전자물리특강: OLED Fabrication Methods

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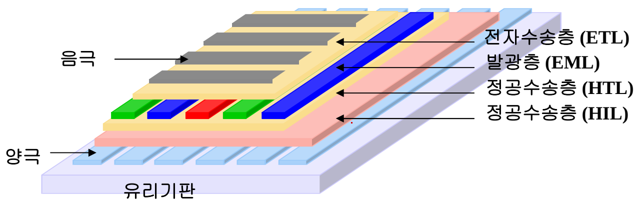
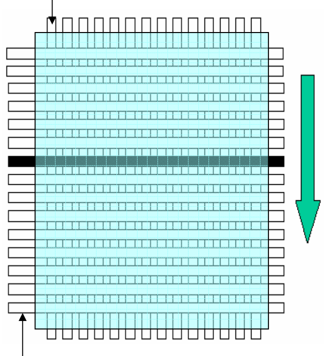
PMOLED



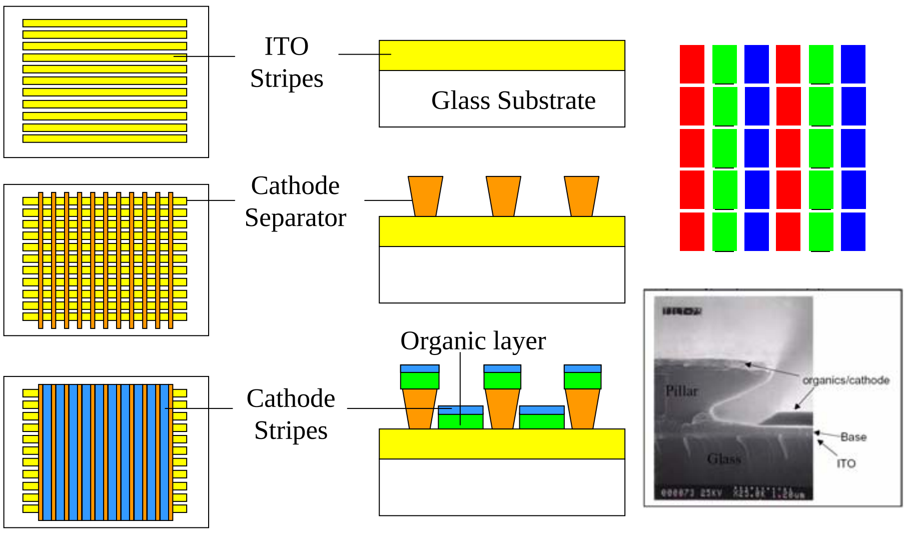
PMOLED 구조

Data Line(Anode : ITO)



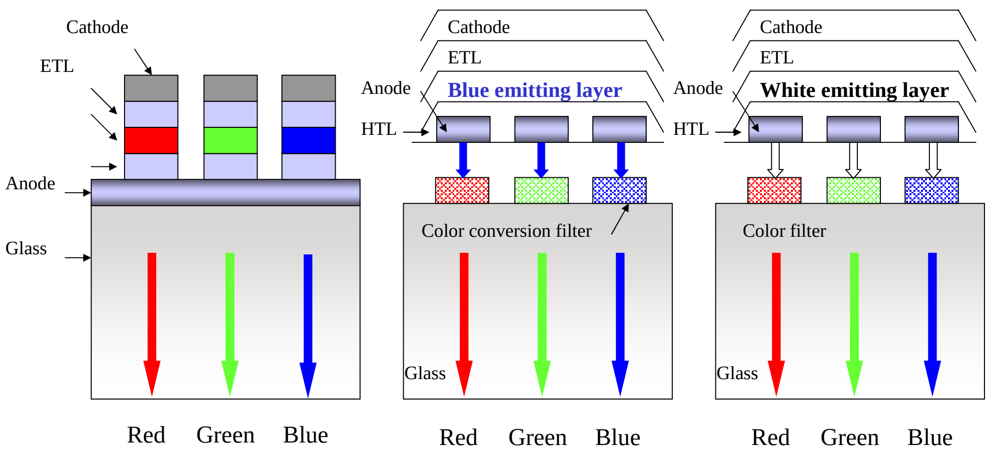
Scan Line (Cathode : Al)

Pixellation: small molecules

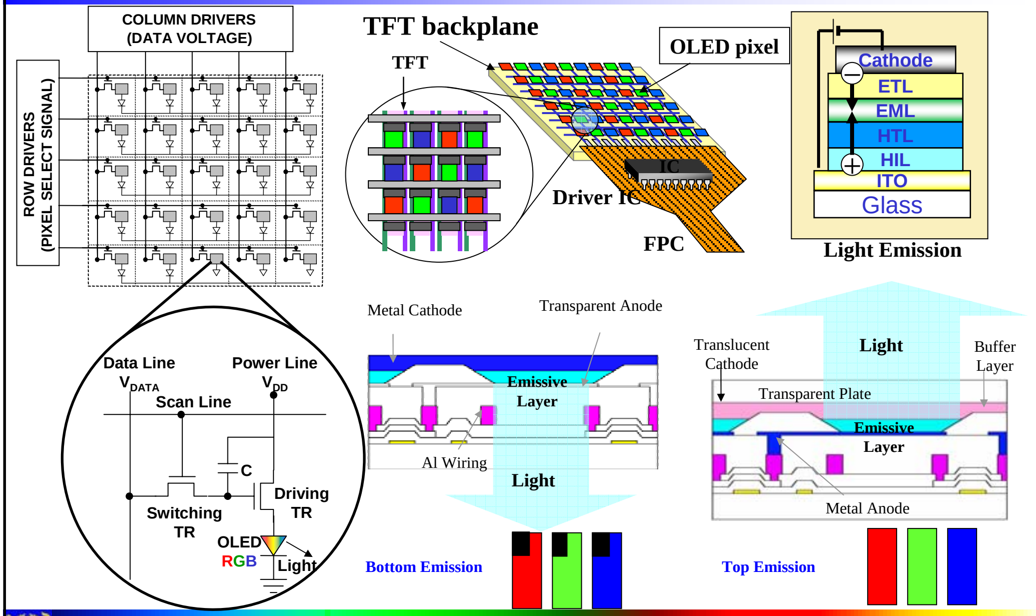


Methods of Full Color Display Fabrication

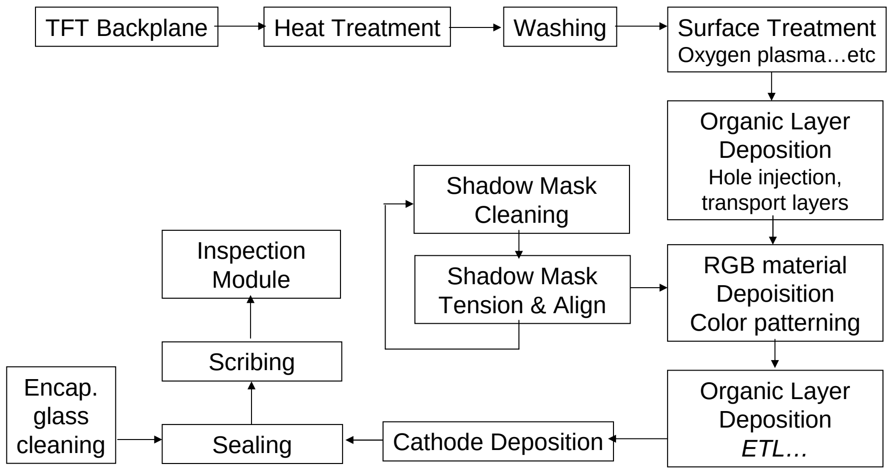
RGB method | Color conversion method | Color filter method



AMOLED



AM OLED Process Map



Source: B. D. Chin (KIST), IMID 2006

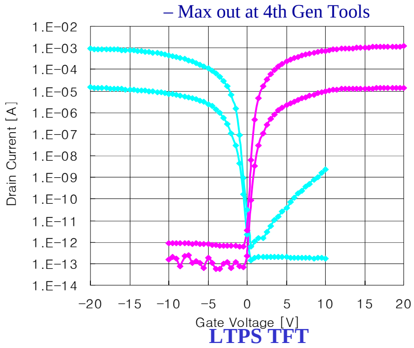
TFT Backplane Technology

	Features	Issues
LTPS TFT	High mobility (> 10's cm²/Vs), Operational stability n- and p-type possible, Complex circuit integration Vacuum process only, Indirect patterning for roll to roll	Uniformity over large area Expensive process Developing technology
a-Si:H TFT	Low mobility (< 1 cm²/Vs), Vacuum process only Very matured technology Low temp (< 150 °C) process available Indirect patterning for roll to roll	Uniform over large area Operational instability
Organic TFT	Low to medium mobility (< 10 cm²/Vs) Both vacuum and solution process Low temp (< 100 °C) process available Direct patterning possible for roll to roll Low mobility (< 1 cm²/Vs) for solution device	Patterning and encapsulation Immature technology Operational instability
Metal Oxide TFT	Medium mobility (< 10's cm²/Vs) Both vacuum and solution process Direct patterning possible for roll to roll Low mobility (< 1 cm²/Vs) for solution device High temp annealing (> 200 °C) for solution device	Very immature technology Operational instability High OFF current (nA~pA)

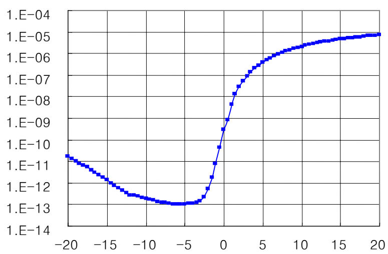
Source: Y. T. Hong, SNU

LTPS vs a-Si TFTs

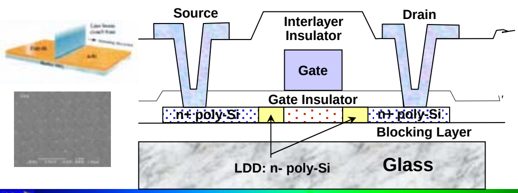
LTPS –TFT (ELA)
- Expensive process (~2 x a-Si TFT)
- Poor Uniformity
- Max out at 4th Gen Tools



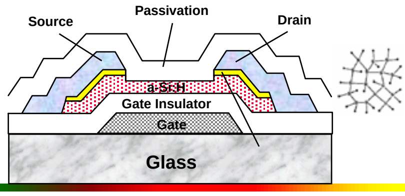
a-Si –TFT
- Low mobility (< 1 cm2/Vs)
- Operational instability (V_{th} shift)



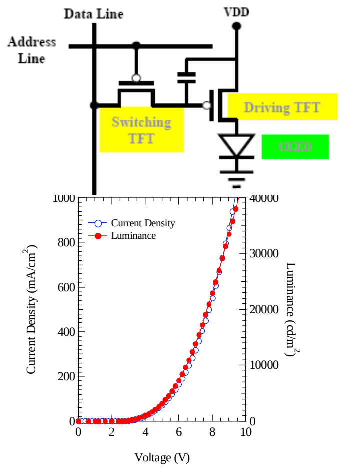
LTPS TFT

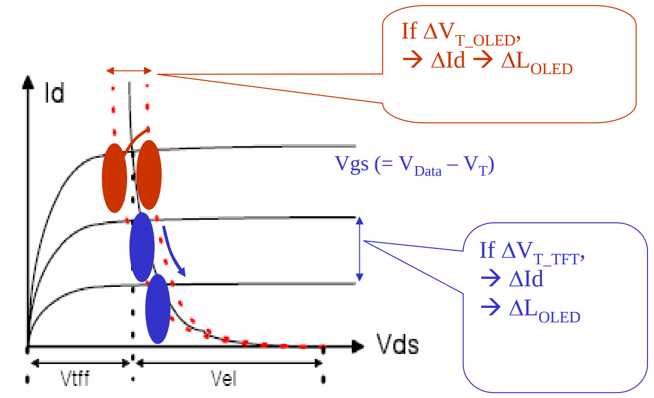


a-Si TFT



AMOLED Brightness Nonuniformity





$$I_{OLED} = \frac{1}{2}\mu C_{ox}\frac{W}{L}(V_{Data} - V_{th})^2$$

$$Light \propto I_{OLED} \times Efficiency$$

Switching – operates in linear regime
Driving – typically operates in saturation regime

Source: J.H. Kwon, Kyung Hee Univ.

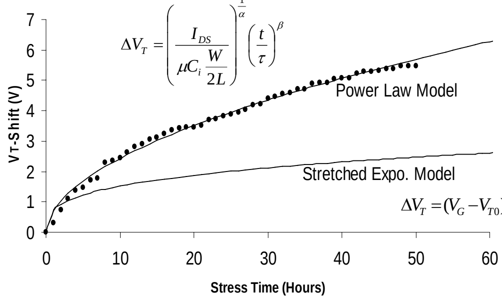
Threshold voltage shift of a-Si TFT

전자물리특강
2007. 2학기

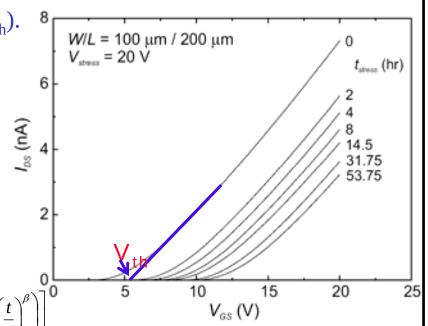
- Long term bias stress leads to threshold voltage shift (ΔV_{th}).

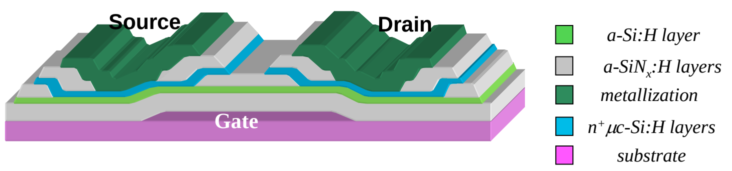
$$I_{OLED} = \frac{\mu_{eff}}{\alpha} C_i^{\alpha-1}\frac{W}{L}(V_{GS} - V_T)^{\alpha}$$

$$\Delta V_T = \left(\frac{I_{DS}}{\mu C_i \frac{W}{2L}}\right)^{\frac{1}{\alpha}}\left(\frac{t}{\tau}\right)^{\beta}$$



$$\Delta V_T = (V_G - V_{T0})\left[1 - \exp\left(-\left(\frac{t}{\tau}\right)^{\beta}\right)\right]$$

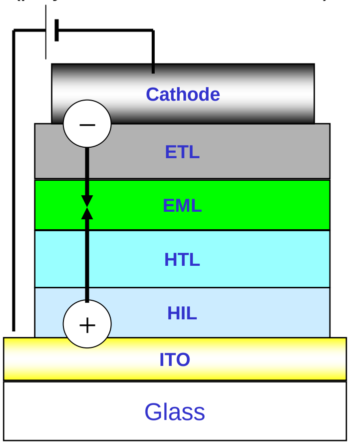




A. Nathan, IMID'05

Organic LEDs - Structure

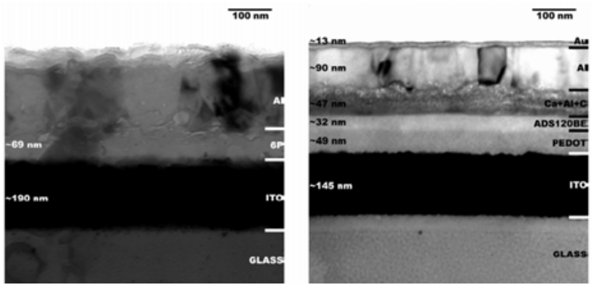
Organic Semiconductor LEDs
(polymers or small molecules)



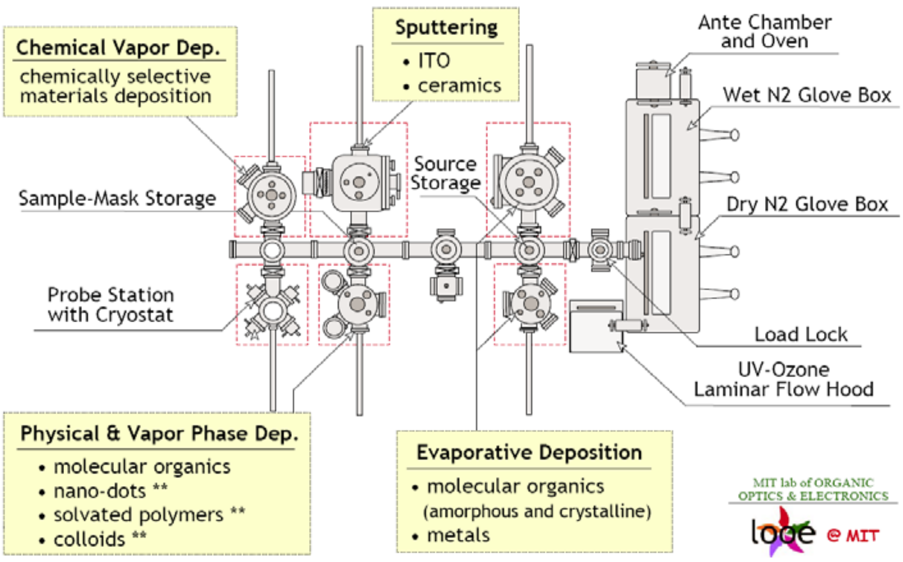
Abstract of MC2003
Microsc. Microanal. Vol.9 (suppl.3) 266 (2003)

TEM Investigations of Cross-Sectional Prepared Organic Light Emitting Devices

Bernhard Schaffer[a], Christoph Mitterbauer[a], Alexander Pogantsch[b], Stephan Rentenberger[b], Egbert Zojer[b], Andreas Schertel[c], Ferdinand Hofer[a]

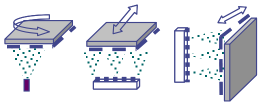
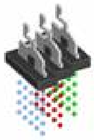
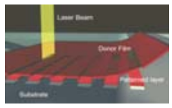


OLED deposition system (Lab. scale)



MIT lab of ORGANIC OPTICS & ELECTRONICS
loole @ MIT

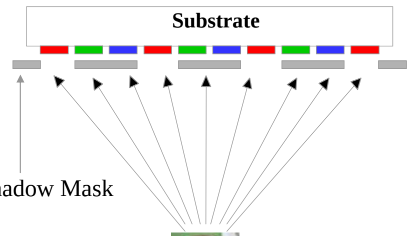
Comparison of OLED color patterning methods

Items	Evaporation (Precision Shadow Mask)	Ink-Jet Printing	Laser-Induced Thermal Imaging (LITI)
Materials	Molecular Materials Only 	Polymer (LEP) 	Polymer (LEP) Molecular Materials Hybrids (Blend) 
Printing Accuracy	± 15㎛	± 15㎛	± 2.5㎛
Resolution	~180ppi	~150ppi	~300ppi
Aperture Ratio (Top Emission)	40~50%	~60%	70~80%
Materials Usage	-	Smallest	-
Glass Size	730x460mm (~2005)	730x920mm	730x920mm (~2005)
Machine Price	Very Expensive	Cheapest	Middle

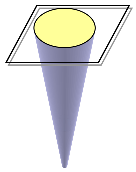
Source: Samsung SDI, FPD int. 2004

Vacuum evaporation

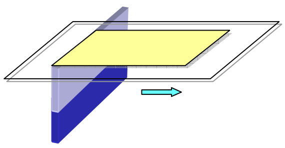
Vacuum Deposition



Source

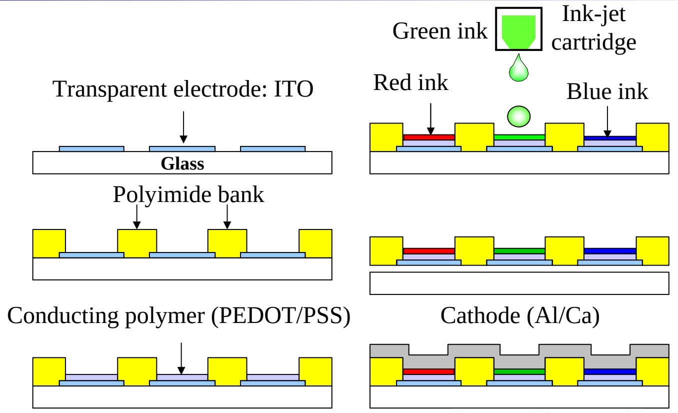


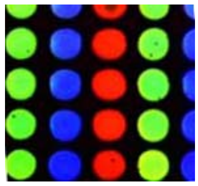
Point Source

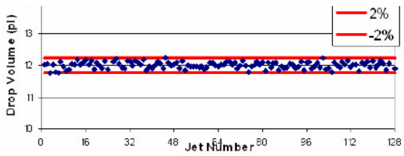


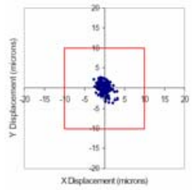
Linear Source

Inkjet



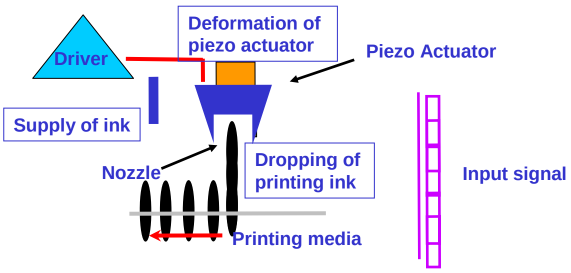


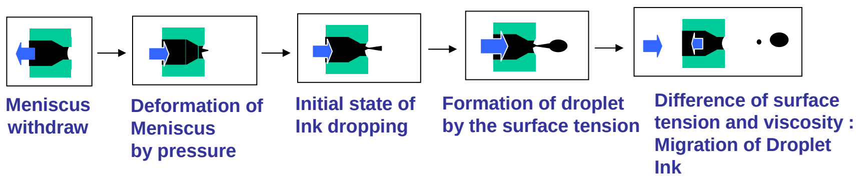




Inkjet printing tool - Litrex 140P

Jetting Principle of Piezo Ink Jet



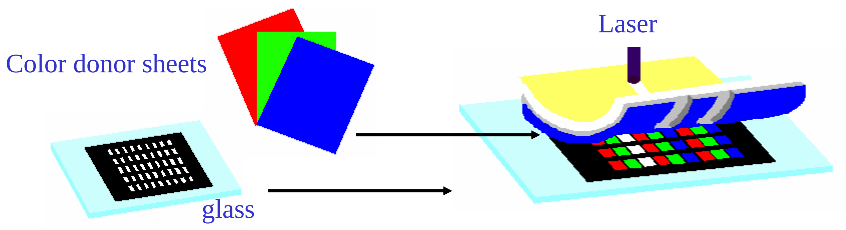


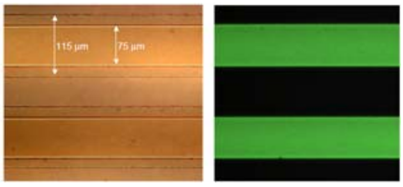
Epson/ Tektronix/ Hitachi

LITI

LITI Process (Contact transfer in ambient condition)

Samsung SDI / 3M





Samsung SDI, 17” UXGA (1,600×1,200) AMOLED

Laser Transfer

- Laser Transfer

Laser Imager (CREO)
CW w/modulation, NIR,
Raster scan
Donor Film
Base Film / Absorbing Layer
/ **Ejection Layer** / Transfer Layer

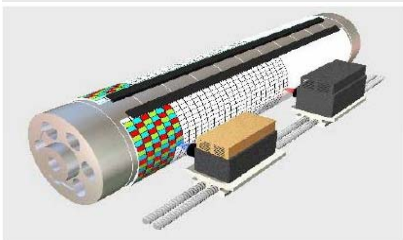


Figure 6: Extremely compact machine design combining Creo thermal head with an inkjet head

E. Elizur (CREO) / SID 02 DIGEST

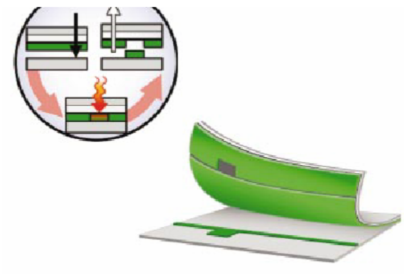
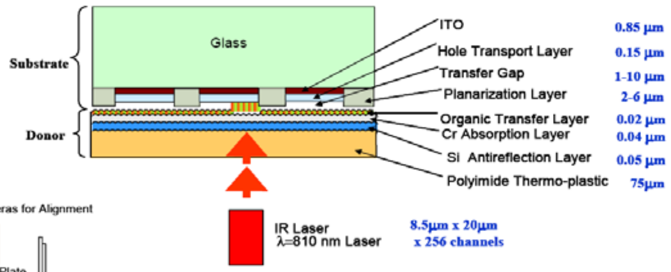
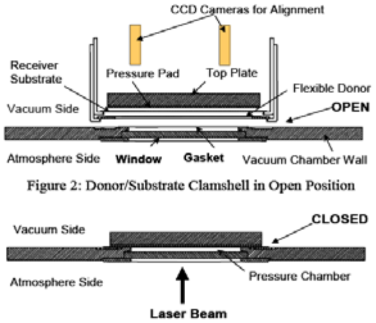


FIG. 1. (Color) *Illustration of the Printing Process.* The two flexible films, a multilayer donor and a receiver are held together by vacuum. The laser beam is focused onto a thin absorbing layer that converts light into heat, an optional ejection layer placed directly underneath, and a DNNSA–PANI/SWNT conducting layer coated on top. The heat generated at the metal interface decomposes the surrounding organics creating a gas bubble that when expanding propels the conducting layer onto the receiver. After imaging is completed the donor and receiver films are separated.

Blanchet et al. Appl. Phys. Lett.,2003, 463 (Du Pont)

RIST: Non-Contact transfer

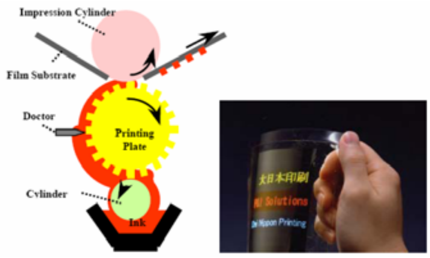




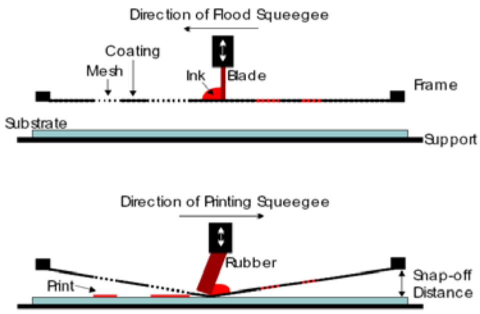
Color patterning method
without shadow mask
: transfer in a vacuum chamber

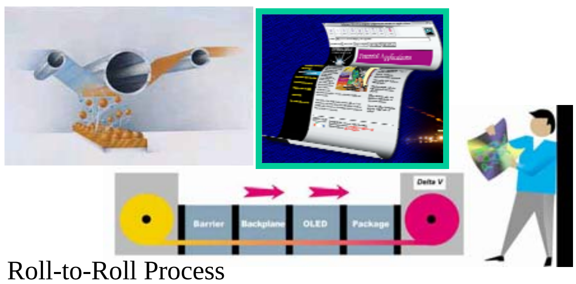
Boroson et al. SID 2005 Digest p172
(Eastman Kodak)

Other Printing Methods: Gravure, Screen or R2R Printing

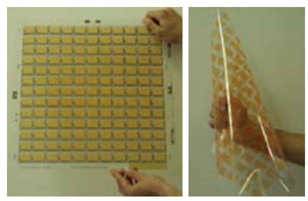


Gravure Printing
(Dai Nippon Printing Co, *SID 05 DIGEST, pg. 1196 (2005)*)





Roll-to-Roll Process



Screen Printing
H. Antoniadis, IMID'05