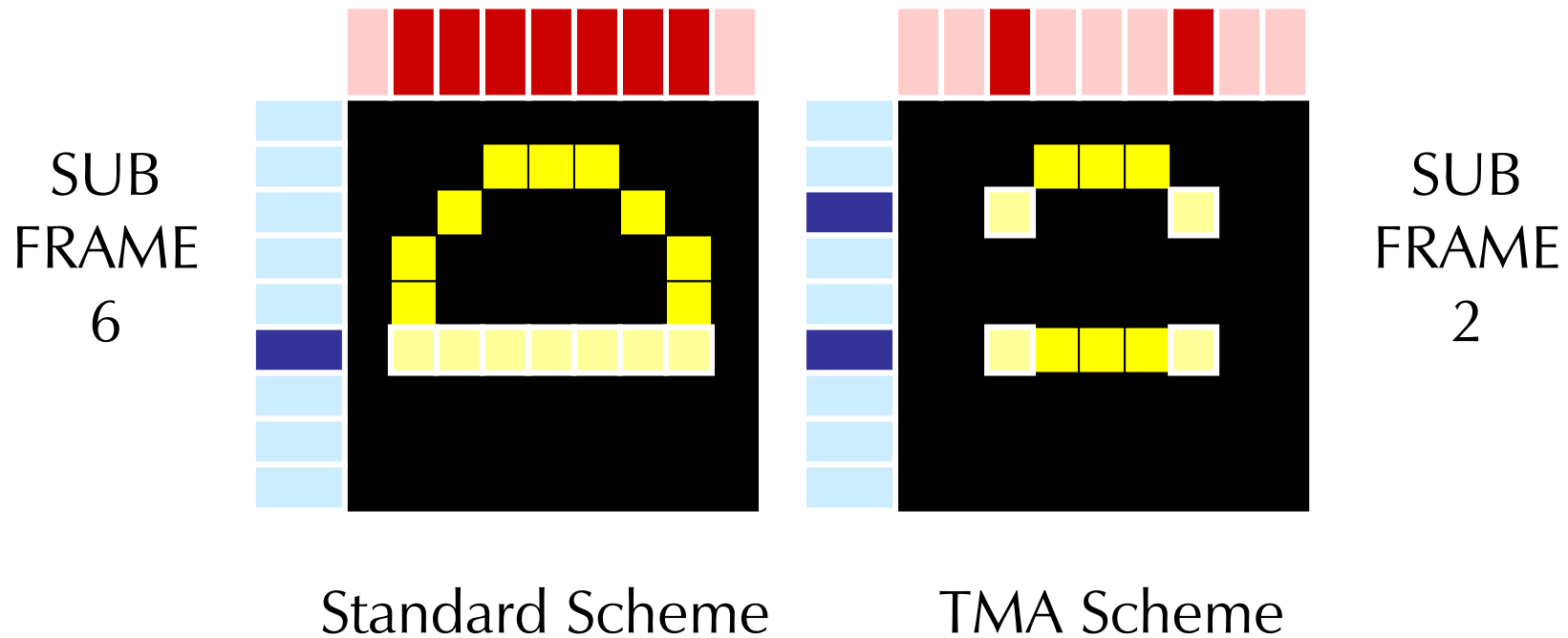
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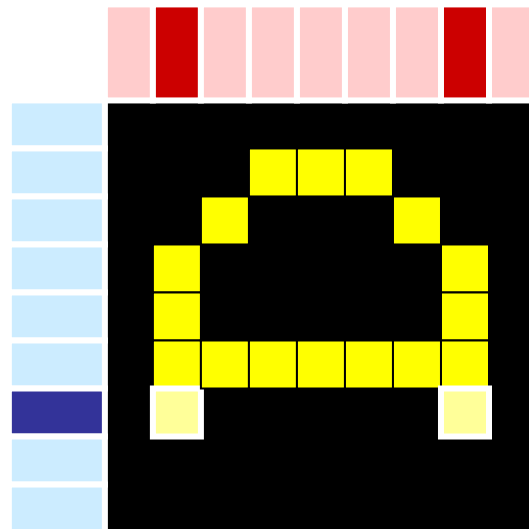


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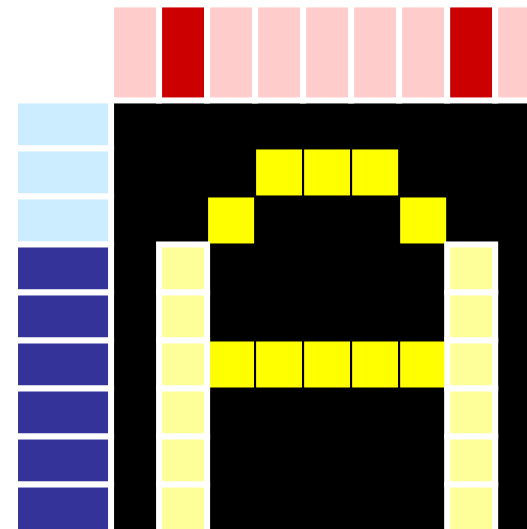
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SUB  
FRAME  
7



Standard Scheme

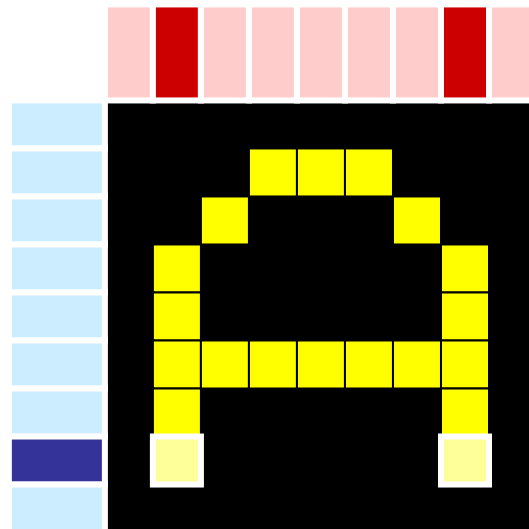
SUB  
FRAME  
3



TMA Scheme

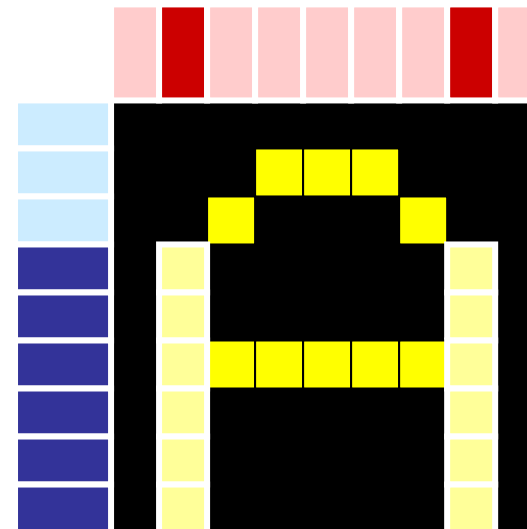
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SUB  
FRAME  
8



Standard Scheme

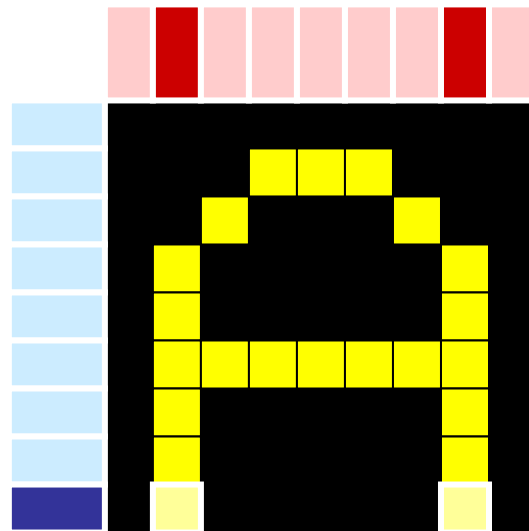
SUB  
FRAME  
3



TMA Scheme

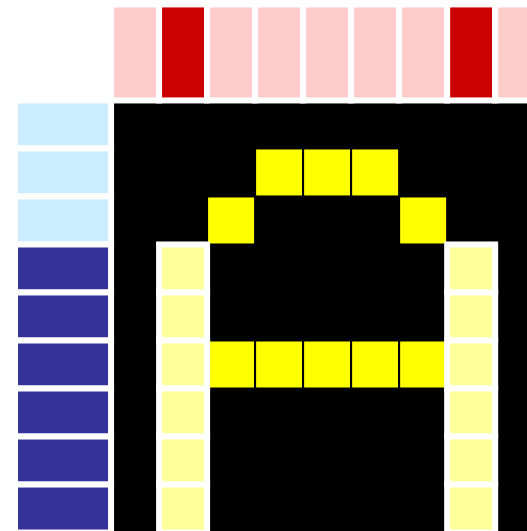
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SUB  
FRAME  
9



Standard Scheme

SUB  
FRAME  
3

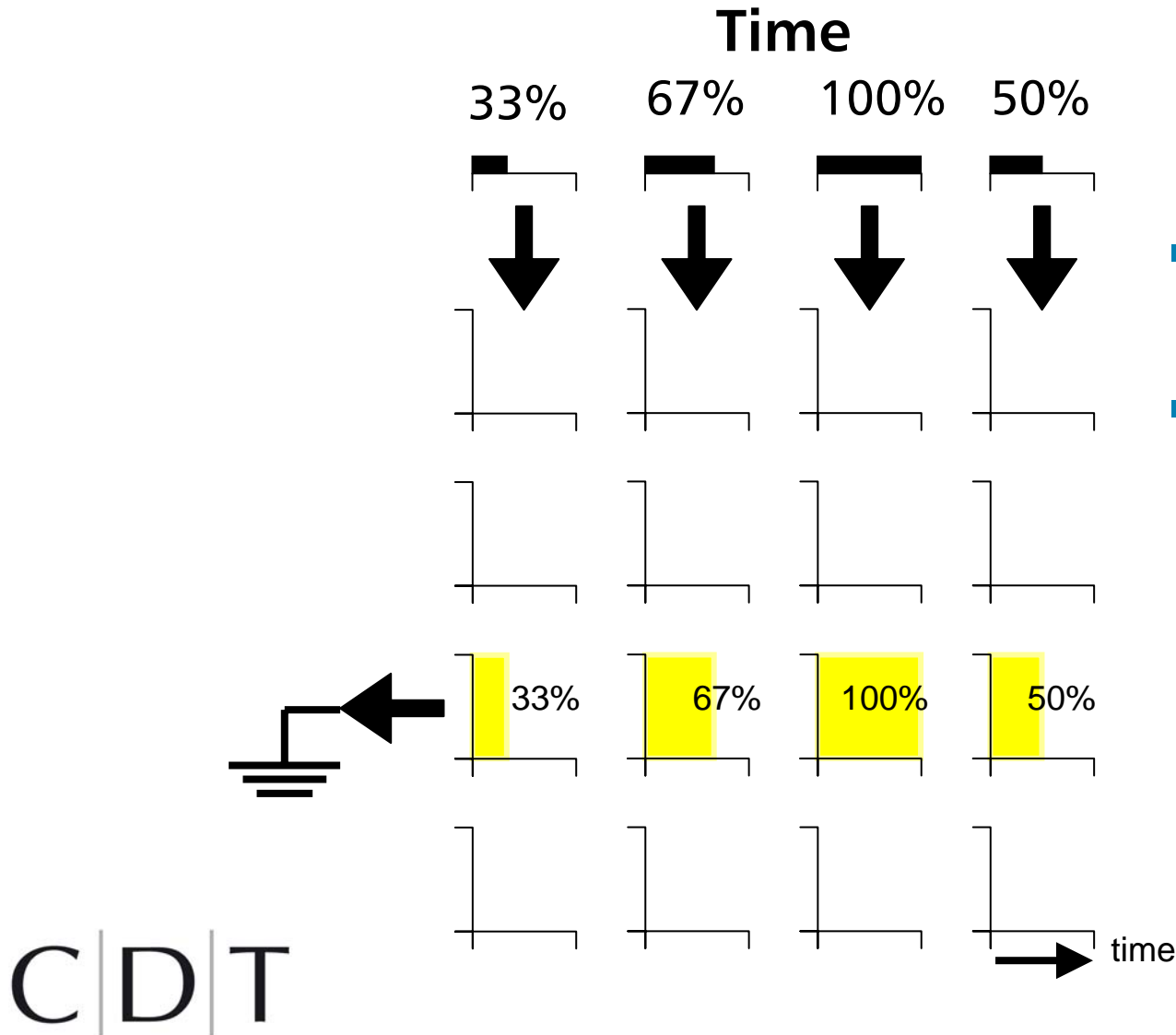


TMA Scheme

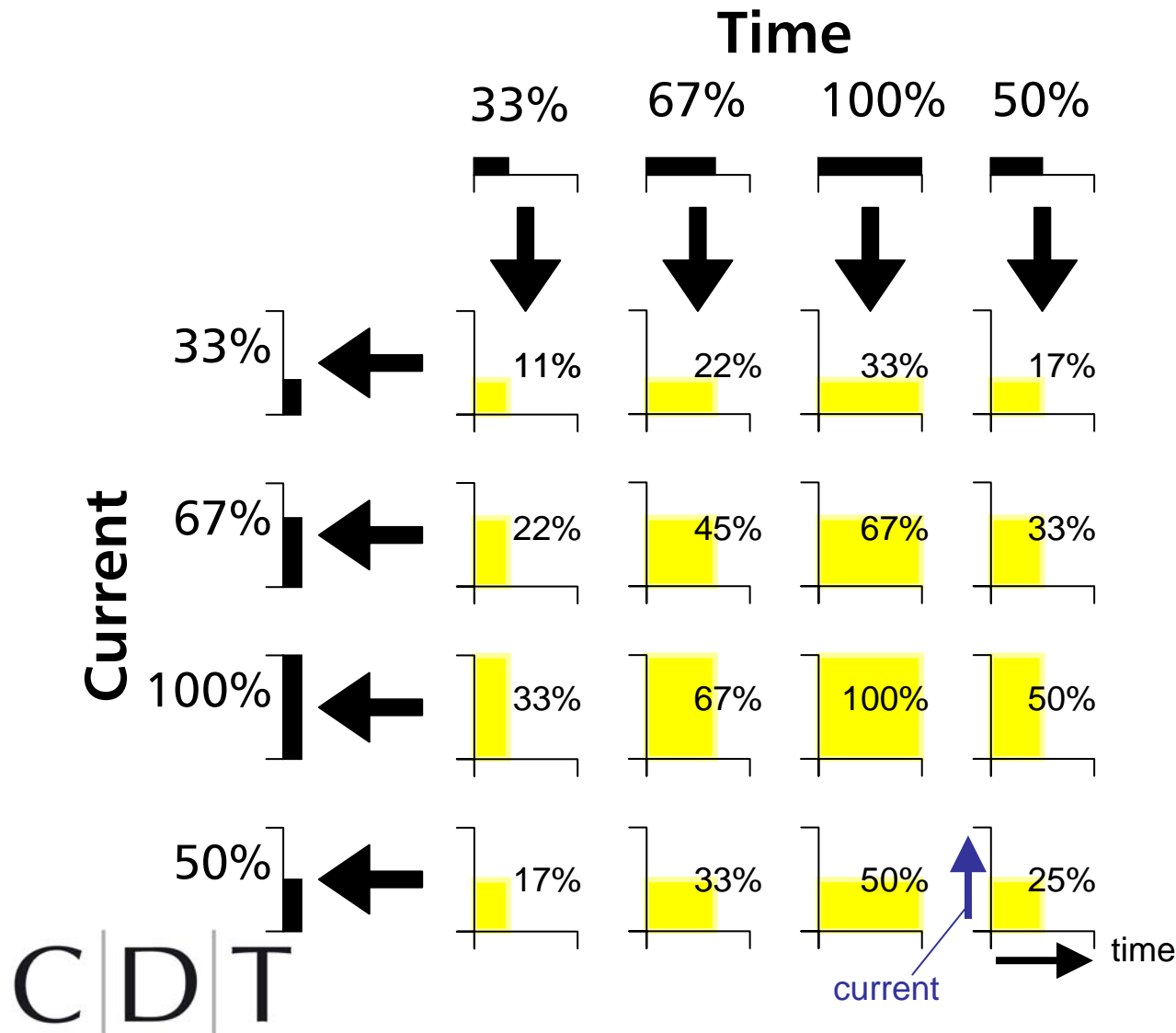
- Frame count, in example, down by a factor of 3
  - 1/3 peak luminance
  - ~3x life
  - Reduced power consumption
  - ...or for the same display life
    - 70% brighter
    - or 3x larger display

- TMA Requires:
  - How to drive multiple lines of a PMOLED display.
  - How to process an image to generate the required data.
- CDT has developed a driving scheme and image processing which can drive ALL the rows of an OLED display simultaneously
  - CDT has observed:
    - Lowers the peak luminance of the OLED pixels
    - Lower voltage driving (factor of 2 observed)
    - Reduced capacitive losses
    - Displays run significantly cooler
    - Longer lived devices
  - Extends the range of PMOLED displays
    - Higher resolution and/or
    - Larger displays and/or
    - Brighter displays

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- Single row grounded at a time
- PWM drive signal to column to develop greyscale



- Pixel output is the multiple of the row and column drive
- Light pattern is the product of applied row and column vectors
- Standard linear algebra can be used.

- Drive scheme equivalent to matrix multiplication
- Driving data MUST be all positive
- Algorithm MUST be efficient to minimise chip resource

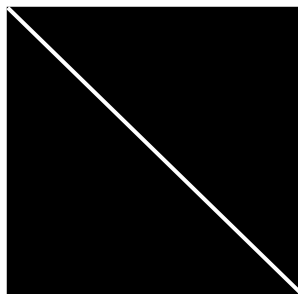
Column Data



Column Data



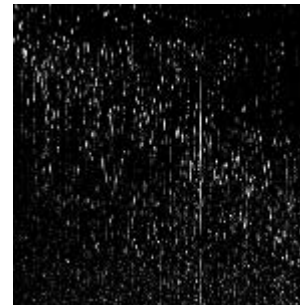
Row Data



time



Row Data



time

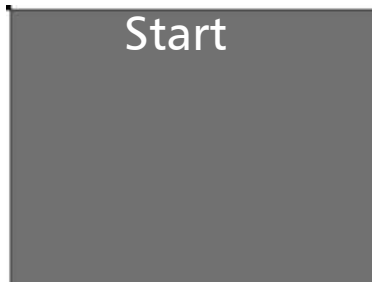


Standard Passive Matrix

TMA

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# TMA Algorithm: Image Factorisation

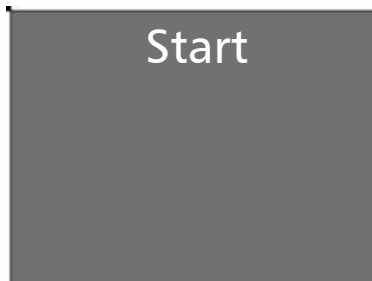


100 iterations



## Conventional Algorithm

## CDT's Algorithm



# Enhanced Efficiency From TMA

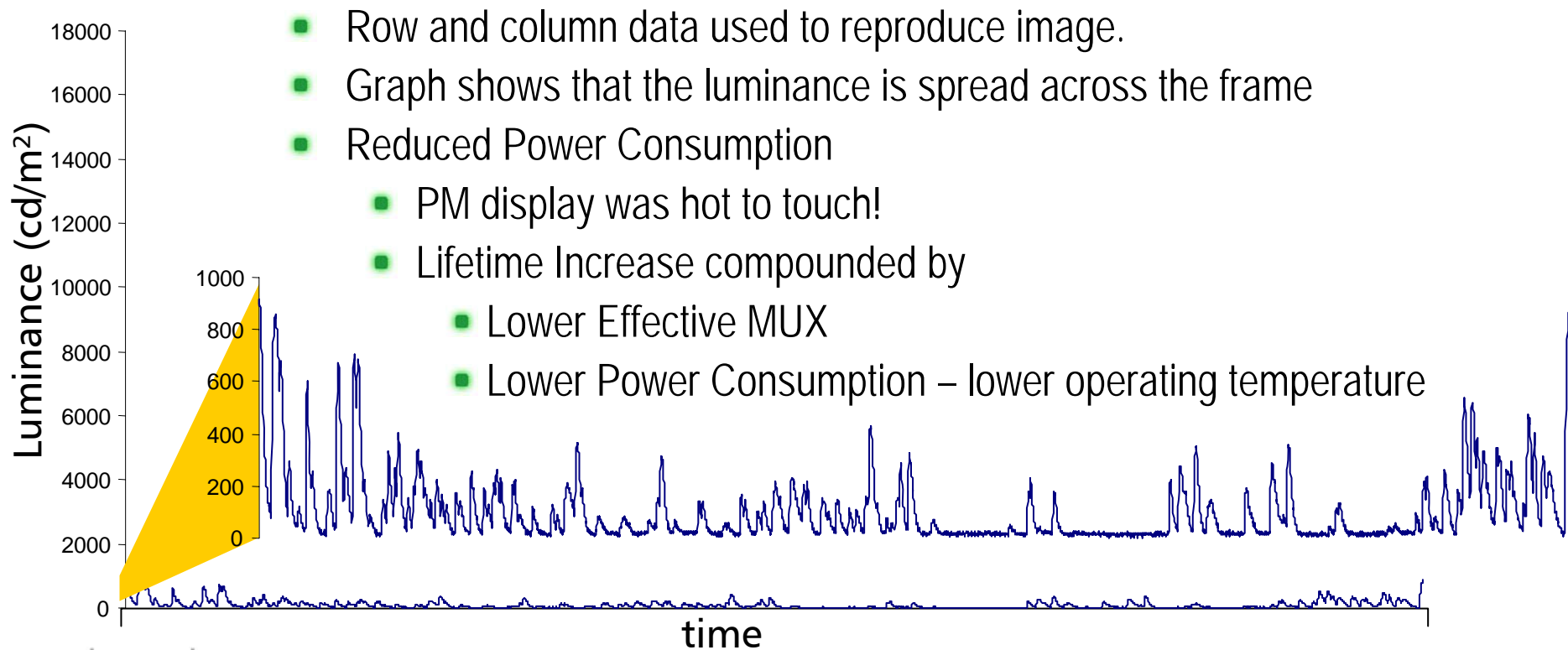


- Test on 128 MUX Color Display  
120 cd/m<sup>2</sup>
- PM Mode 1.0 lm/W
- TMA 2.2 lm/W
  - Note: White can be produced by MUX of 1 (3.3 lm/W)



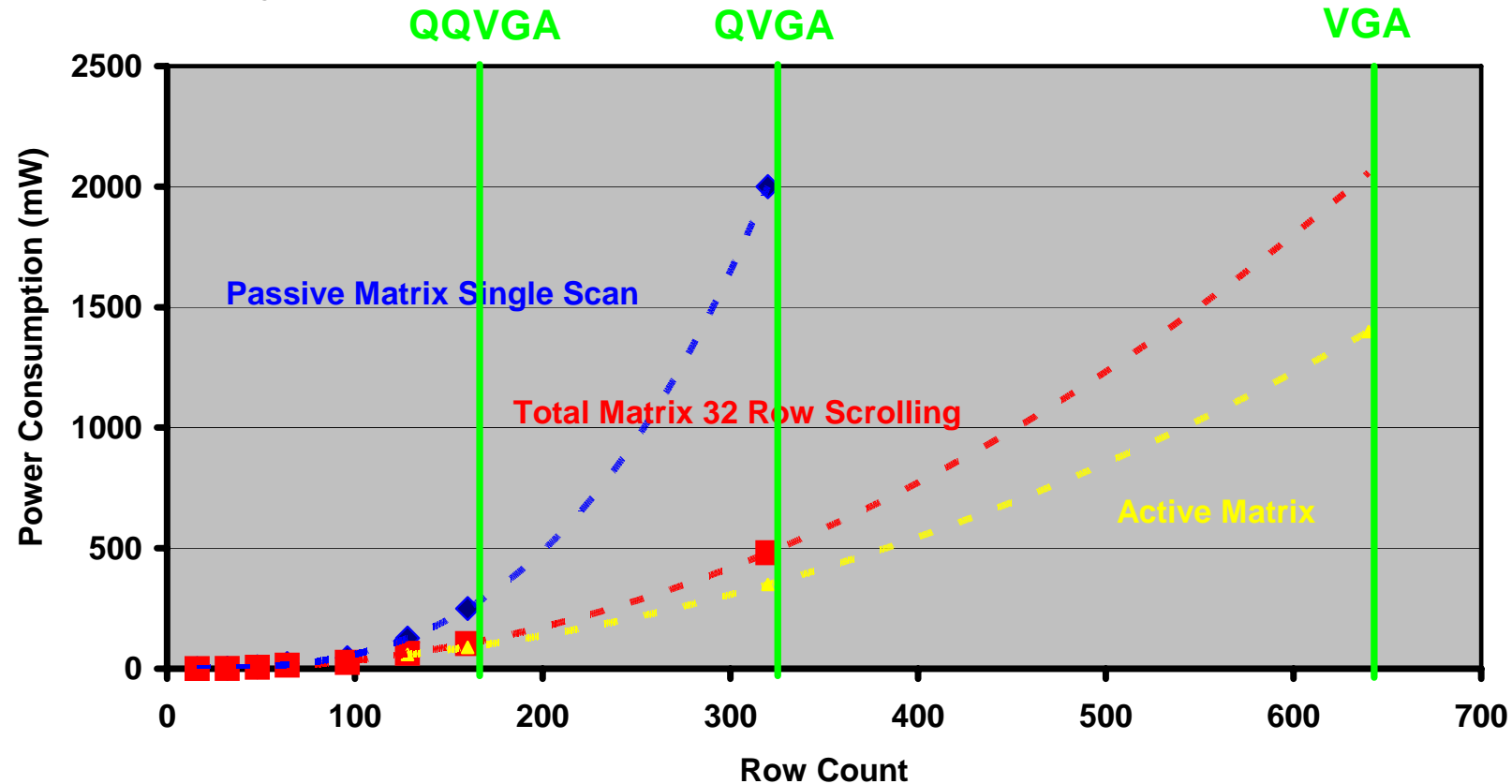
# Display Measurements (QQVGA)

Display luminance measurement on 160 MUX  
 From a small group of pixels during 1 frame  
 - Normal PM peak ~ 16,000 cd/m<sup>2</sup>



- Full TMA
  - Maximum Power consumption reduction and lifetime extension
  - Requires larger processor
  - Suitable for TV applications
- Scrolling TMA
  - Significant reduction in power consumption
  - Much smaller processor
  - Depends on number of rows
  - CDT developing first processor based on 32 rows for mobile applications

## 32 Row Scrolling TMA



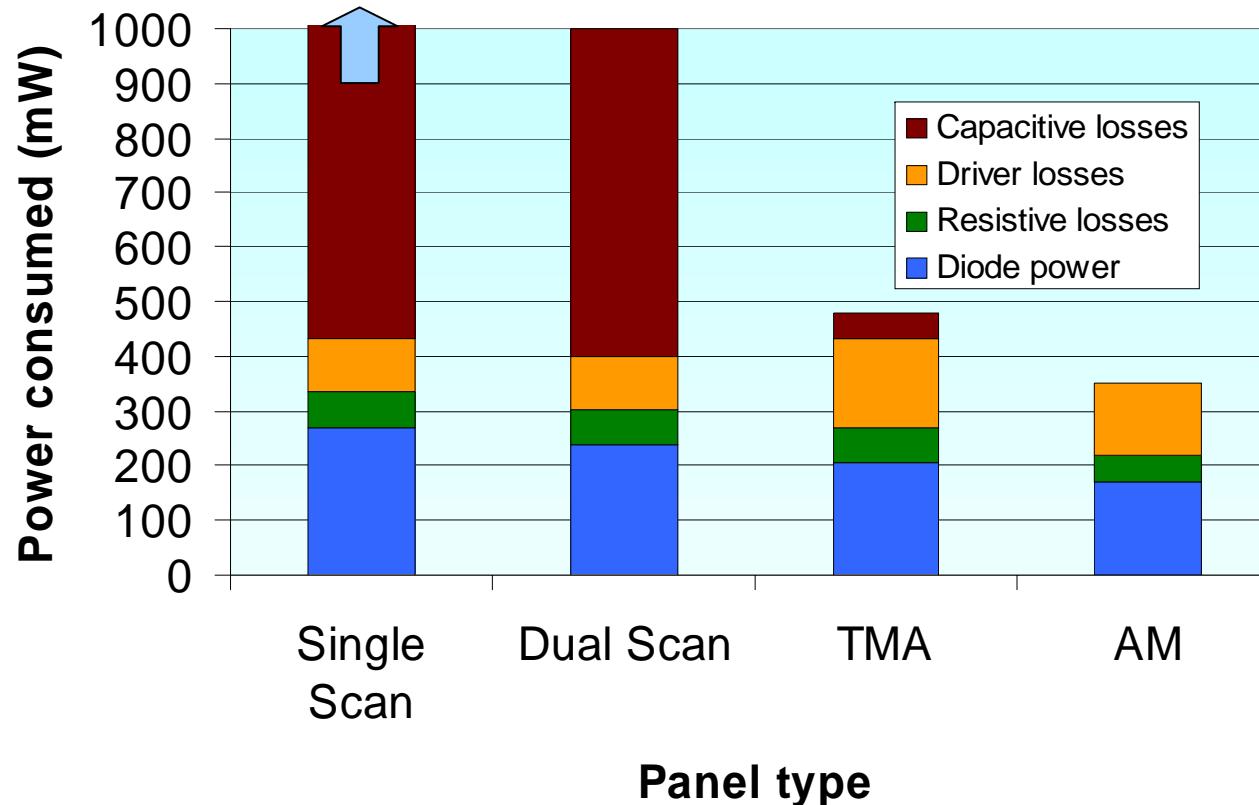
- For mobile applications using 32 row scrolling TMA to give best cost/power consumption benefit
- Estimate > 20% reduction at QVGA Resolution if full TMA used (i.e. similar to AM-OLED)
- Fluorescent SM-OLED characteristics used in model (Data Privately Supplied)

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# OLED module power comparison

## 2.8" QVGA OLED module power consumption

2000mW total comparison



Dual scan data privately supplied. Other data derived in comparison.

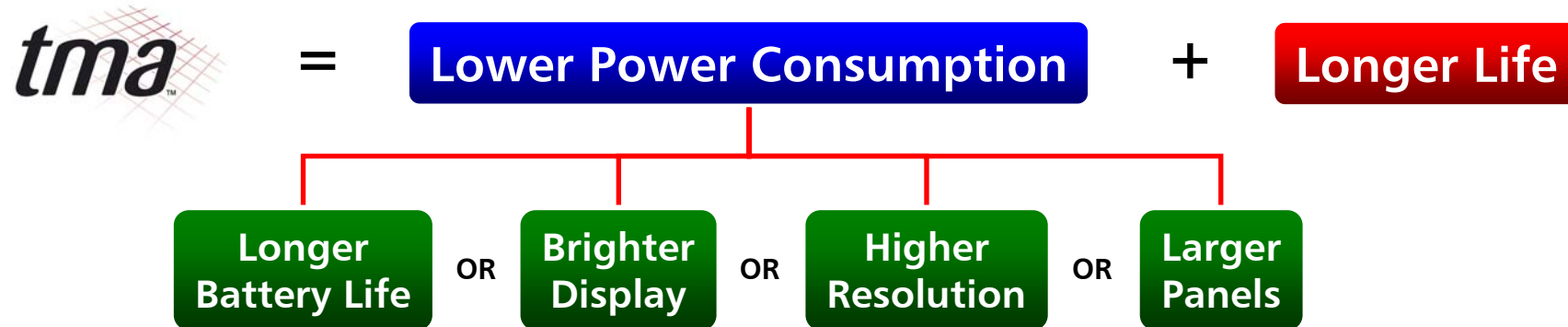
QVGA = 320 x 240 (rgb)

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# Chip Development Timeline

- Samples of Row and Column (External Vendor) drivers available End of July
- TMA Demo using Row/Column Chips + FPGA Processor + Customer Display End of August
- CDT Column Drivers (1<sup>st</sup> Spin) End of August
- CDT Row Drivers (1<sup>st</sup> Spin) End of September
- TMA Processor Chip - Release to Fab End of September
- TMA Processor (Incl. Nokia Instruction Set, Pre & Post RAM, Timing Controller) End of December
- Complete Chip Set Sampling February 2008
  
- Note: Timeline allows for 2<sup>nd</sup> spin on Row and Column Drivers as this is highest risk area

- TMA is applicable to ALL OLED technologies!

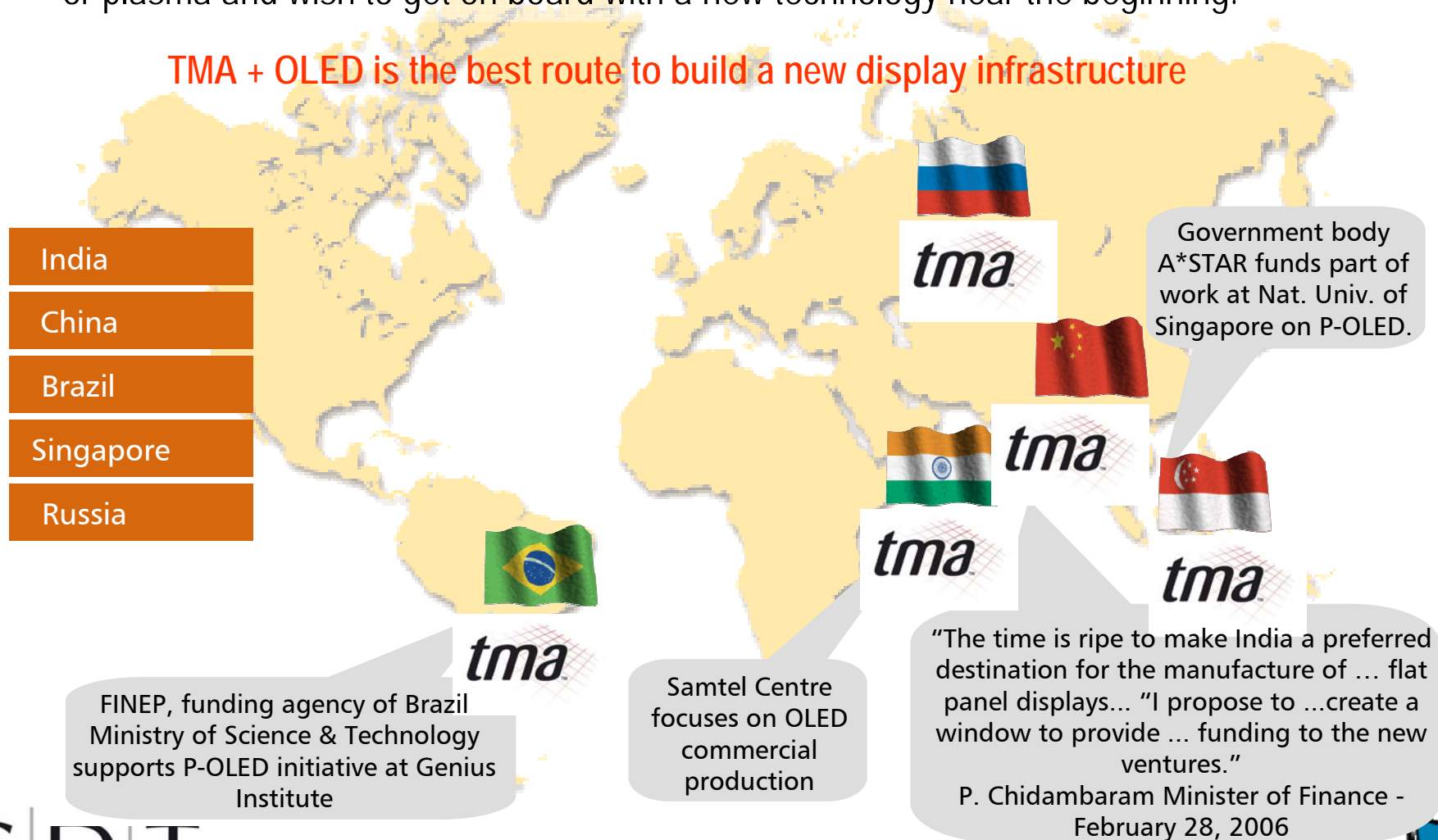


- Passive Matrix Producers feeling a lot of pain due to “low tech” low margin business competing against excess STN LCD Capacity!
  - Ness, Teco, Univision, Delta have all “retired”
  - LGE, SDI, Kolon, RitDisplay, Pioneer, Optrex, Fuji Electric, TDK, Osram, still in production but who will survive?
- TFT LCD Club is an expensive entry ticket that only a few can afford
  - Is their historical commitment to LCD holding OLED back?
- **TMA potentially is the entry ticket to higher resolution OLED displays with heavily reduced capital investment**
  - 70 to 80% of initial capital investment for TFT LCD is the backplane
  - Huge knowledge and infrastructure base required for TFT Production
  - Daunting for smaller companies and for developing economies!

# Involvement of Emerging Economies

“Countries such as China and India recognise they are too late to compete in LCD or plasma and wish to get on board with a new technology near the beginning.”

**TMA + OLED is the best route to build a new display infrastructure**



- Initial chip sets targeting QVGA mobile market applications
- Full TMA has potential to take PM-OLED into TV markets!
- **TMA TECHNOLOGY HAS THE POTENTIAL TO CHANGE THE GAME AND “DE-CARTELISE” THE DISPLAY INDUSTRY**

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[www.cdttltd.co.uk](http://www.cdttltd.co.uk)

Nasdaq: OLED