

# Microcup<sup>®</sup> Electronic Paper

by *Roll-to-Roll*

## Manufacturing Processes

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# Where Are SiPix?

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**Milpitas, California**  
**Headquarter &**  
**Advanced R&D Labs**



**Fremont, California**  
**Production**



**Taipei, Taiwan**  
**Applications**

# Who are SiPix?



- 06/1999 SiPix Imaging was founded in Boston, MA  
Camera and Printer/Media Programs were started.
- 12/1999 Display program (EPD & LCD) was launched.
- 08/2000 Relocated from Boston to Silicon Valley.
- 02/2003 Production test run started.
- 12/2003 90 Scientists/Engineers in U.S.A. and 15 in Asia.

# What Does SiPix Make?

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## Electrophoretic Displays 電泳顯示器(EPD) :

Non-emissive display based on the electrophoresis of charged particles in a colored dielectric solvent

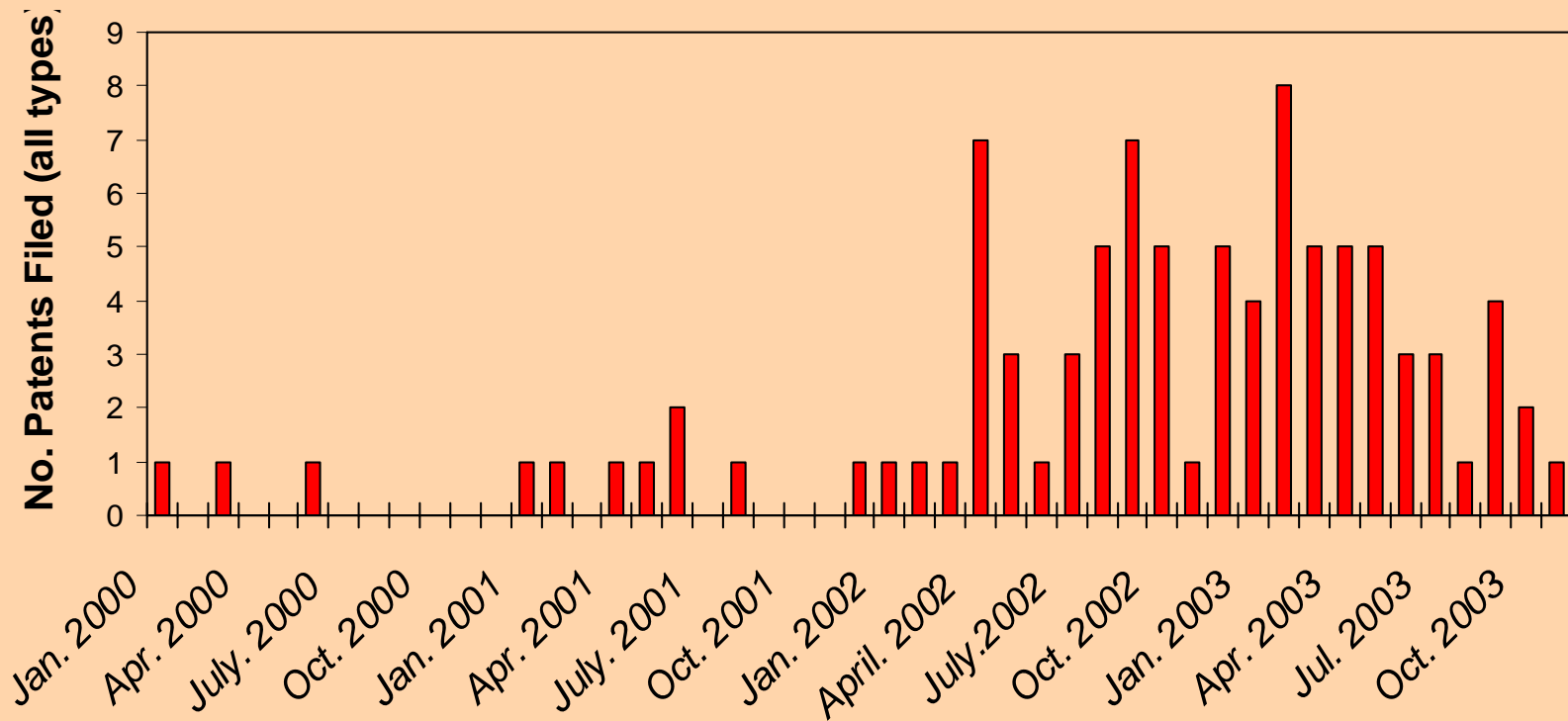
### The SiPix Revolution:

Paper-like, flexible & scratch resistant EPD

- ~ 180° Viewing angles
- High contrast ratios
- Low operation voltage
- Low power consumption

# SiPix Intellectual Property

## Patents Filed by Month



- More than 78 US patents pending for Microcup<sup>®</sup> EPDs
- 14 US patents allowed.

# SiPix Revolutionizes Information Displays



## SiPix EPDs provide:

### Readability:

- High Whiteness
- Good Contrast Ratio
- Wide View Angle
- Ambient & Sun Light
- Readable

### Portability:

- Light Weight
- Thin & Flexible
- Durable
- Writeable/Printable
- Format Flexible

### Affordability:

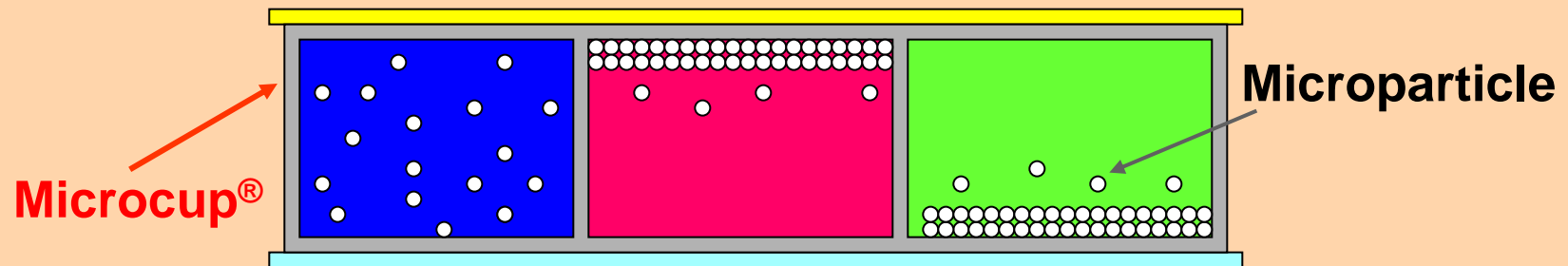
- Product reusability
- Low Material Cost
- Easy Manufacturing
- Environmental Friendly
- Low Power Consumption



How are **SiPix Microcup<sup>®</sup>**

EPDs made?

# SiPix Microcup<sup>®</sup> EPDs

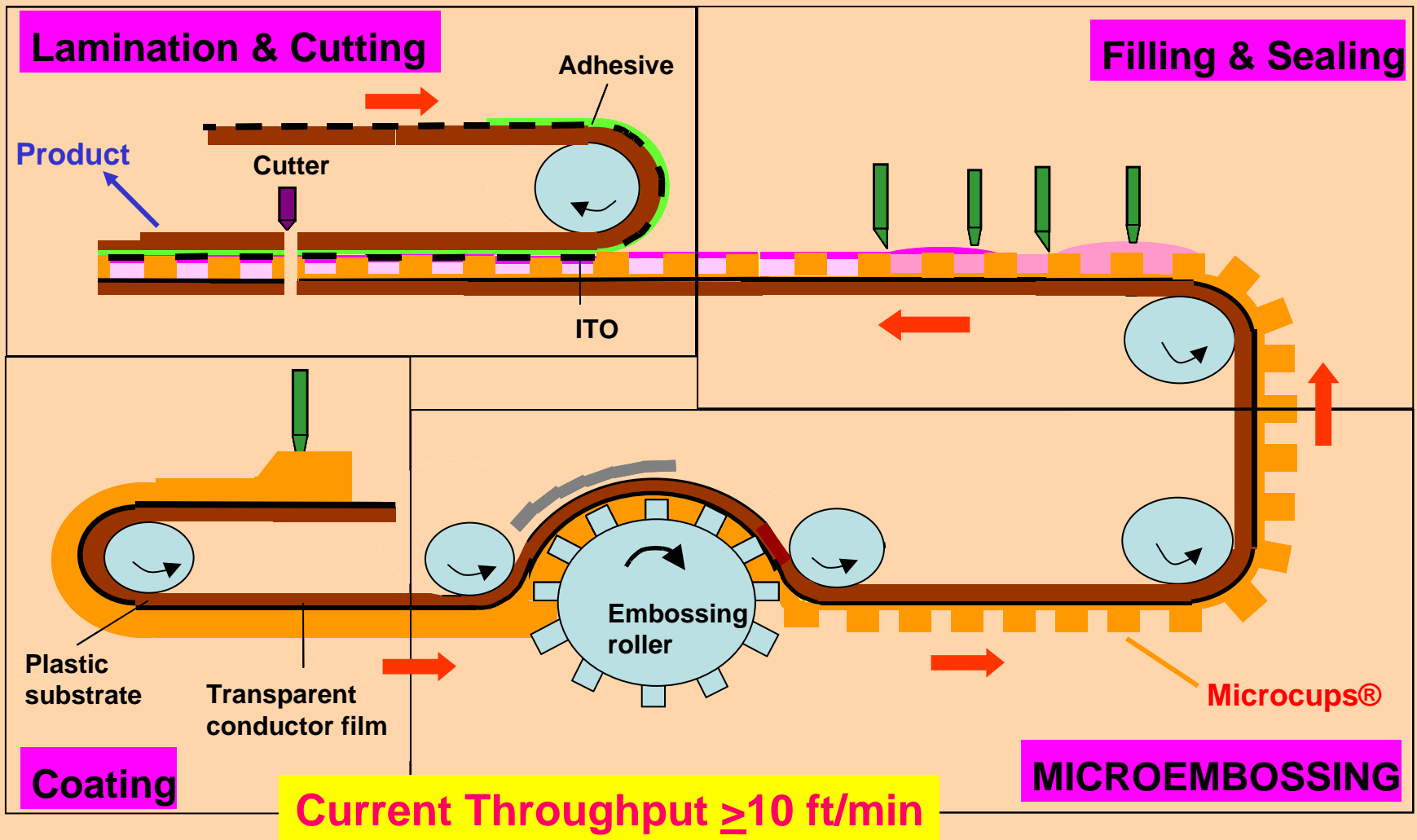


## High speed roll-to-roll, format flexible processes

- High speed microembossing processes
- Seamless filling and sealing processes
- Submicron, stable, density-matched microparticles

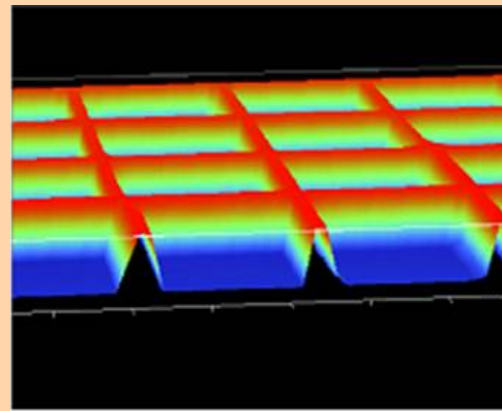
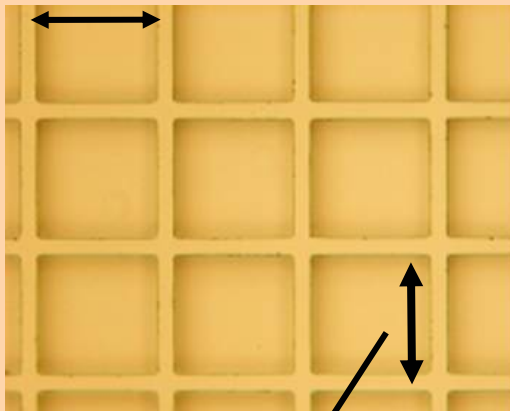
## Proprietary driving mechanisms

# SiPix Roll-to-Roll Process

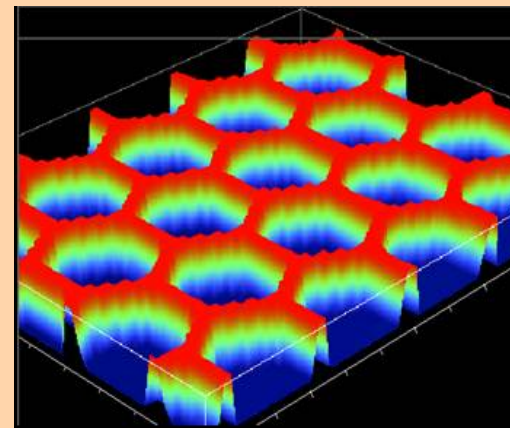
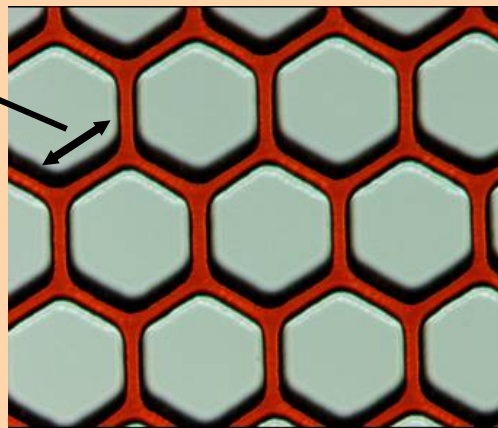


# SiPix Microcups<sup>®</sup>

60 ~ 180  $\mu\text{m}$

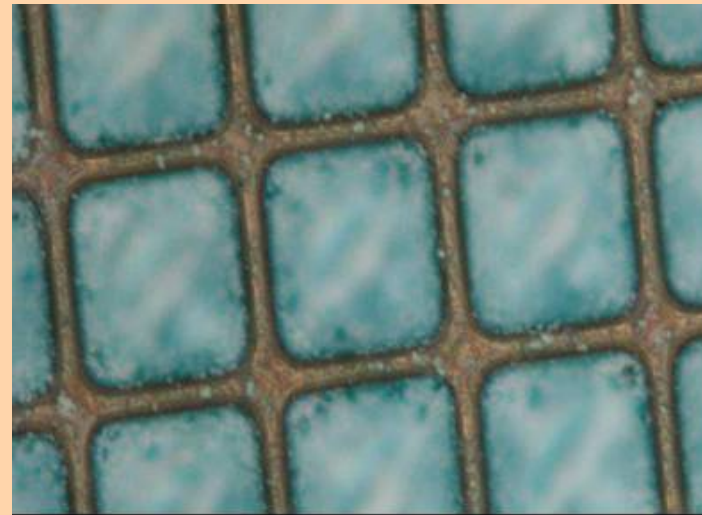
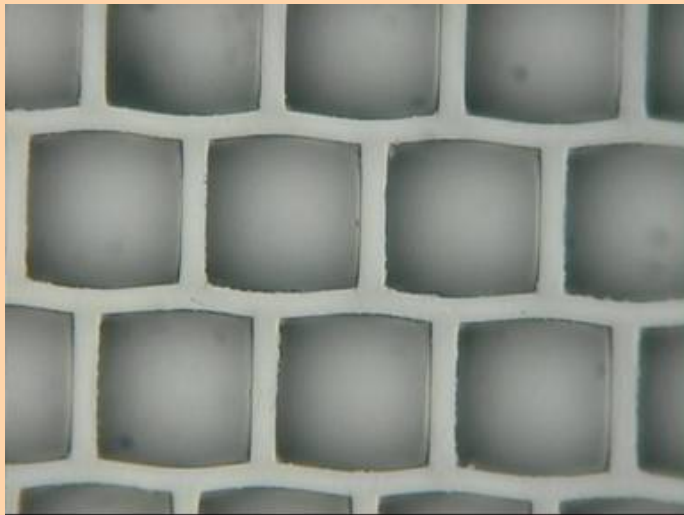


5 ~ 25  $\mu\text{m}$

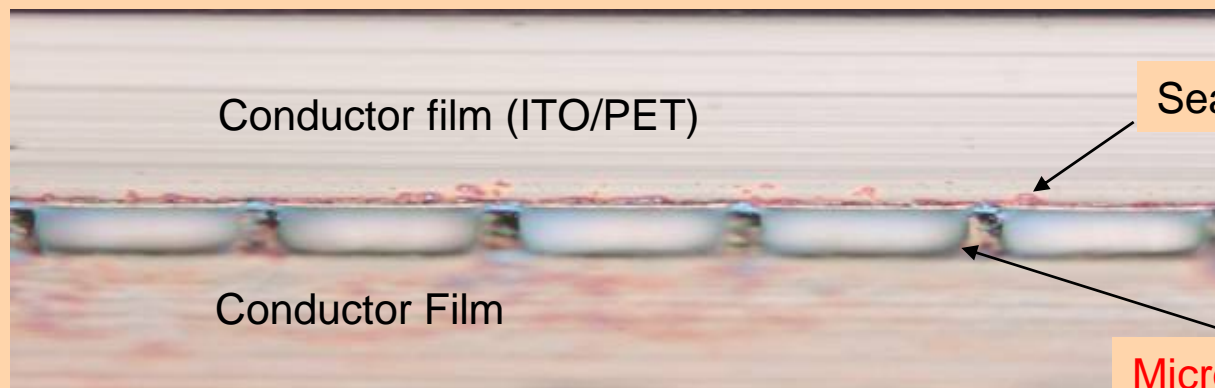


# SiPix Seamlessly Sealed Microcups<sup>®</sup>

*Negligible weight loss after 5 days in 80°C oven*

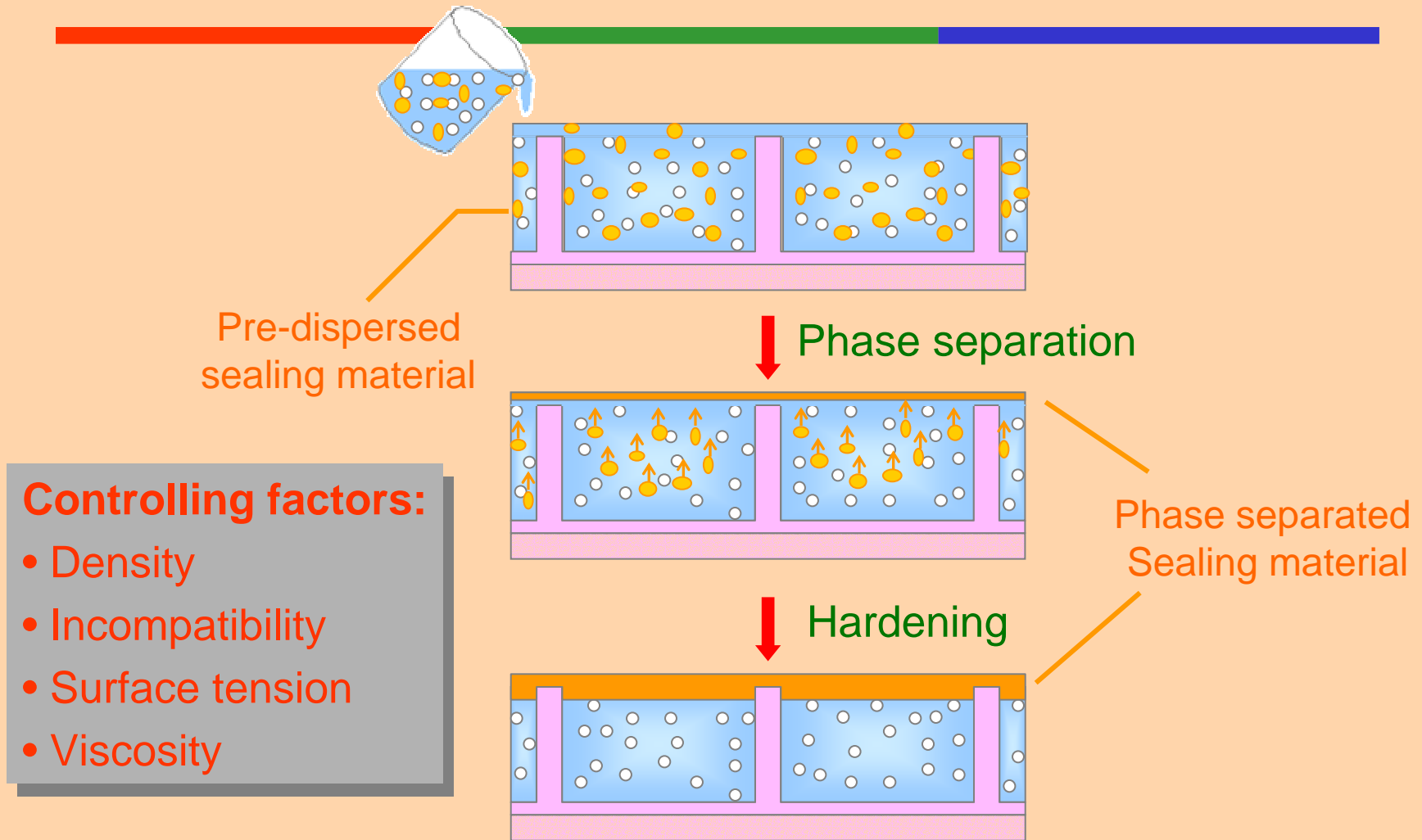


Cell gap:  
15~30  $\mu\text{m}$ .



Microcup<sup>®</sup> Partition

# SiPix One-Pass Filling & Sealing



**Seamless sealing may be accomplished in seconds.**

# SiPix Microcup<sup>®</sup> EPDs



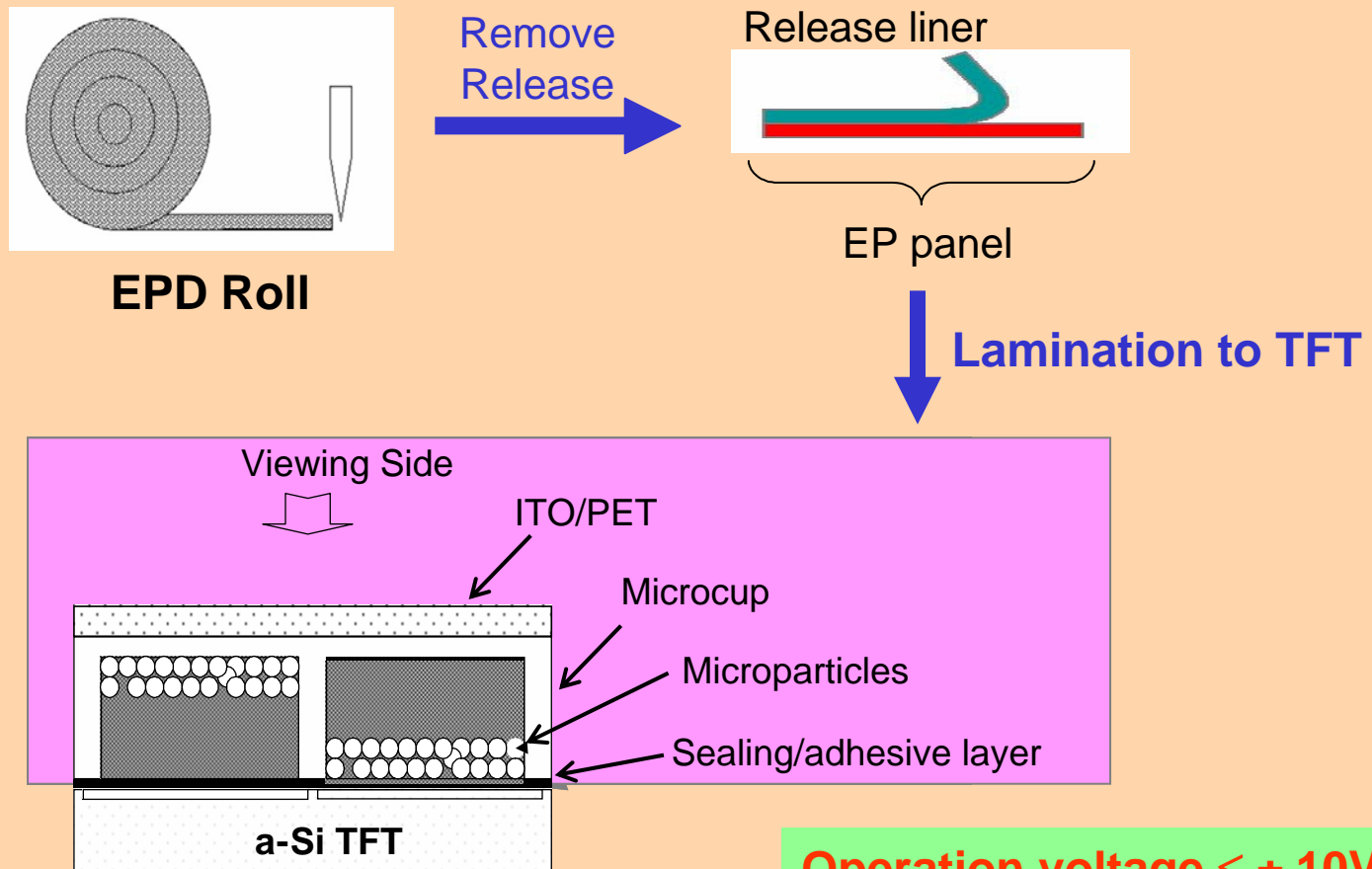
- Active Matrix (AMEPD) & Direct Drive (DDEPD) EPDs

Each display element (each pixel) includes an active component such as a transistor to maintain its state between scans.

- Passive Matrix EPD (PMEPD)

Each pixel is driven by a column and a row electrode. Pixels are turned on when the wires intersecting at that pixel are both energized.

# SiPix Microcup<sup>®</sup> AMEPDs & DDEPDs



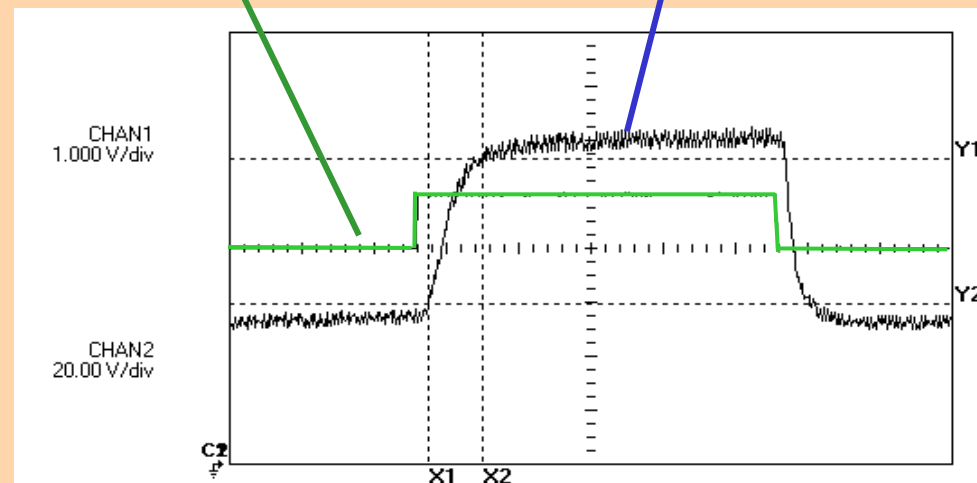
Operation voltage  $\leq \pm 10V$

# SiPix Microcup<sup>®</sup> AMEPDs & DDEPDs



Electrical Input

Optical output



Electro-optical response curves of the  
1<sup>st</sup> generation a-Si TFT Microcup<sup>®</sup>

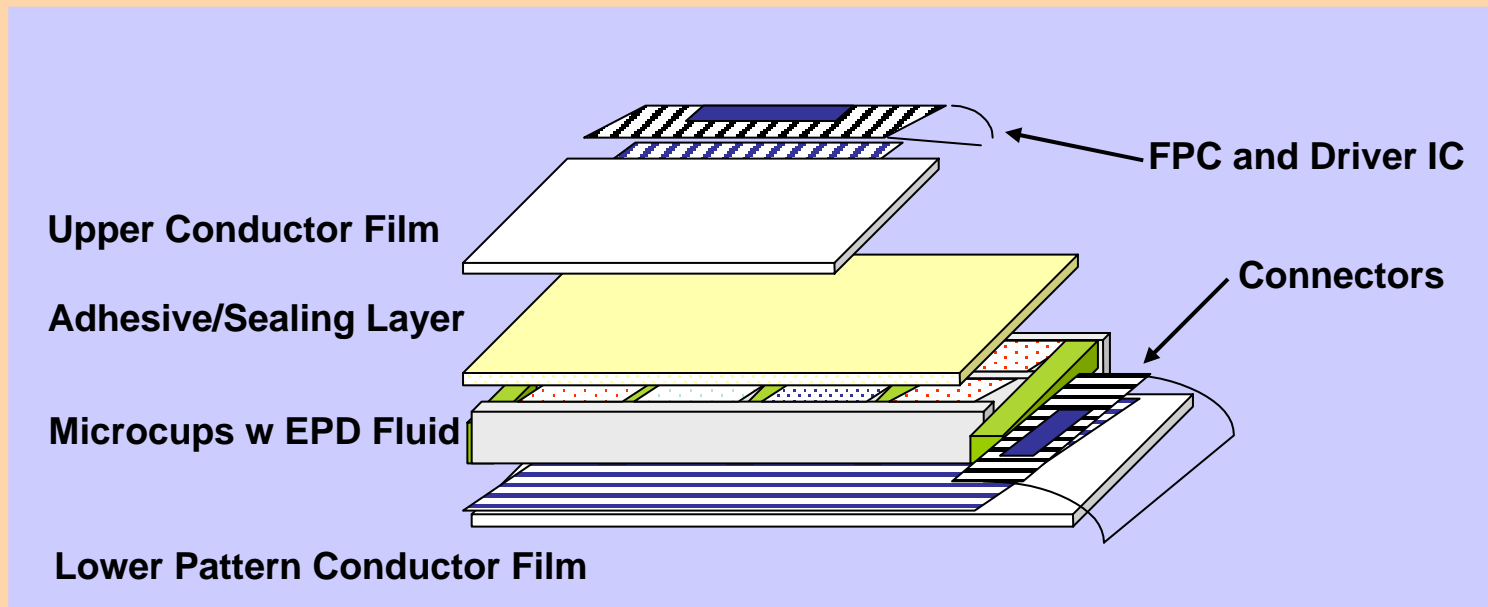
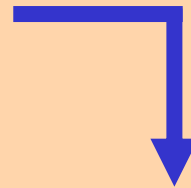
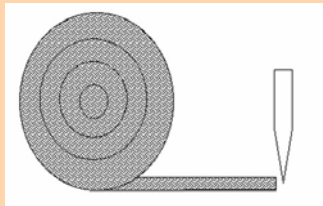
Operation voltage  $\pm 10$  V

$t_{on} \sim 300$  ms

CR  $\sim 10$

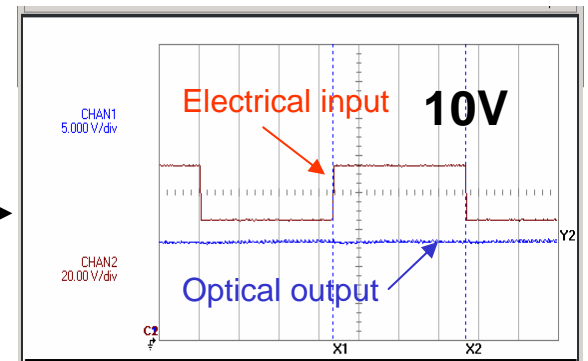
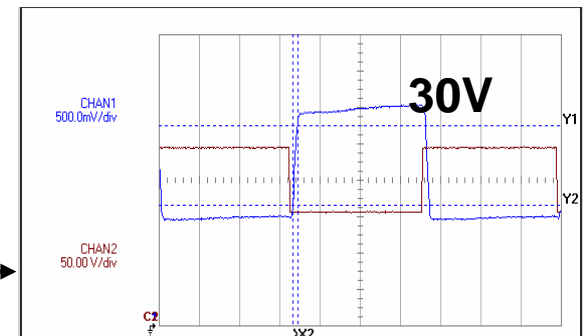
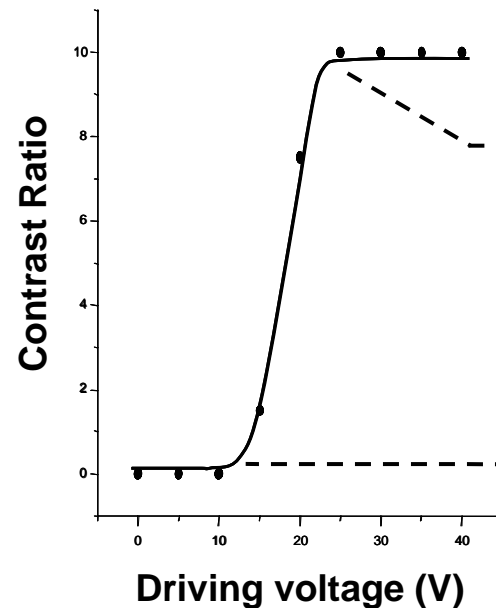
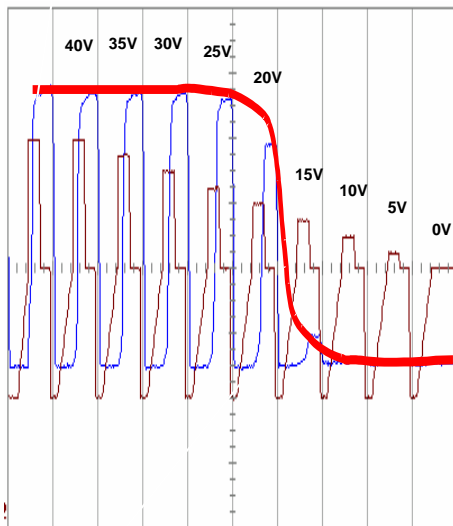
# SiPix Microcup<sup>®</sup> PMEPDs

EPD Roll



# SiPix Microcup<sup>®</sup> PMEPDs

Threshold Voltage  $\geq 10V$ ; Operation:  $\geq 25V$ ;  
Sharp Gamma (for e-board applications)

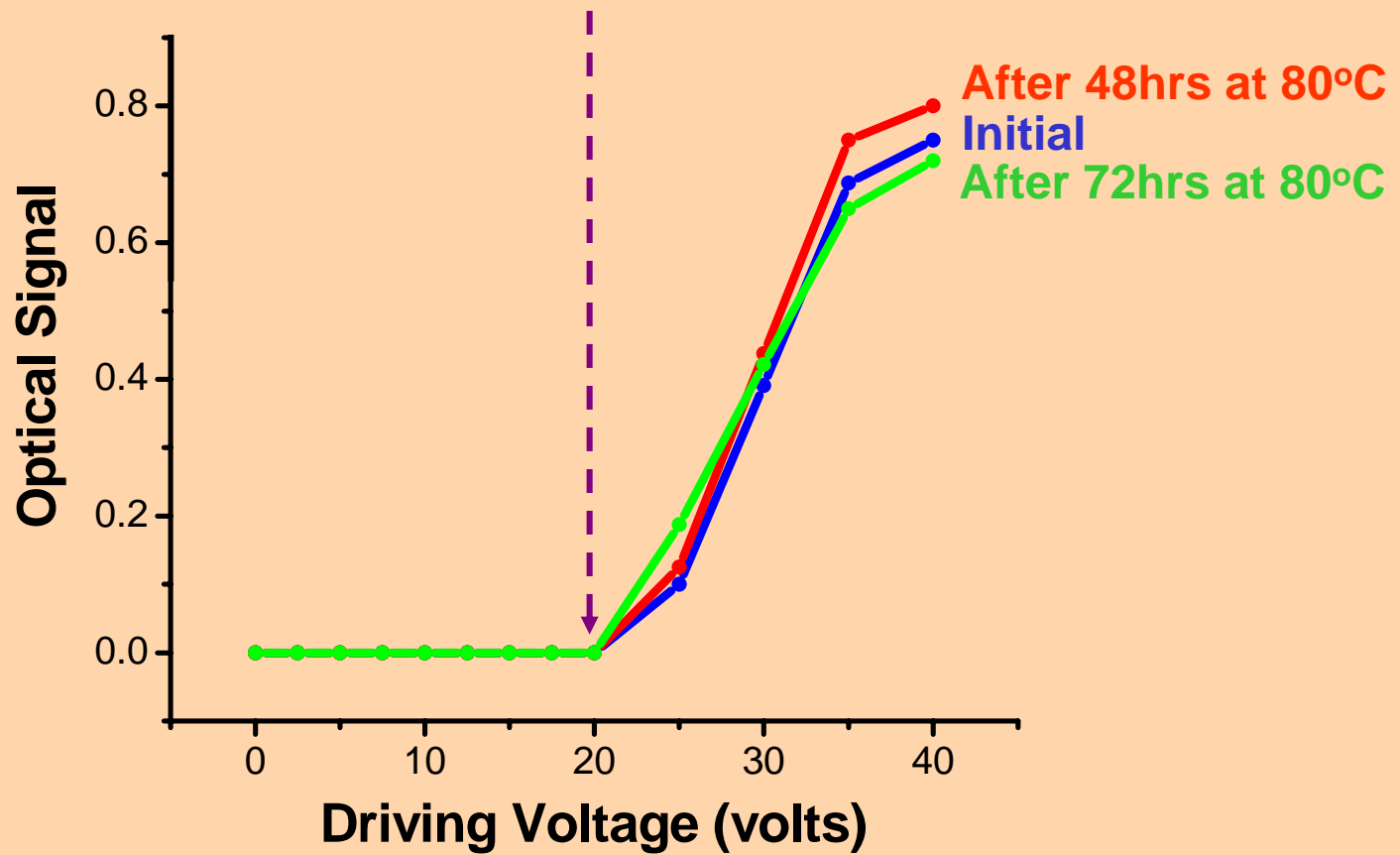


Electro-optical response and contrast ratio-voltage curves of the 1<sup>st</sup> generation Microcup<sup>®</sup> PMPED.

Today  $T_{on} = 20$  msec

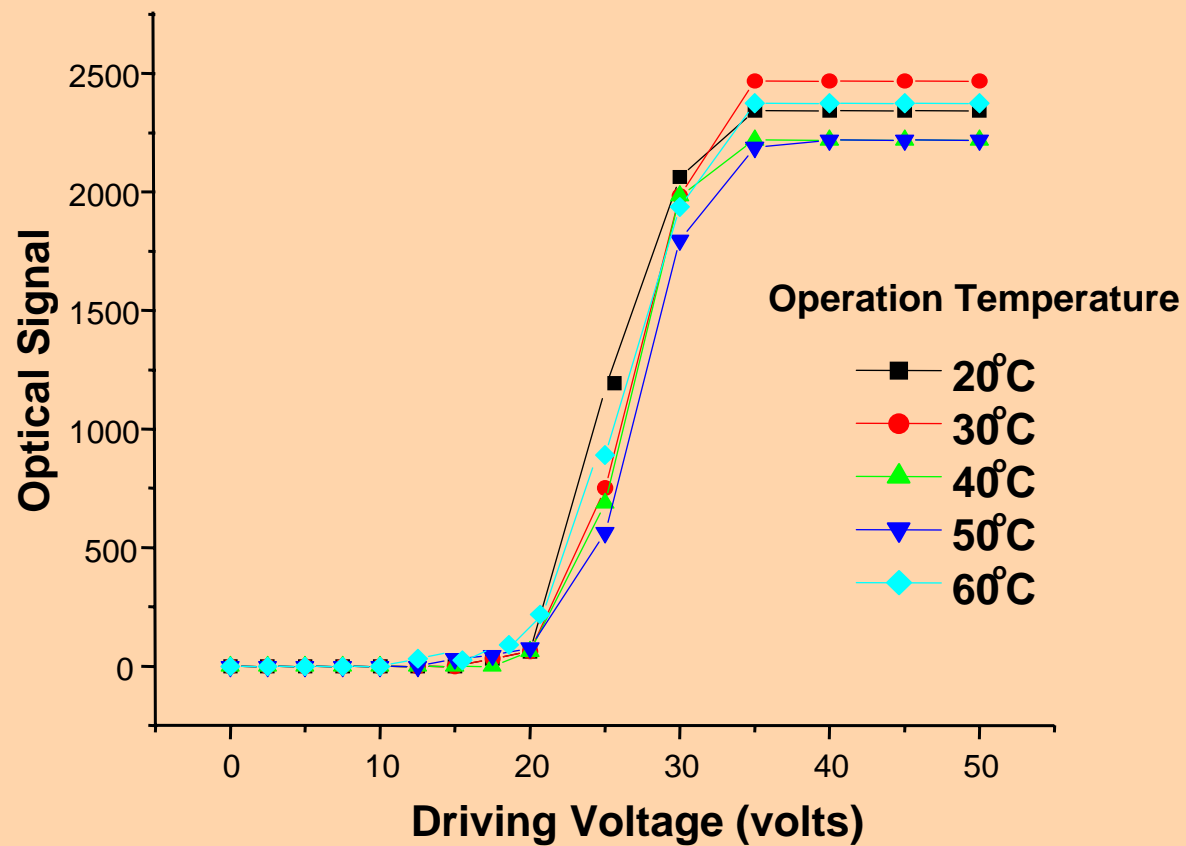
# SiPix Microcup<sup>®</sup> PMPEDs

No change in threshold after aging at 80°C



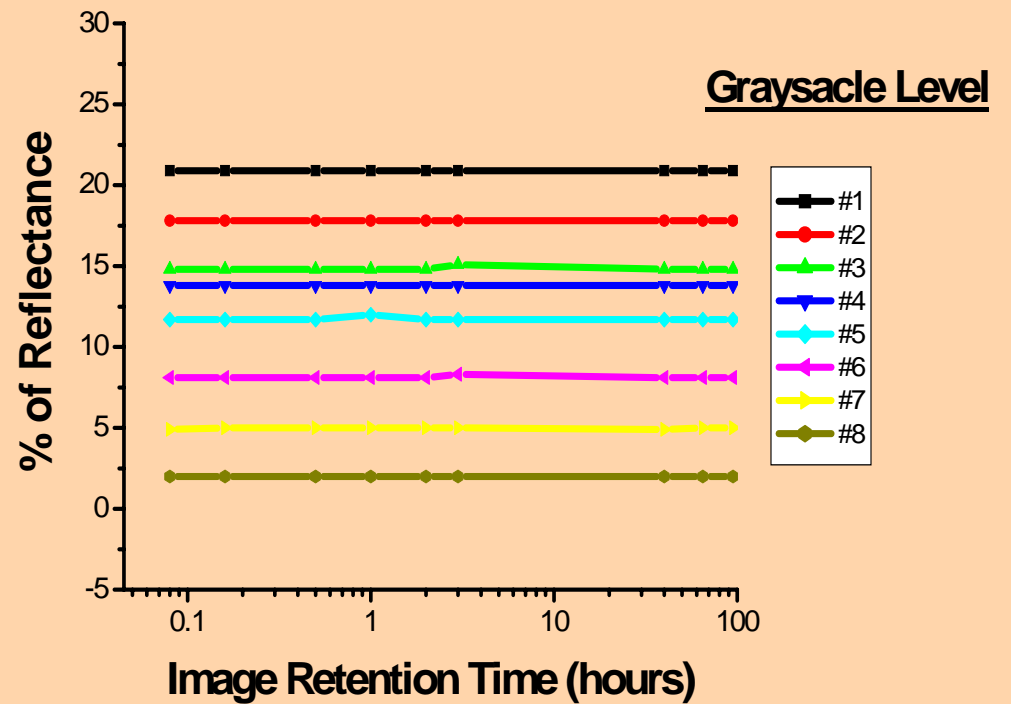
# SiPix Microcup<sup>®</sup> PMPEDs

No change in threshold between 20 ~ 60°C



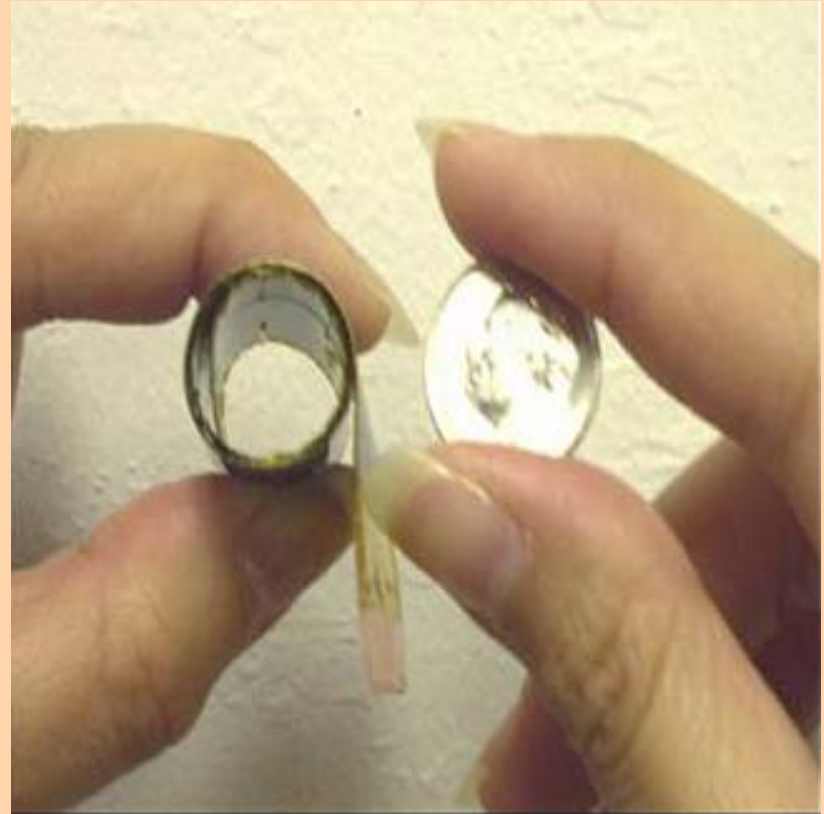
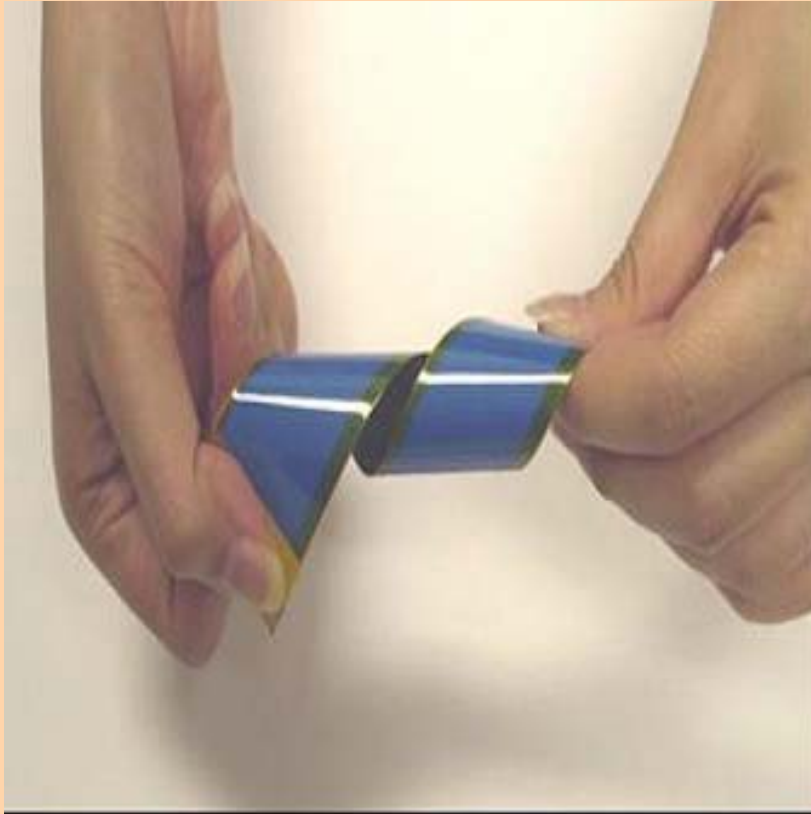
# SiPix Microcup<sup>®</sup> PMPEDs

More than 12 grayscale levels have been demonstrated with super bistability



# SiPix EPDs: Super Flexibility

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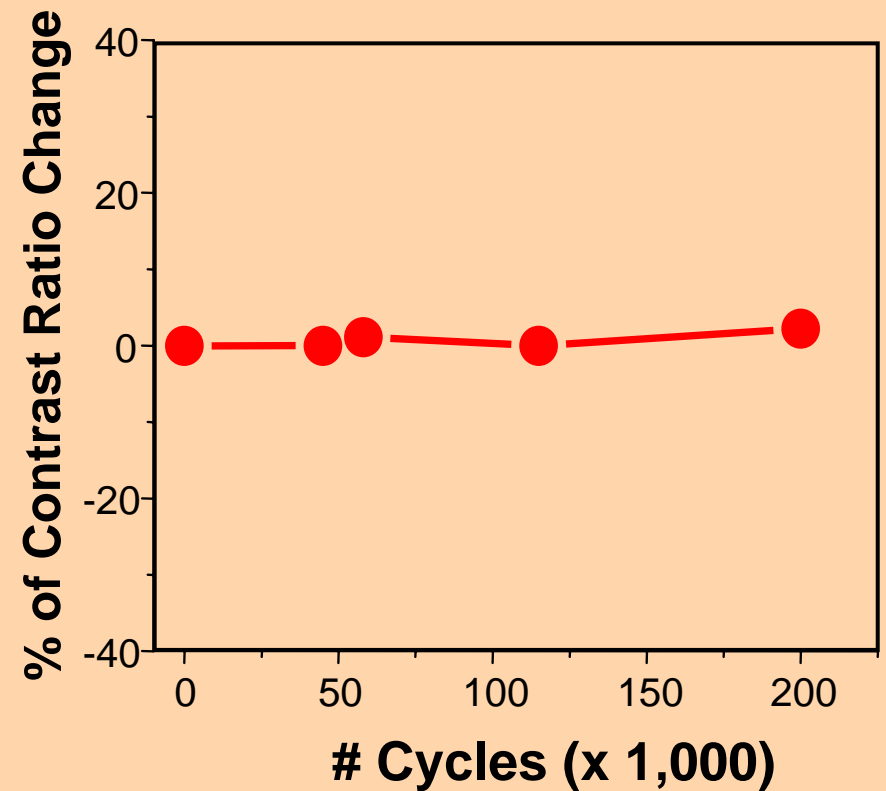
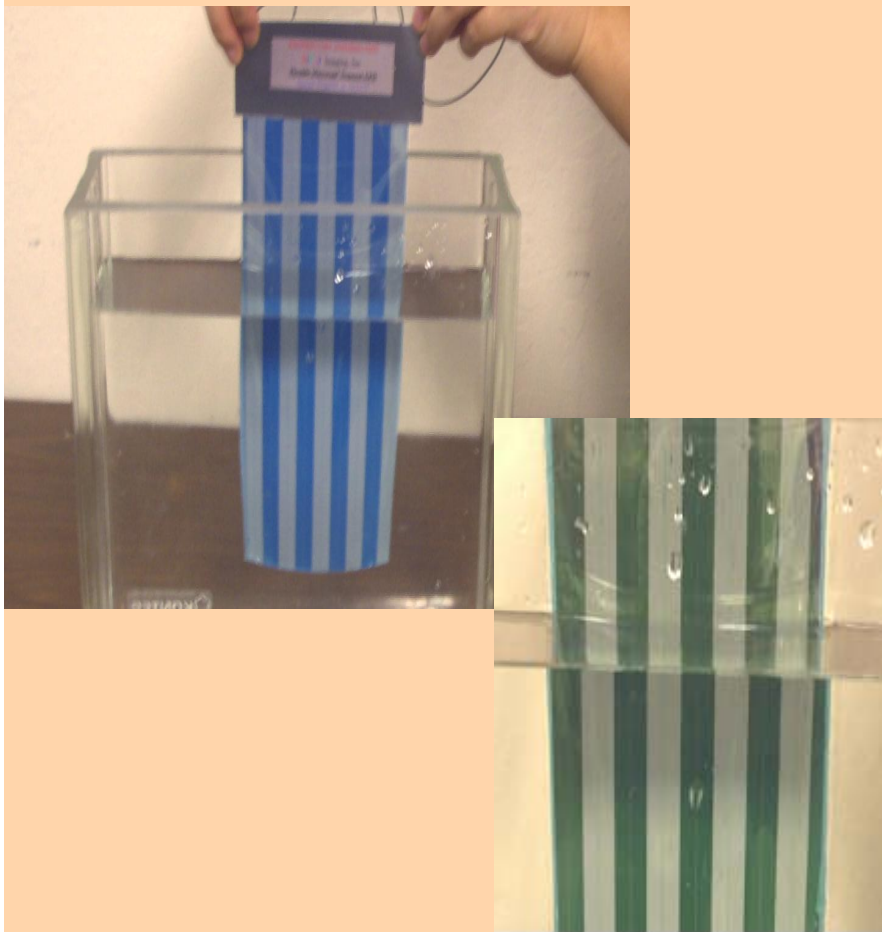


# SiPix EPDs: Super Durability

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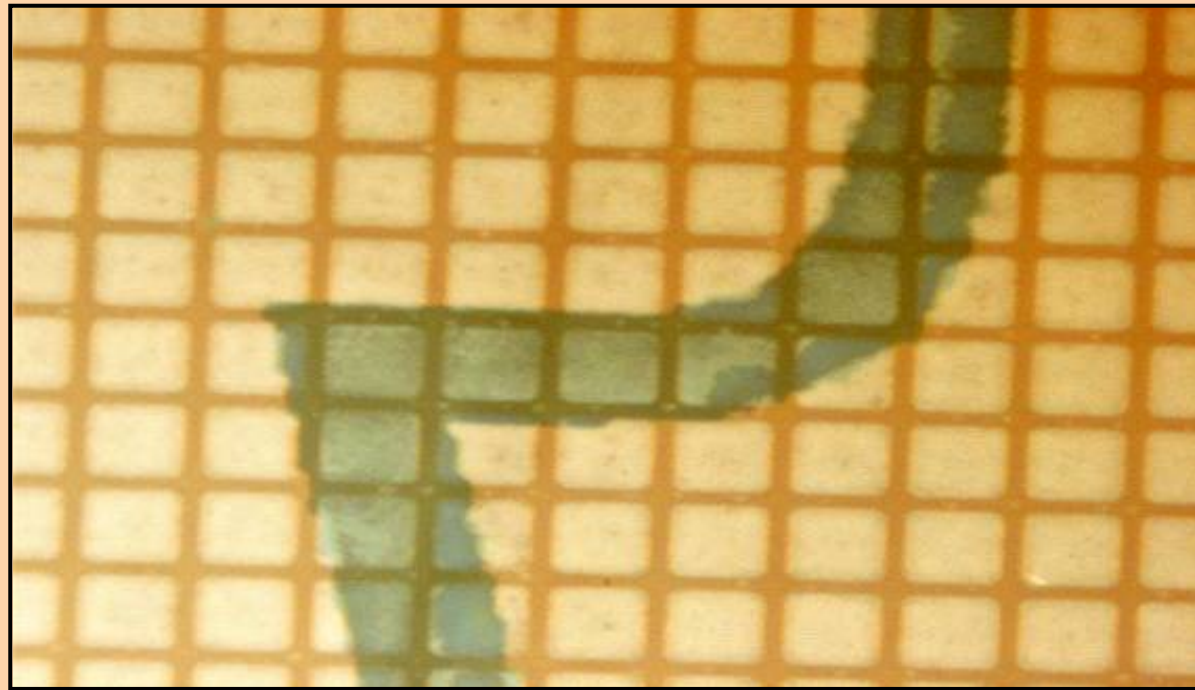


# SiPix EPDs: Super Water Resistance



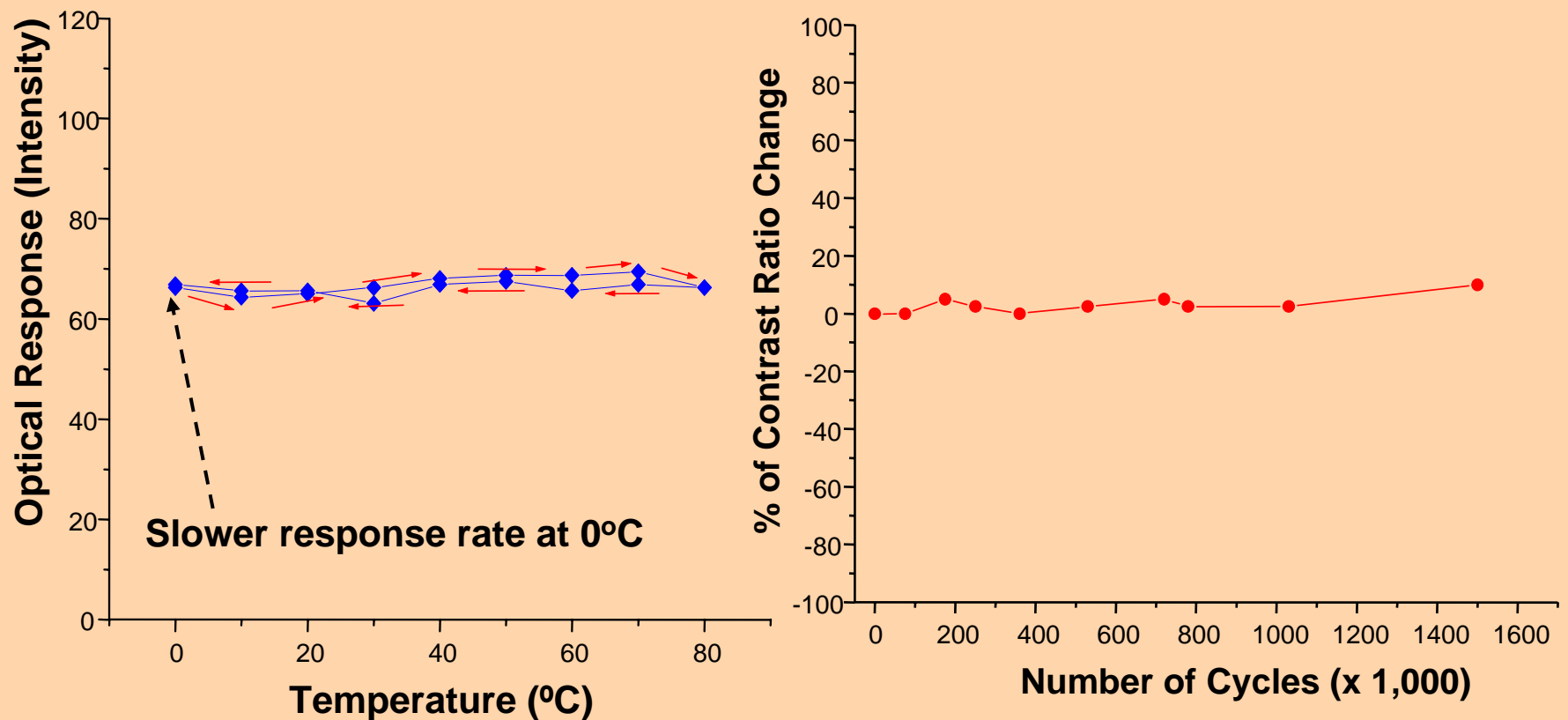
# SiPix EPDs: Super Edge Sharpness

100  $\mu\text{m}$



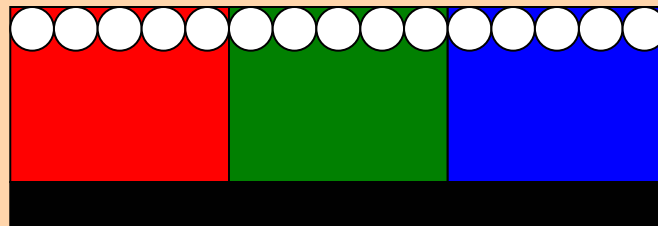
# SiPix EPDs: Super Temperature Latitude

Negligible Change in Contrast Ratio between 0 ~ 80°C

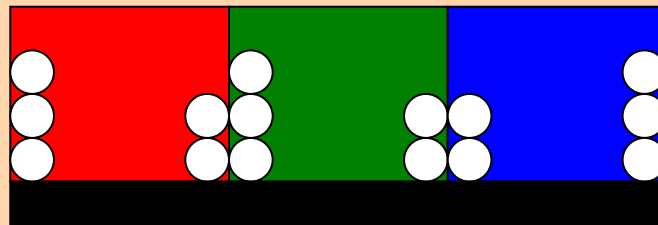


# SiPix Color Dual Mode EPDs

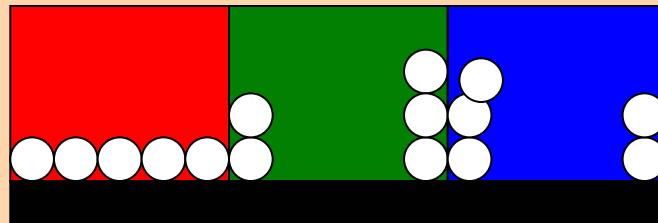
White State



Black State



Color (Red) State





# SiPix Microcup<sup>®</sup> EPDs

## Applications

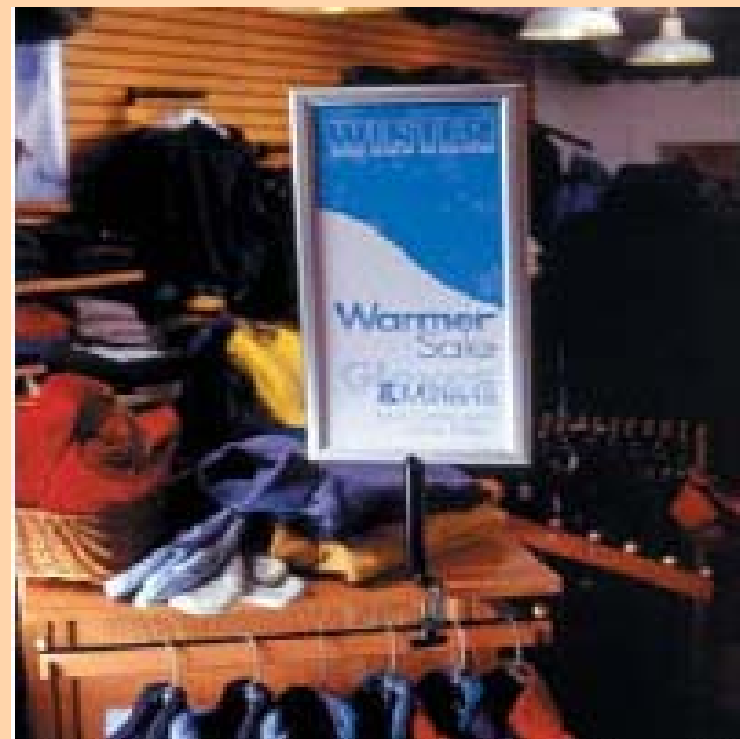
# SiPix Applications: Price Tags

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# SiPix Applications: E-Signs

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# SiPix Applications: Smart Cards



# SiPix Applications: PDA

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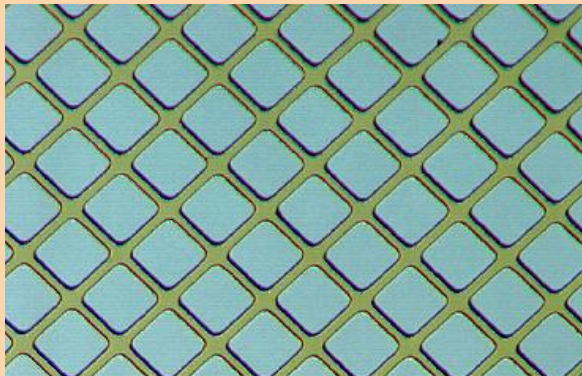


# SiPix Applications: Toys

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# SiPix Microcup<sup>®</sup> EPD is Superior

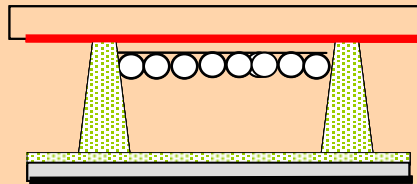


Microcup<sup>®</sup> EPD

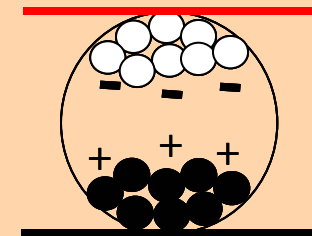


Microcapsule EPD

Cell gap:  
15-30  $\mu\text{m}$



High Payload  
(aperture ratio)



Cell gap:  
30-70  $\mu\text{m}$

- Super mechanical properties
- Dry embossing and non-Aqueous sealing processes
- Color separation is possible
- Microcup<sup>®</sup> and fluid can be optimized independently
- Superior environmental resistance

# Summary



**SiPiX Microcup<sup>®</sup>** EPDs by *Roll-to-Roll* processes provide:

- ❖ Low cost
- ❖ High throughput
- ❖ Excellent format flexibility
- ❖ Super electro-optical properties
- ❖ Great environmental friendliness