



# Fotoelektronik Elemanlar ve Katlanabilir Teknoloji



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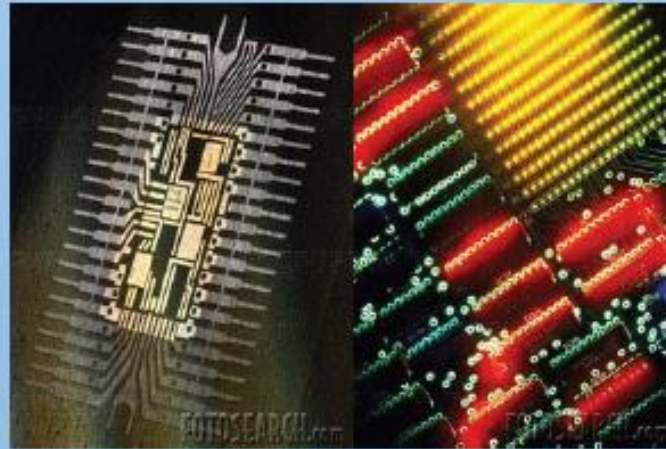


# Sunum

- İnorganik teknoloji
- Organik ve İnorganik Malzemeler
- Organik Yarıiletkenler
- Organik LED,
- Kendiliğinden Organize Tekkatman Yüzeyler
- OPV ve OLED'lerin Çalışma Prensipleri

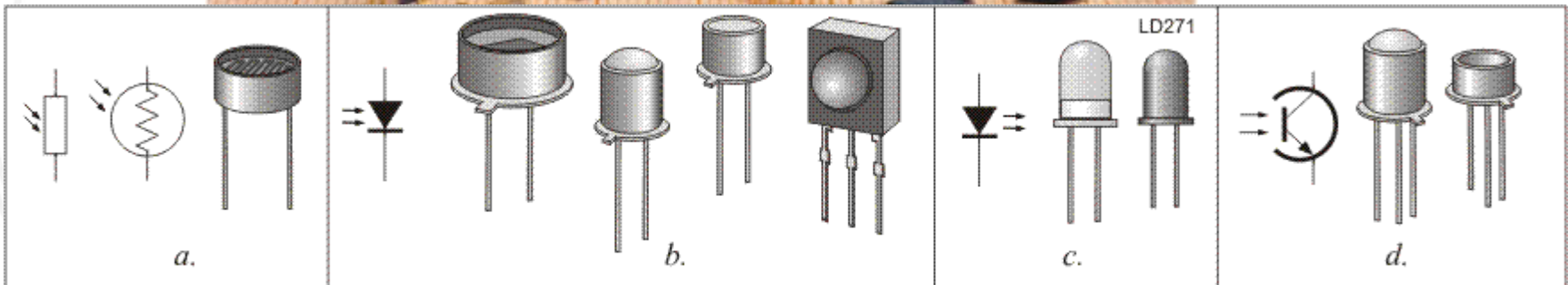
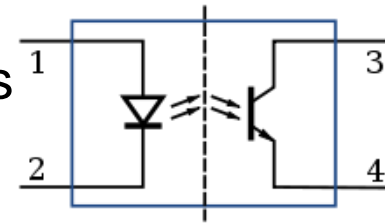


# *Inorganik Teknoloji*





- **LEDs** (Light Emitting Diodes),
- **Foto Transistor**,
- **Foto Diyot**,
- **Foto Resistor** (or LDR – Light Dependant Resistors are very useful especially in light/dark sensor circuits),
- **Optocoupler** yada **opto-isolator**(is a component that transfers electrical signals between two isolated circuits by using light. Opto-isolators prevent high voltages from affecting the system receiving the signal). etc.



9.3. Opto-electronic components: a - resistors, b - detecting (receiving) diodes, c - emitting (transmitter) diodes, d - transistors

# İnorganik ve Organik Malzemeler

- İnorganik elektronik temeli **Silisyum,...**
- Organik elektronik temeli **Karbon,...**

## İnorganik yarıiletkenler



- Foto-kondaktivitleri yüksek
- iletkenlik bant geçişleri ile mümkün
- ekziton oluşumu kolay (bant aralığı kısa)
- yük mobilitesi yüksek ( $500 \text{ cm}^2 / \text{Vs}$ )
- Değerlik-iletkenlik bantları
- enerji bant aralığı  $\sim 1.5 \text{ eV}$
- ekziton bağlanma enerjisi  $0.5 \text{ eV}$

**Silisyum**

**(SERT KIRILGAN)**

## organik yarıiletkenler

- Foto-kondaktivitleri düşük
- iletkenlik hopping transfer ile mümkün
- ekziton daha zor (bant aralığı yüksek)
- yük mobilitesi düşük ( $1 \text{ cm}^2 / \text{Vs}$ )
- HOMO-LUMO seviyeleri
- Optik bant aralığı  $1.5-3.5 \text{ eV}$  (görünür bölge emsy)
- Ekziton bağlanma enerjisi  $1 \text{ eV}$  frenkel ekziton



**Karbon**

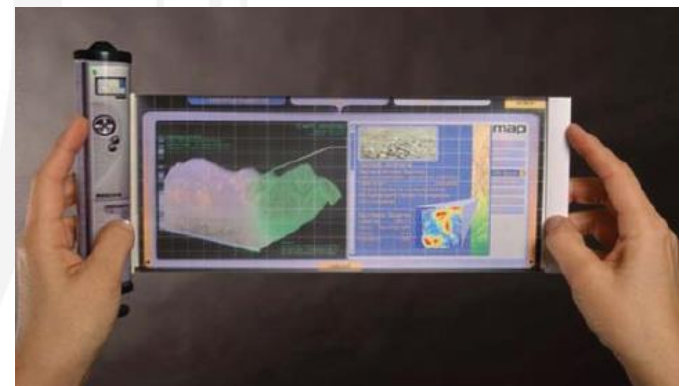
Organik malzemedan oluşturulan elektronik aygıtlar daha az enerji ile çalışırlar ...



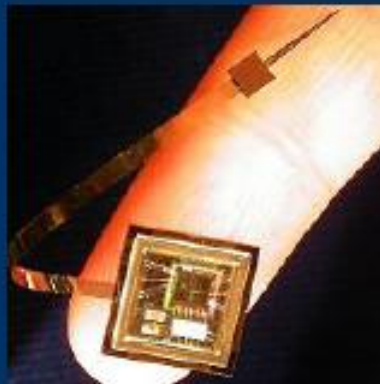
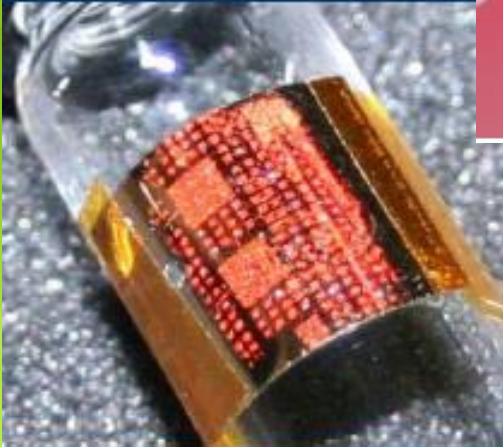
# Esnek Teknoloji



Fig-1 - International Space Station (ISS)



# Organik İnce Film Transistor (OTFT)





# Organik Elektronik Uygulamaları

OLED

Memory

Transistors

Smart Tags

Signage

Lab on Chip

Ambient Sensors

Display

Sensors

Display

Bio Sensors

Lighting

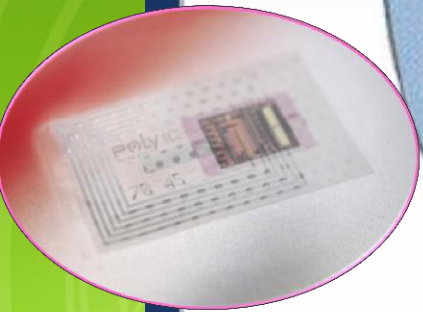
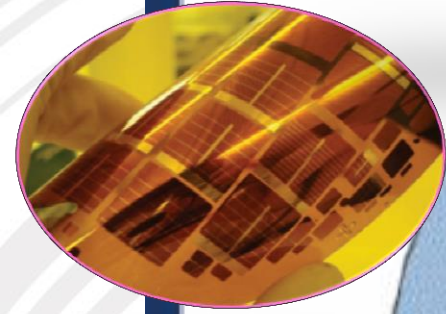
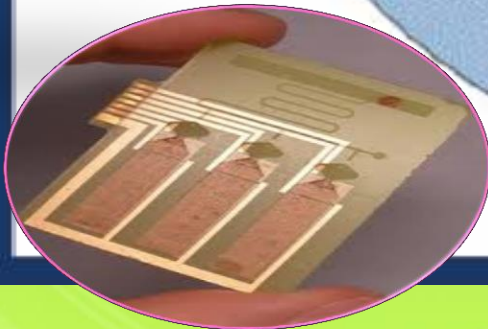
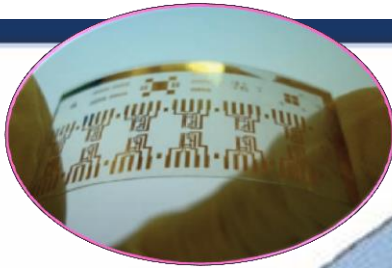
Actuators

Smart Fabrics

Batteries

Solar Cells

Power





# Samsung

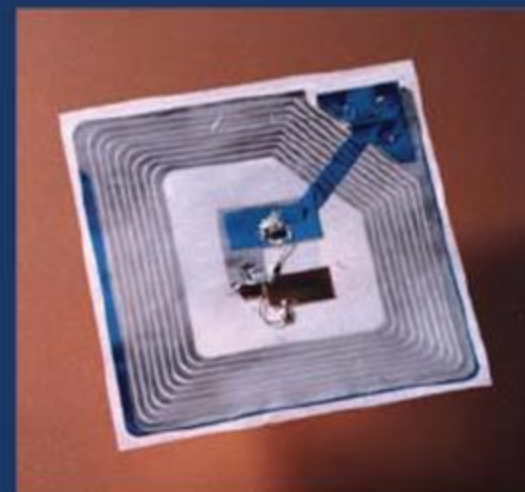


- Samsung SDI's 40-inch OLED panel 8.9mm thick.
- Full HD resolution of 1920 x 1080
- Contrast ratio of 1,000,000:1
- Color gamut of 107% NTSC
- Luminance of 200cd/m<sup>2</sup> (peak luminance of 600cd/m<sup>2</sup>)



- Samsung SDI 4-inch OLED panel 0.05mm-thick
- fluttering in the breeze from a fan
- Resolution of 480 × 272.
- Contrast ratio is 100,000:1
- Color gamut 100% of NTSC standard.
- Luminance is 200cd/m<sup>2</sup>.

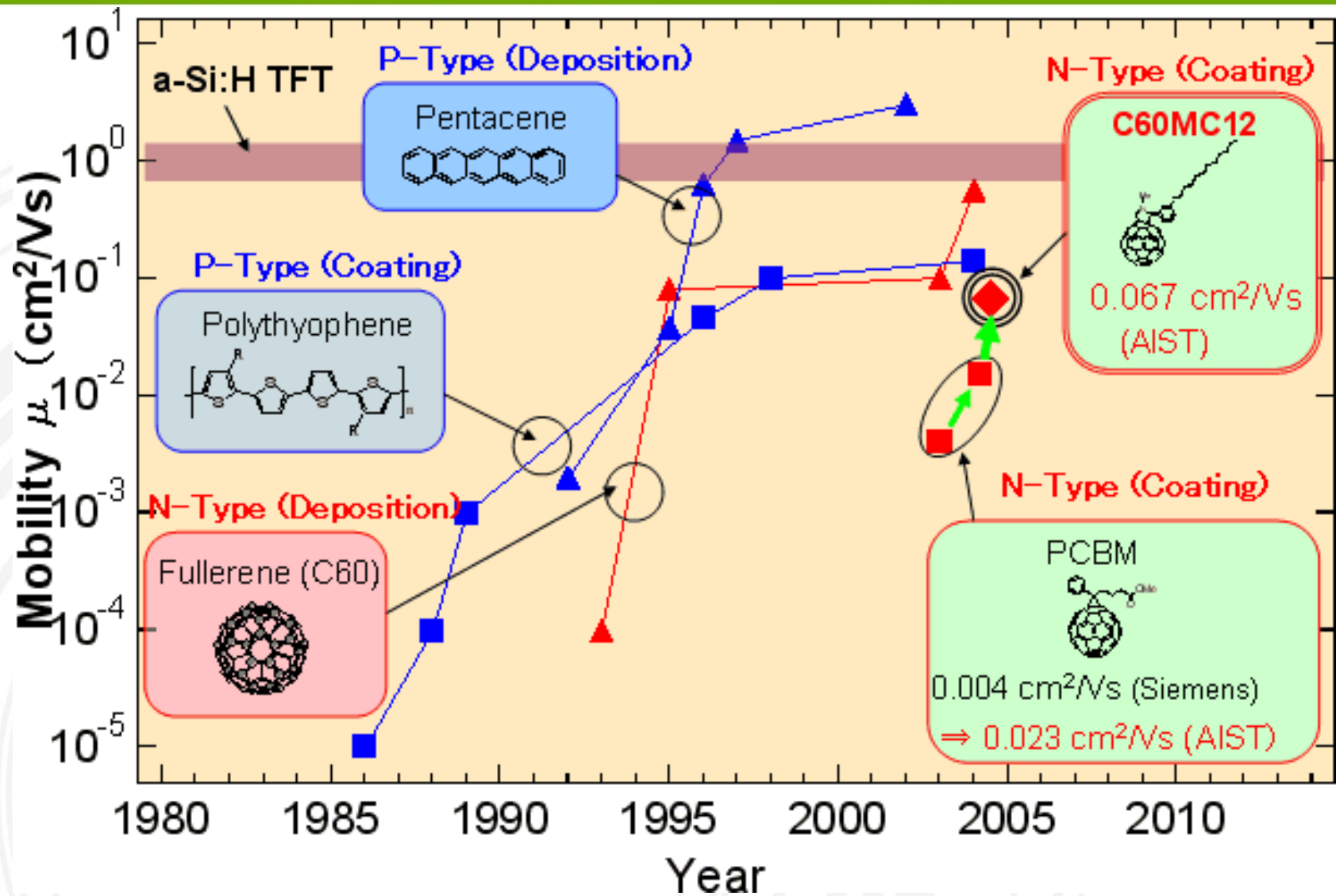
# Organic Semiconductors



Semiconducting properties:

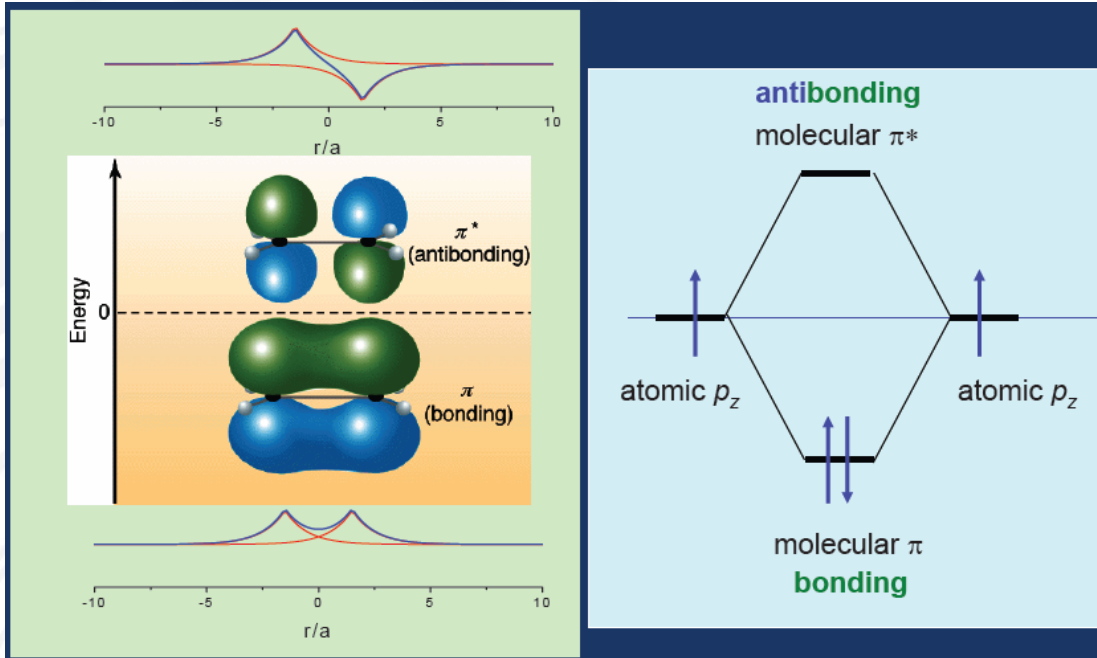
Inorganic Semiconductor	Organic Molecules
Conduction Band Valence Band	Lowest Unoccupied Molecular Orbital Highest Occupied Molecular Orbital
Band gap $E_g = E_{cb} - E_{vb}$	$(E_{LUMO} - E_{HOMO})_{Transport}$
p- and n-type doping	Large anisotropy of carrier mobility Doping: alkali metals or other molecules



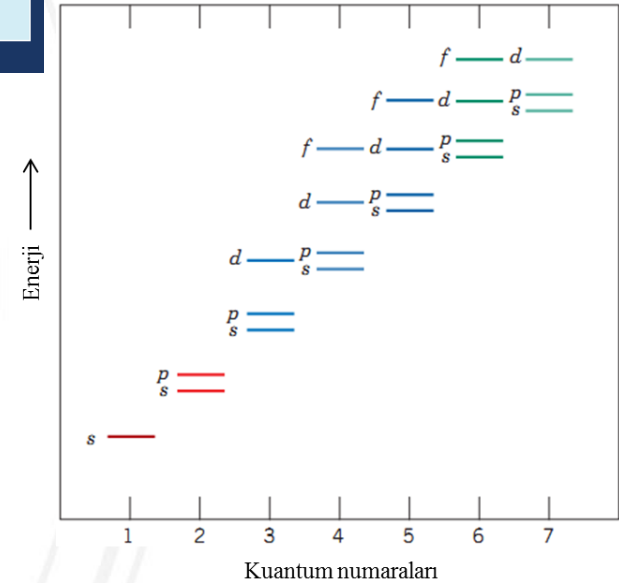


Son 15 yılda yapılan ar-ge ile organik yarıiletkenlerin mobiliteleri 5 kat artırılmıştır.

# Moleküler Orbital Teori



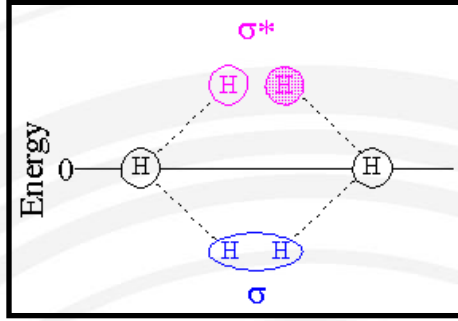
- Kuantum mekaniği (pauli- hund) atomik –moleküler orbitaller
- Orbital; e bulunma olasılığı yüksek yerler
- atomik; s, p, d, f orbitalleri
- hibrit atomik s,p orbitalleri uygun enerji ve simetride bir araya gelerek;  $\sigma$  ve  $\pi$  olarak isimlendirilen moleküler orbitalleri oluşturur.
- dolu orbital; bağ orbitali
- boş orbital; antibağ orbitali



Atomik orbitaller

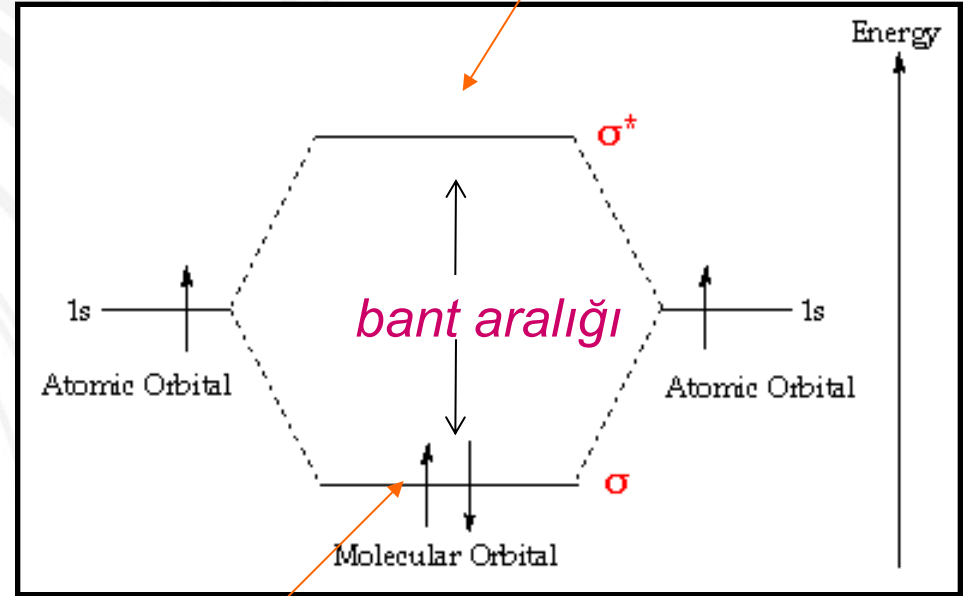


# HOMO / LUMO Enerji Seviyeleri



- ✓ **HOMO** Highest Occupied Molecular Orbital
- ✓ **LUMO** Lowest Unoccupied Molecular Orbital
- ✓ *bant aralığı*, HOMO ile LUMO enerji düzeyleri arasındaki fark
- ✓ kovalent, iyonik, metalik, van der waals(fiziksel)

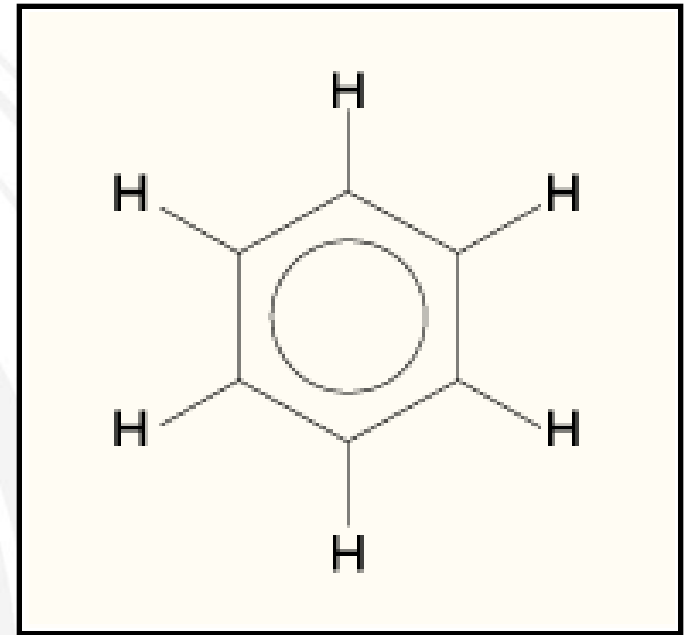
**LUMO** antibağ orbitali




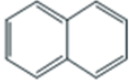
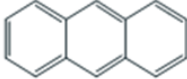
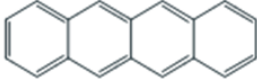
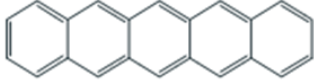
**HOMO** bağ orbitali

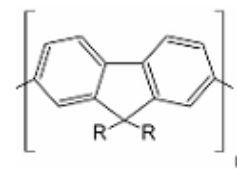
# Delokalizasyon

- ✓ Delocalization in benzene is represented by resonance structures
- ✓ Delocalized electrons are important for conducting polymers and semiconducting organic materials
- ✓ The electrons are free to move throughout the structure, and contribute to conductivity

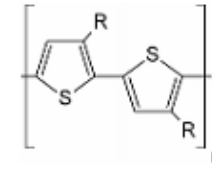




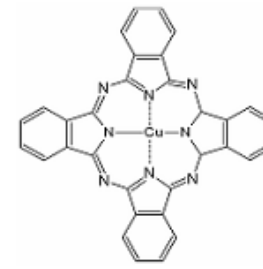
Molekül	Kimyasal yapı	Max Absorbsiyon (nm)
Benzen		255
Naftalen		315
Antrasen		380
Tetrasen		480
Pentasen		580



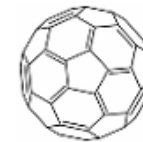
PFO



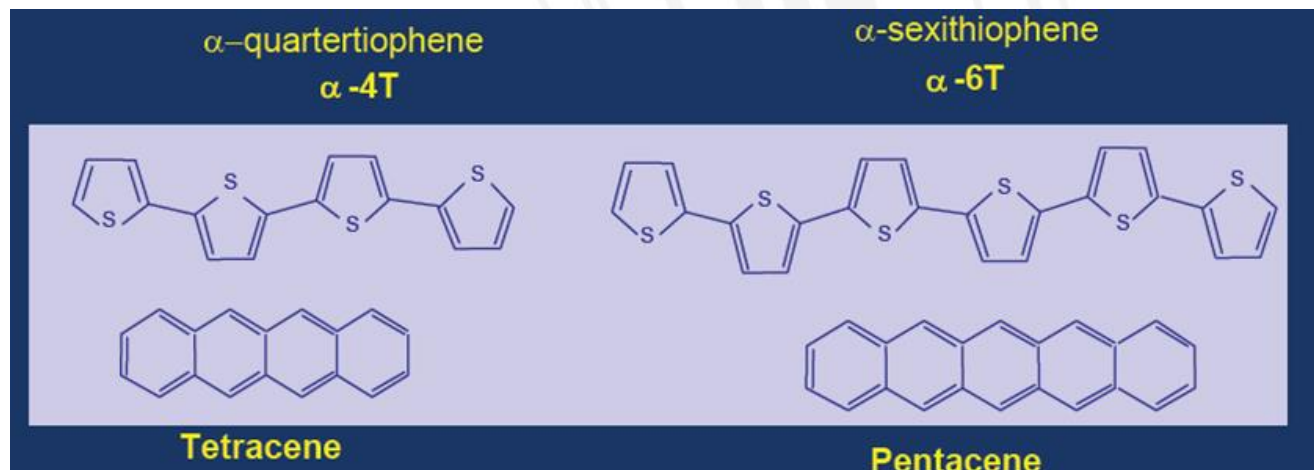
P3AT



CuPc

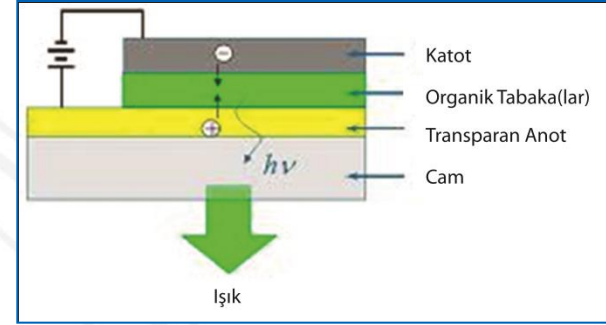


C<sub>60</sub>



# Organic Lights Emitting Diodes-OLED

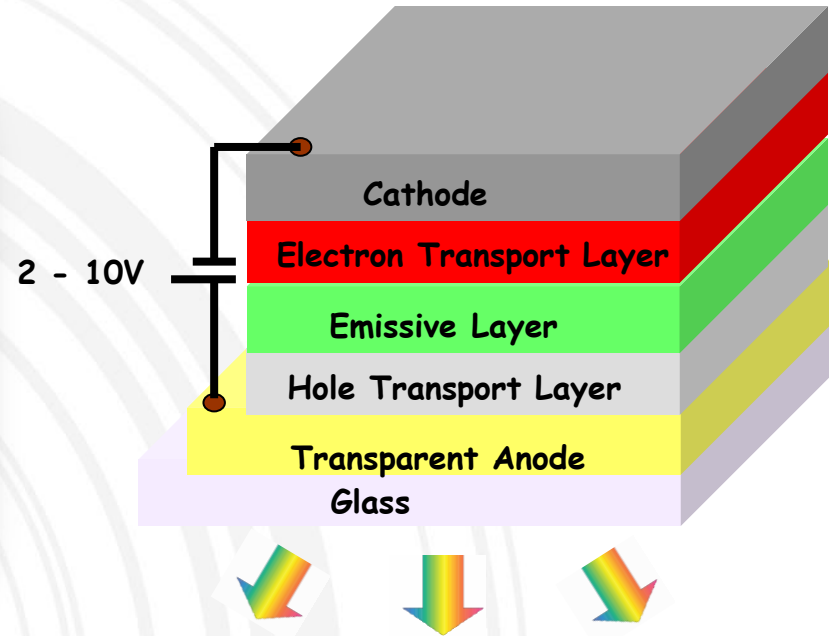
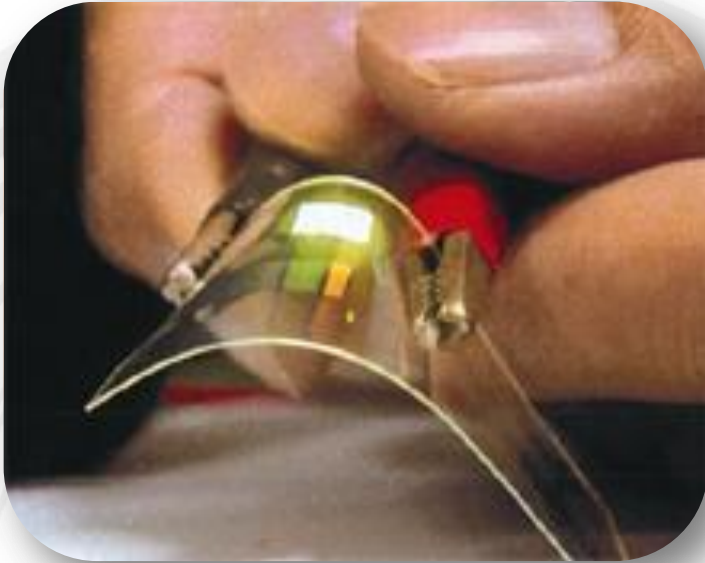
OLED, iki elektrot arasında organik ince filmin voltaj uygulandığında ışık oluşturması



- *kendiliğinden emisyon*
- *fabrikasyonu kolay*
- *Renk çeşitliği ve doğallığı*
- *Hafif ve çok ince yapı*
- *Eesnek*
- *Yüksek parlaklık ve çözünürlük*
- *Geniş görüş açısı*
- *Hızlı tepki süresi*

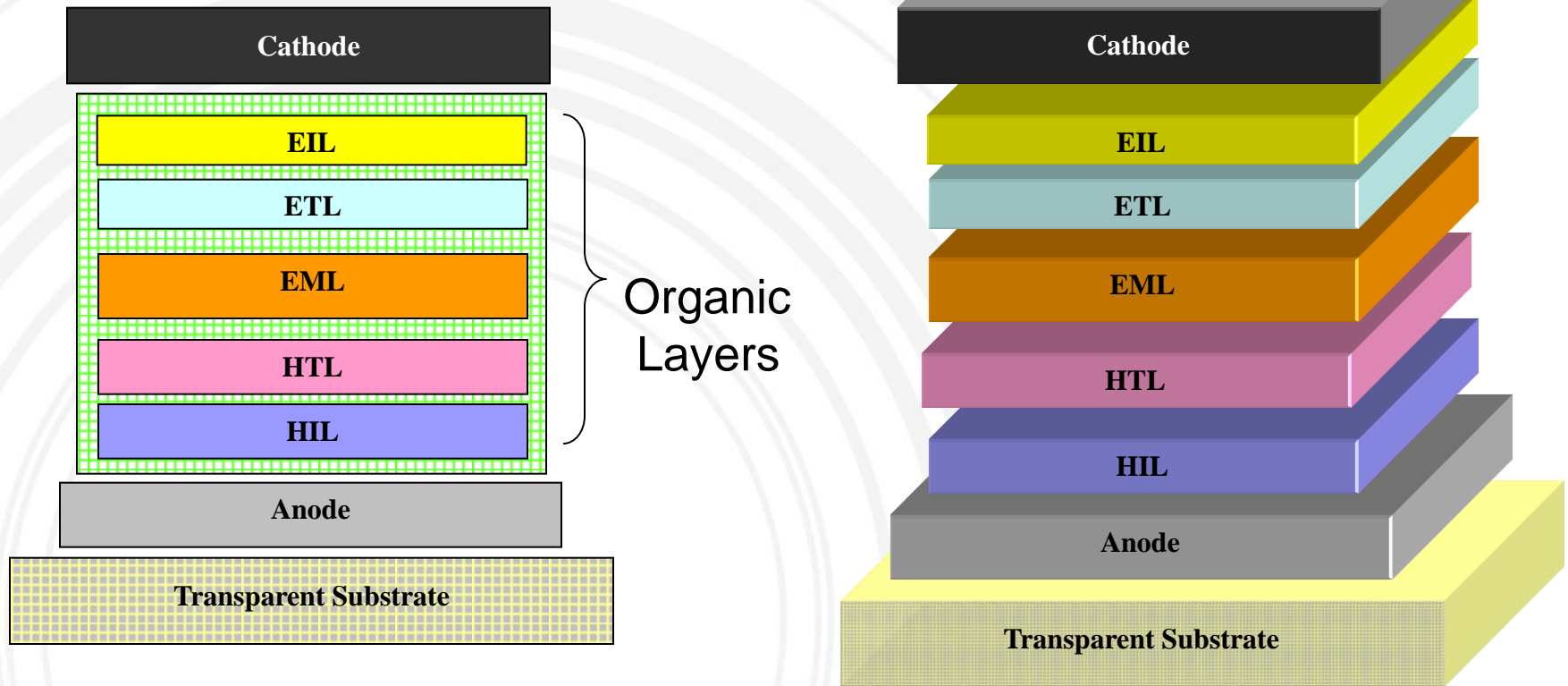


# OLED



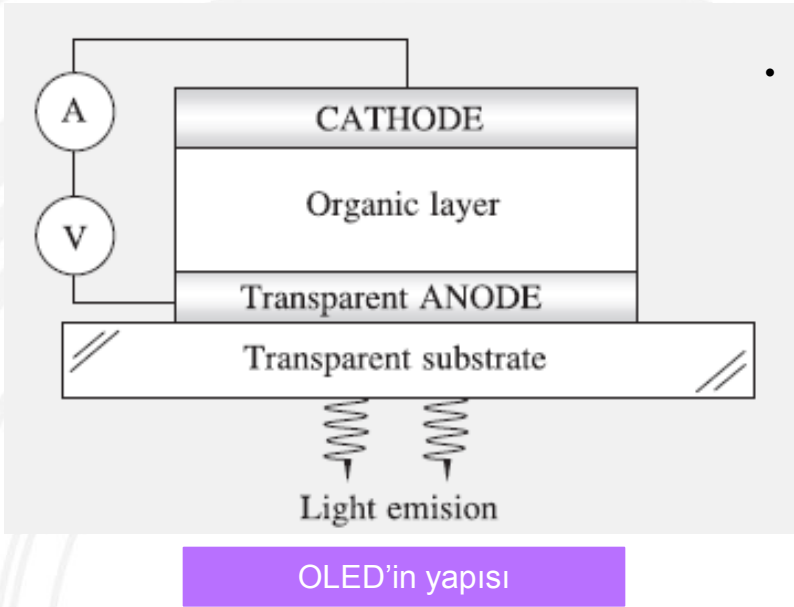


# Multilayer OLED

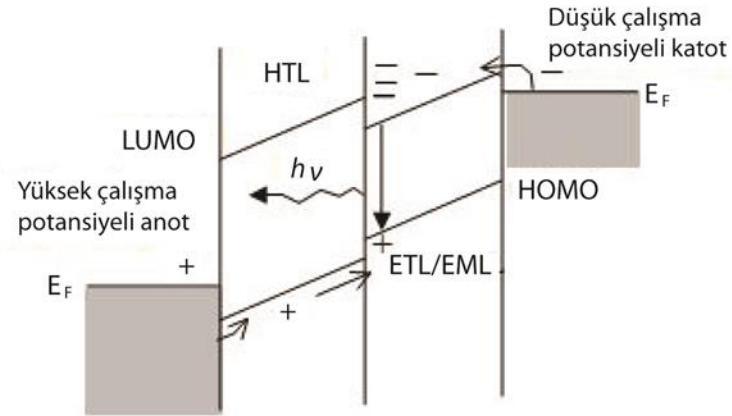


# OLED te Elektrolüminesans

## ■ Elektrolüminesans:



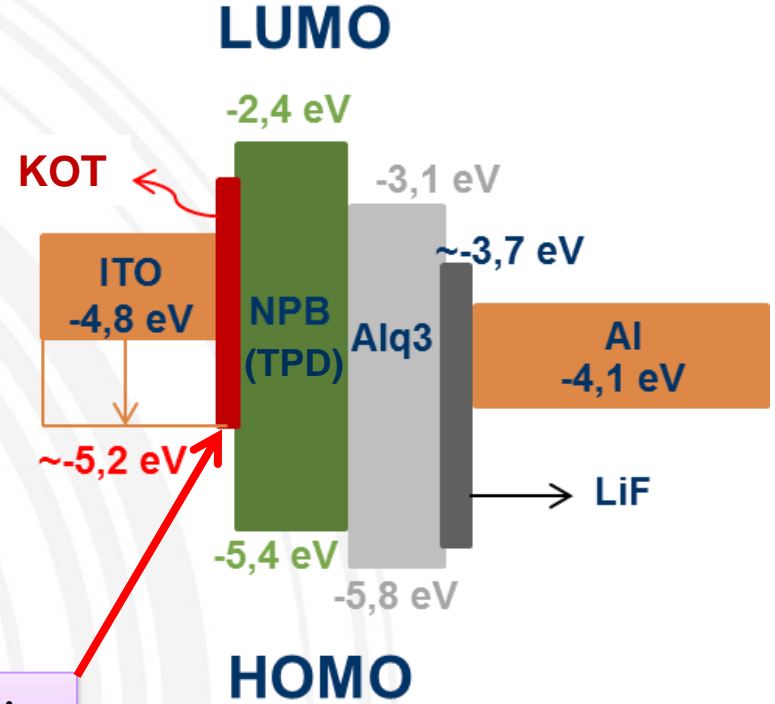
- İki elektrot arasında voltaj uygulandığında elektronlar katottan holler anottan hareket ederek emisyon bölgesinde birleşerek ışık oluşur



Elektrolüminesans prosesi

# Inorganik/Organik Arayüzey

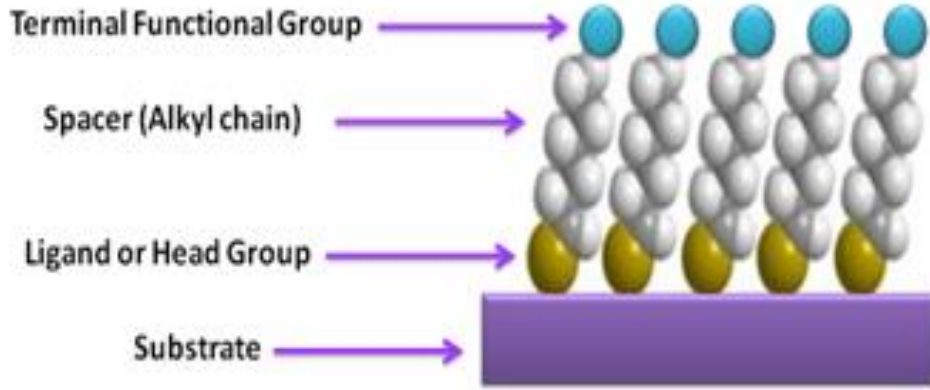
- (hidrofilik/hidrofobik)
  - Yük bariyerini azaltma
  - Anotun çalışma potansiyelini artırma
- Organik yarıiletkenin HOMO suna yaklaştırma



Daha düşük bariyer; hollerin daha kolay injekte olması,  
Hidrofobik hidrofilik uyumsuzluğun çözümü



# Kendiliğinden Organize Tekkatman (KOT)



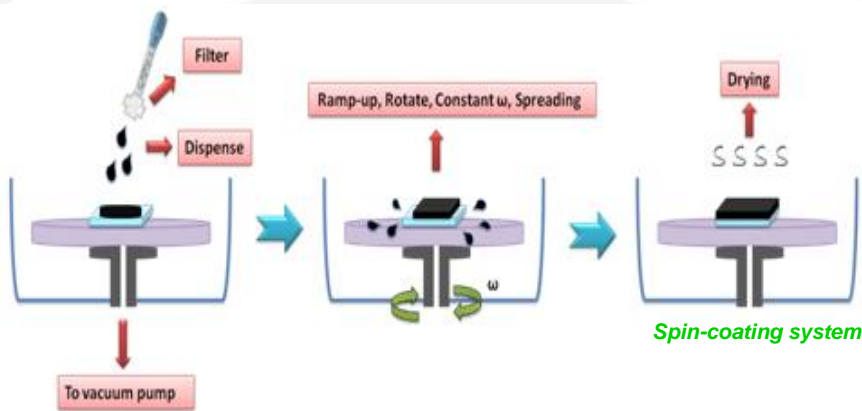
*KOT molekülleri 3 ana kısımdan oluşur*

- i. Baş Grupları*
- ii. Ana yapı*
- iii. Fonksiyonel gruplar*

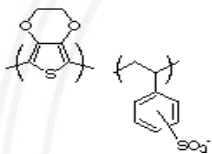
## *KOT'un oluşumunu etkileyen faktörler*

- ✓ Oluşum zamanı*
- ✓ Sıcaklık*
- ✓ Ana yapının aromatikliği*
- ✓ Molekülün büyüklüğü*
- ✓ KOT'un konsantrasyonu ve çözüneni*
- ✓ KOT'un uzunluğu*

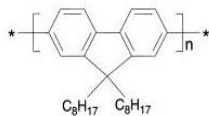
# Polimer LED ve OLED oluşturma



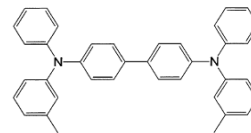
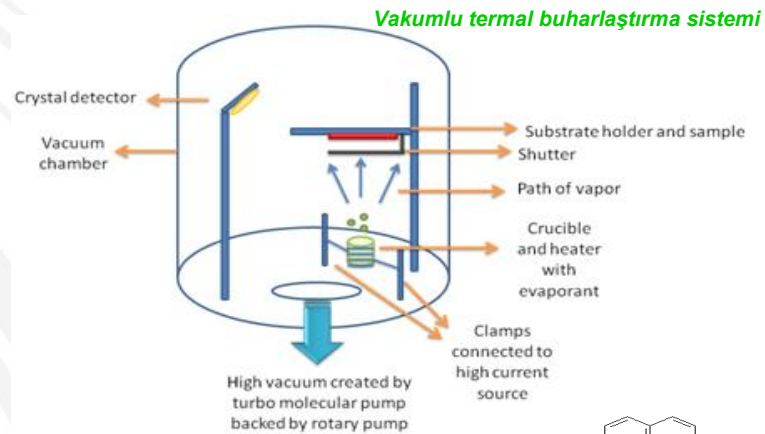
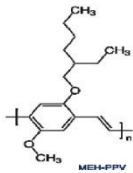
PEDOT-PSS



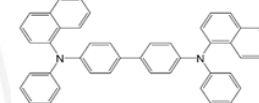
PFO



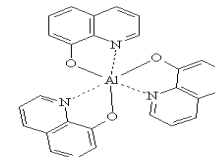
MEH-PPV



TPD



NPB



Alq<sub>3</sub>

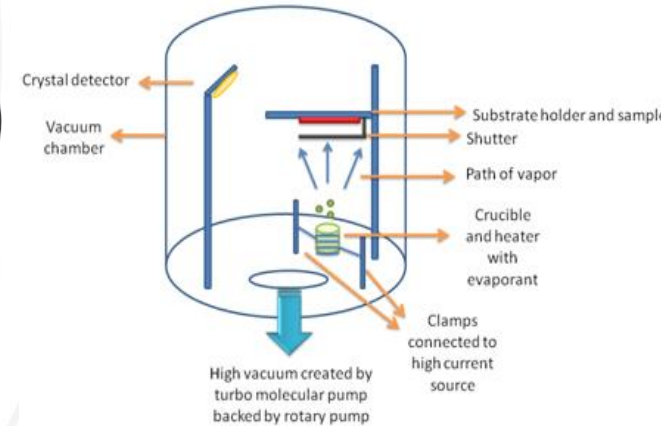
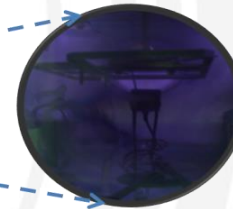
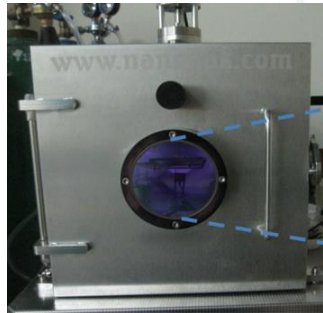
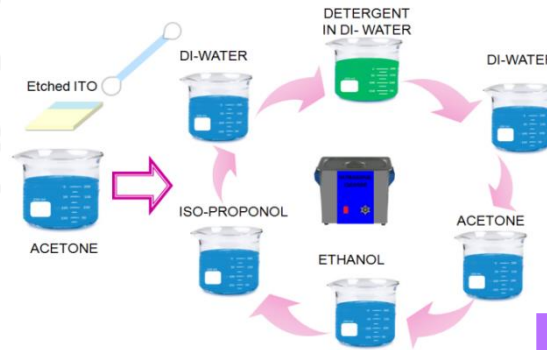
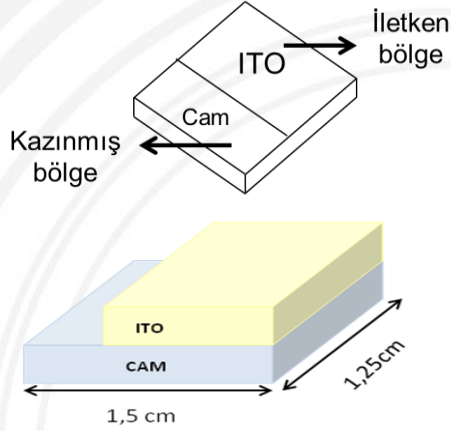
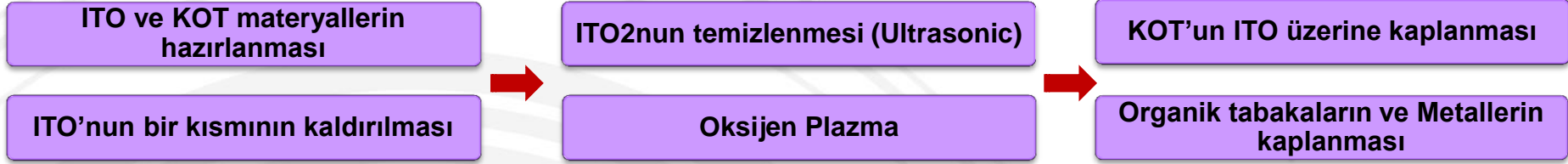
## ***Neden ITO üzeri KOT?***

- ✓ *İnorganik(ITO)/organik arayüzeyinde zayıf bağlanma*
- ✓ *ITO'nun fermi enerji düzeyi ile HTL'nin HOMO seviyesi arası yüksek bariyer*
- ✓ *ITO/**KOT**/HTL; arasında KOT, HTL yapısına benzerlik göstererek tek bir yapıymış gibi davranır, yük iletimi artar.*
- ✓ *Literatürde Anot ve katottan yapılacak yük iyleştirmeleri OLED'in performansını artırdığı gözlemlenmiştir.*



# Deneysel aşamalar ve OLED Oluşturma

## Temizlik ve Oksijen plazma ile yüzeyi aktifleştirme





Chamber

Thickness Monitor

Power Supply



Throttle

Thickness Monitor

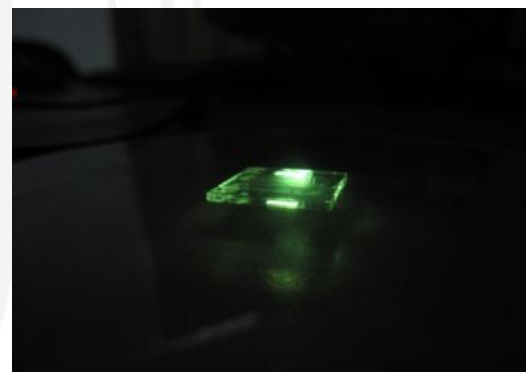
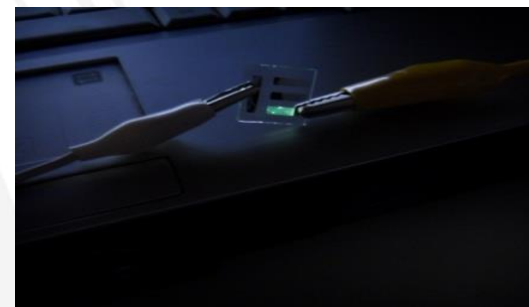
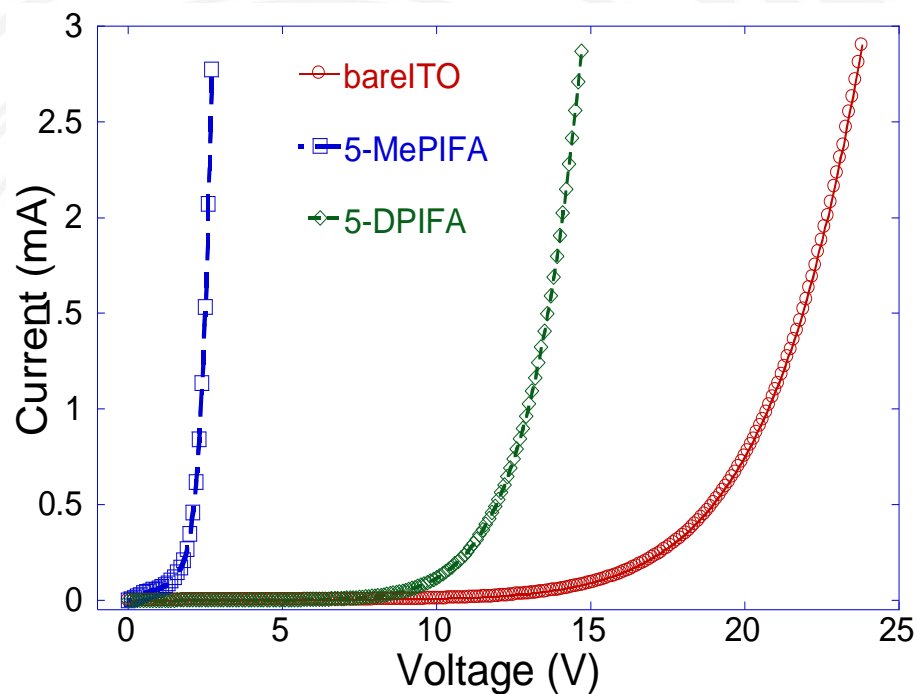
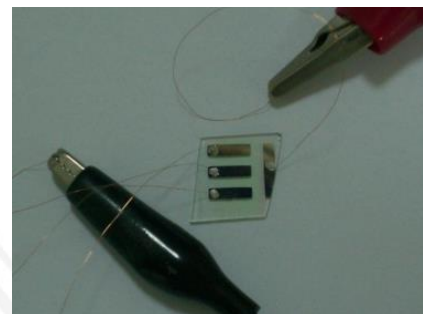
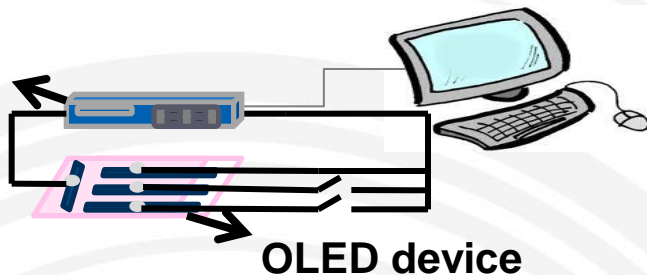
Sample holder

Melting pots

25

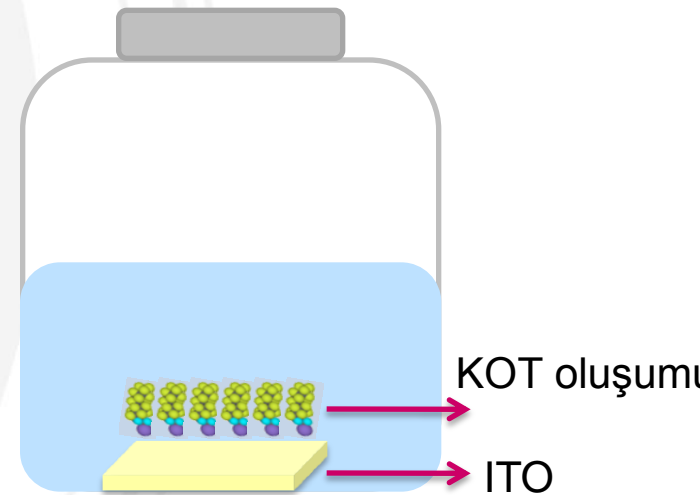
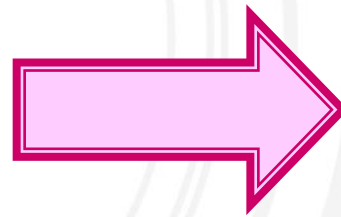
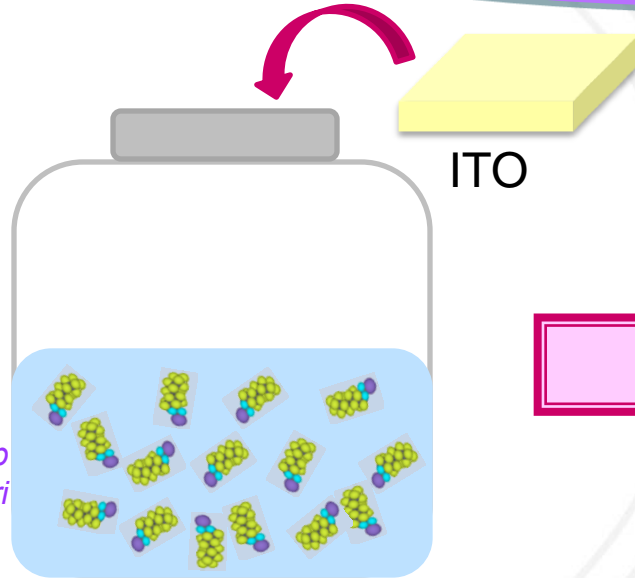
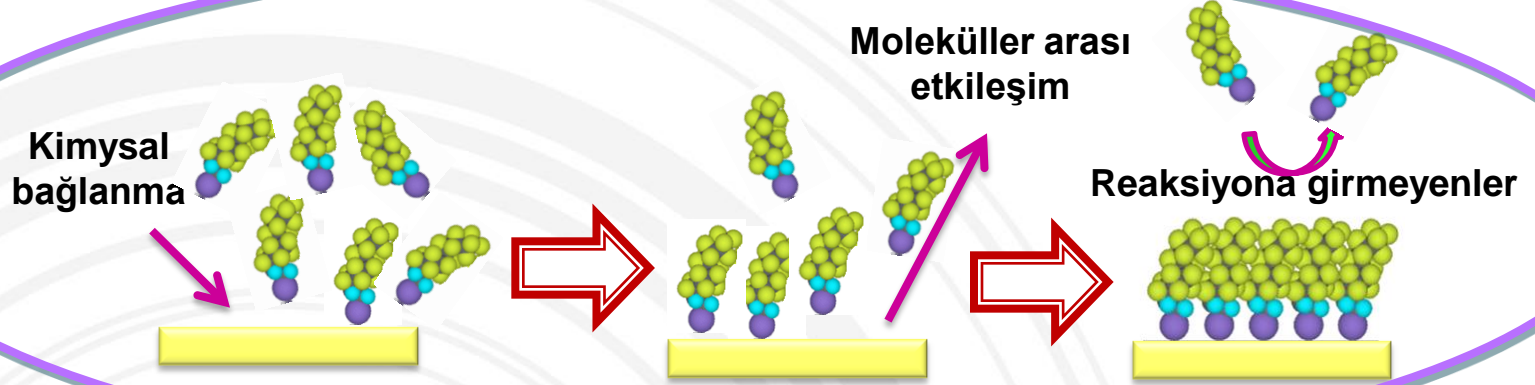
# Characteristic of OLED

Keithley  
2400  
sourcemeter



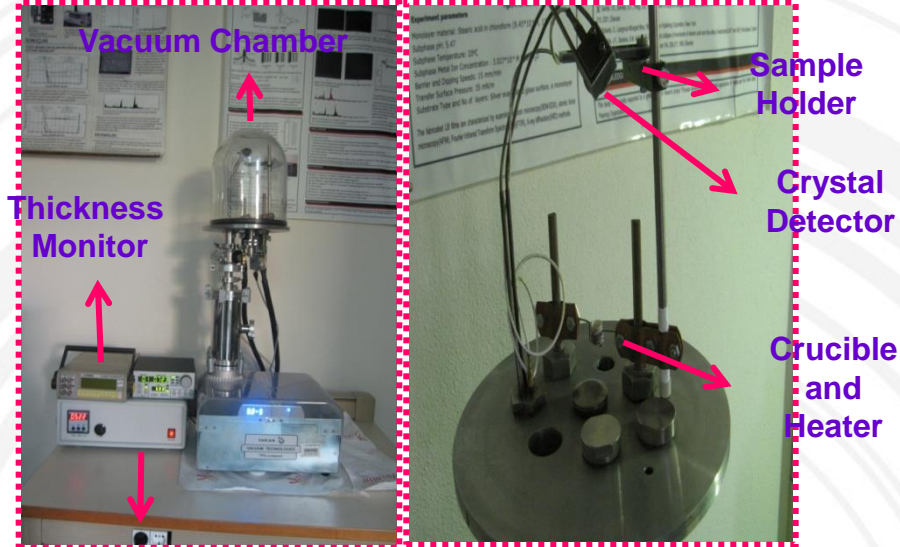
# KOT Oluşumu

ODA SICAKLIĞINDA (25 °C)

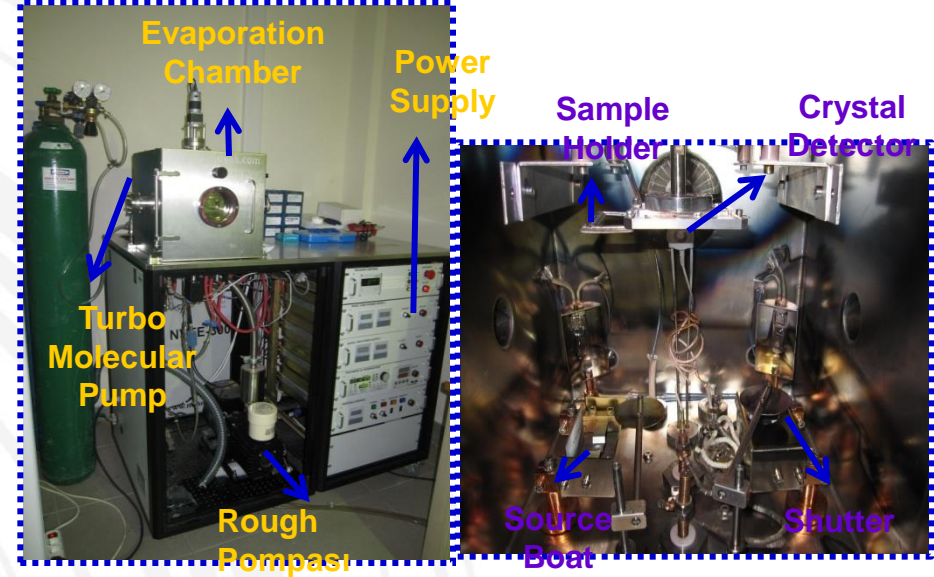




# Organik ve Katot metallerin kaplanması

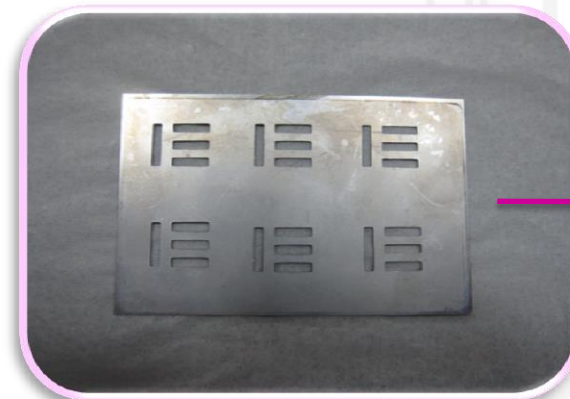


Power Supply



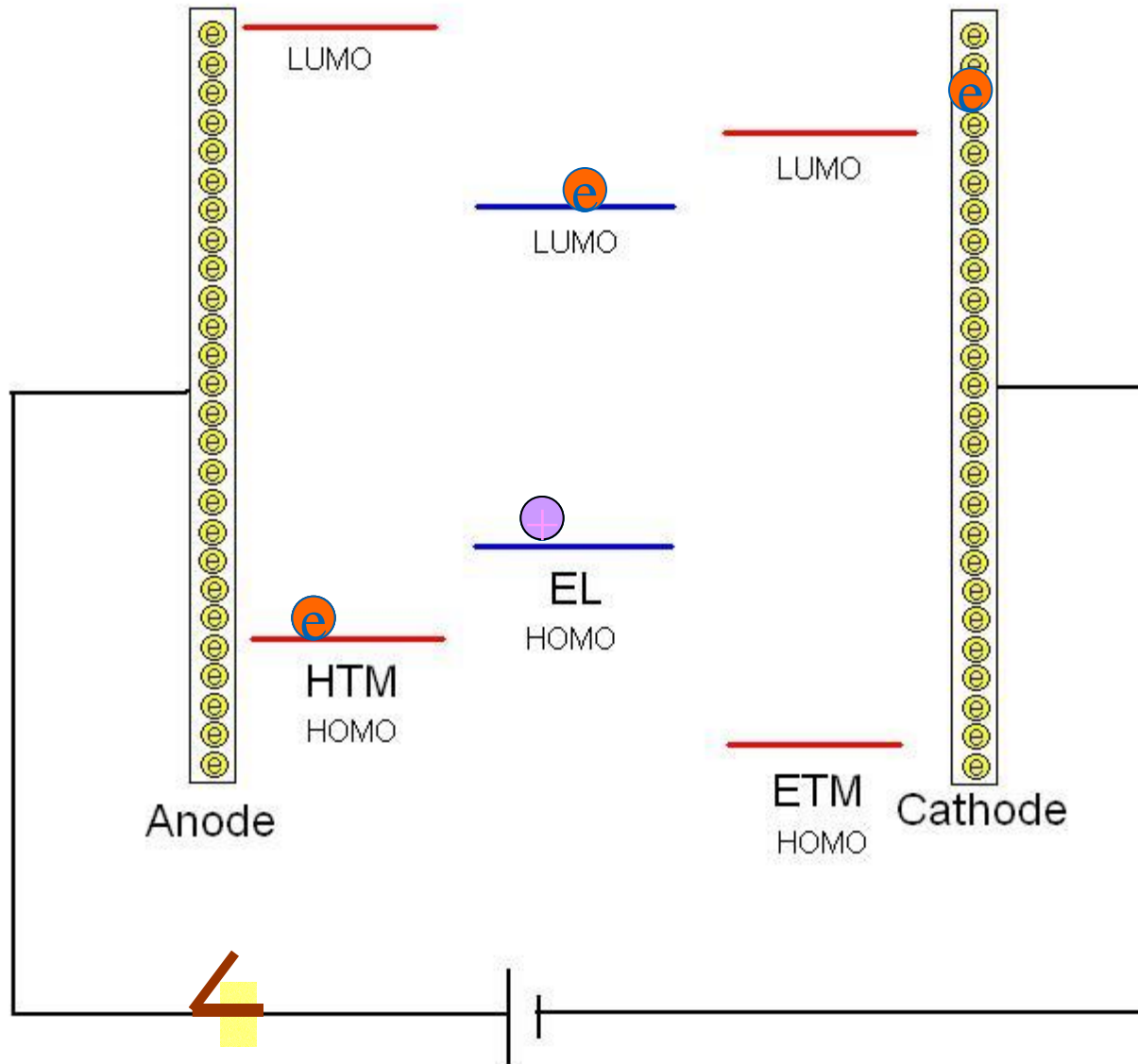
Metaller için (Al)

Organik Moleküller (NPB & Alq<sub>3</sub>)

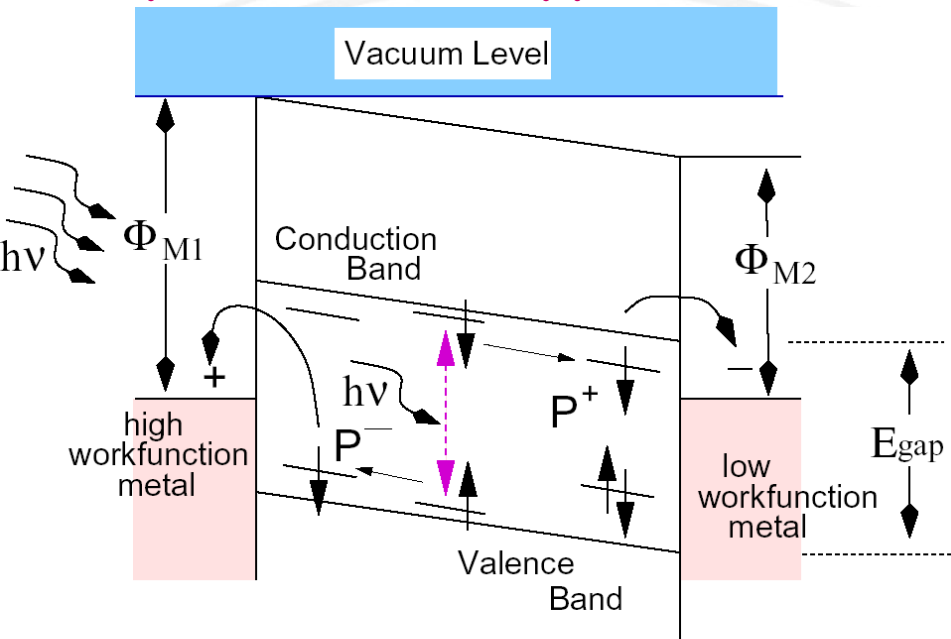


→ Kullanılan maske

# HOW DOES A OLED WORK?



# Separating electrons and holes: A prerequisite for photovoltaic applications

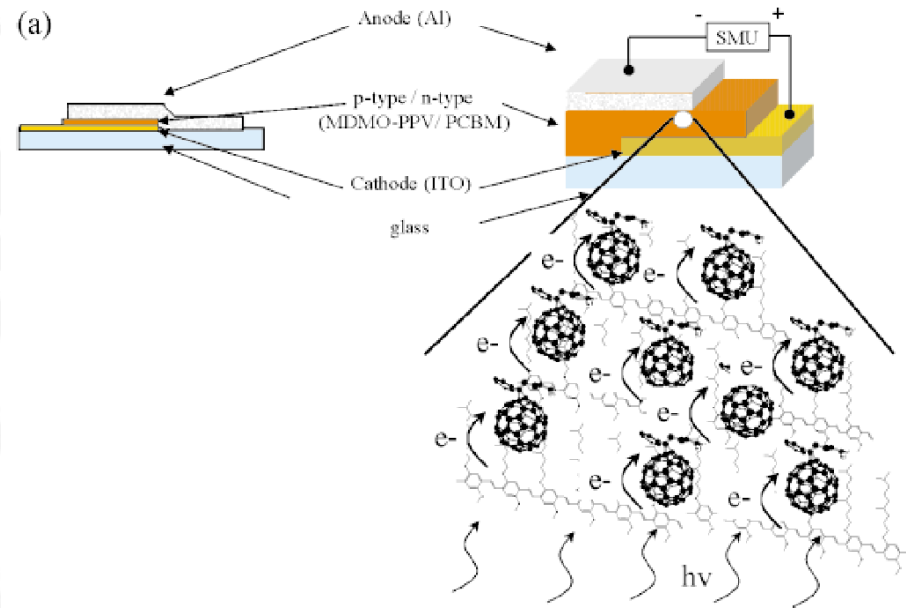


Charge generation process in a single layer device under short circuit conditions

Recombination of P+ and P- reduces device efficiency

From: Christoph J. Brabec, N. Serdar Sariciftci, and Jan C. Hummelen, *Advanced Functional Materials* **11** (2001).

## Blending C<sub>60</sub> and π-conjugated polymer



Nearly 100% electron transfer to the C<sub>60</sub>

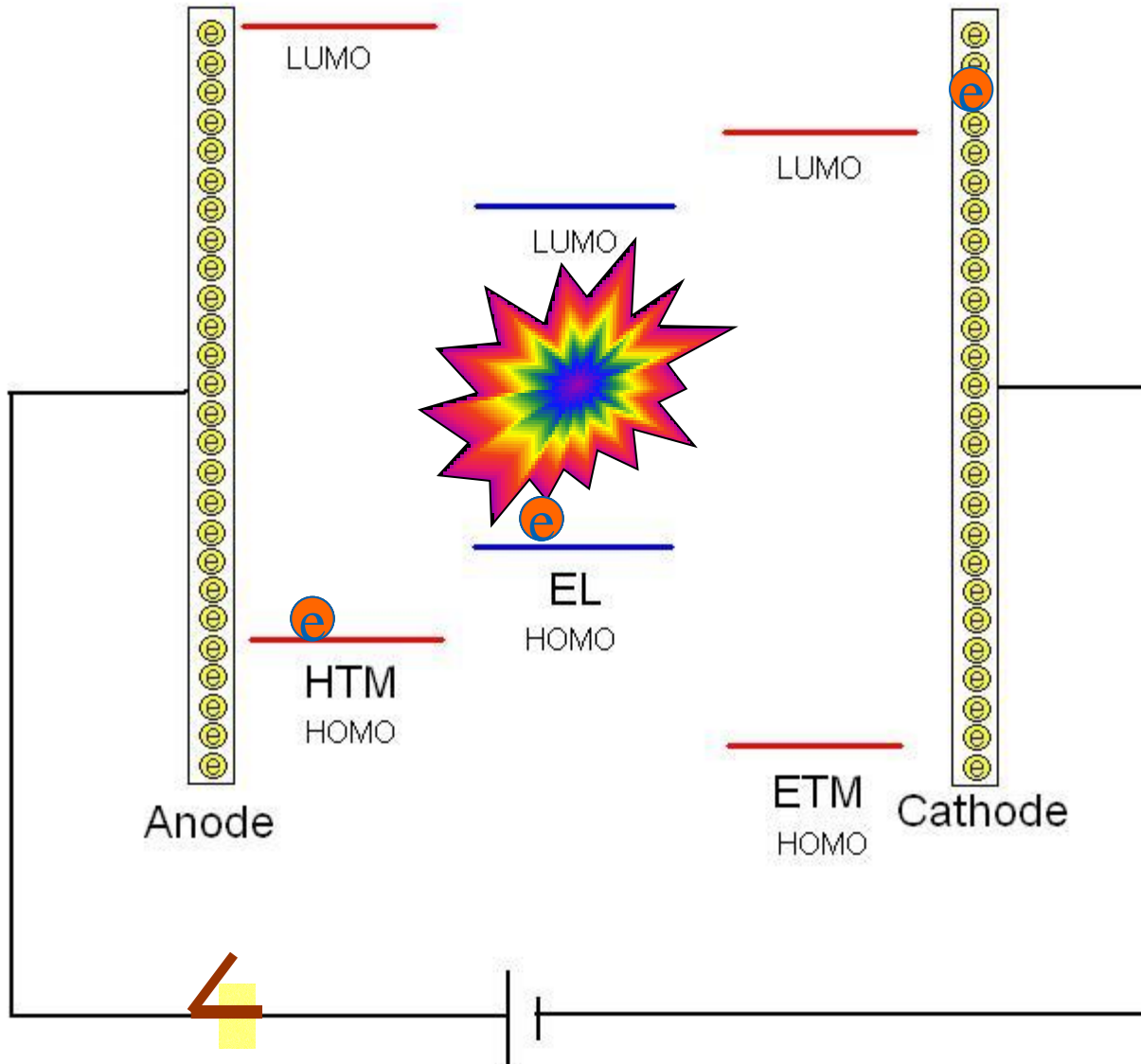
Because of bipolaron BP<sup>2+</sup> formation minimal back transfer

Polymer has good hole mobilities

Design of interface and electron transport are bottle necks

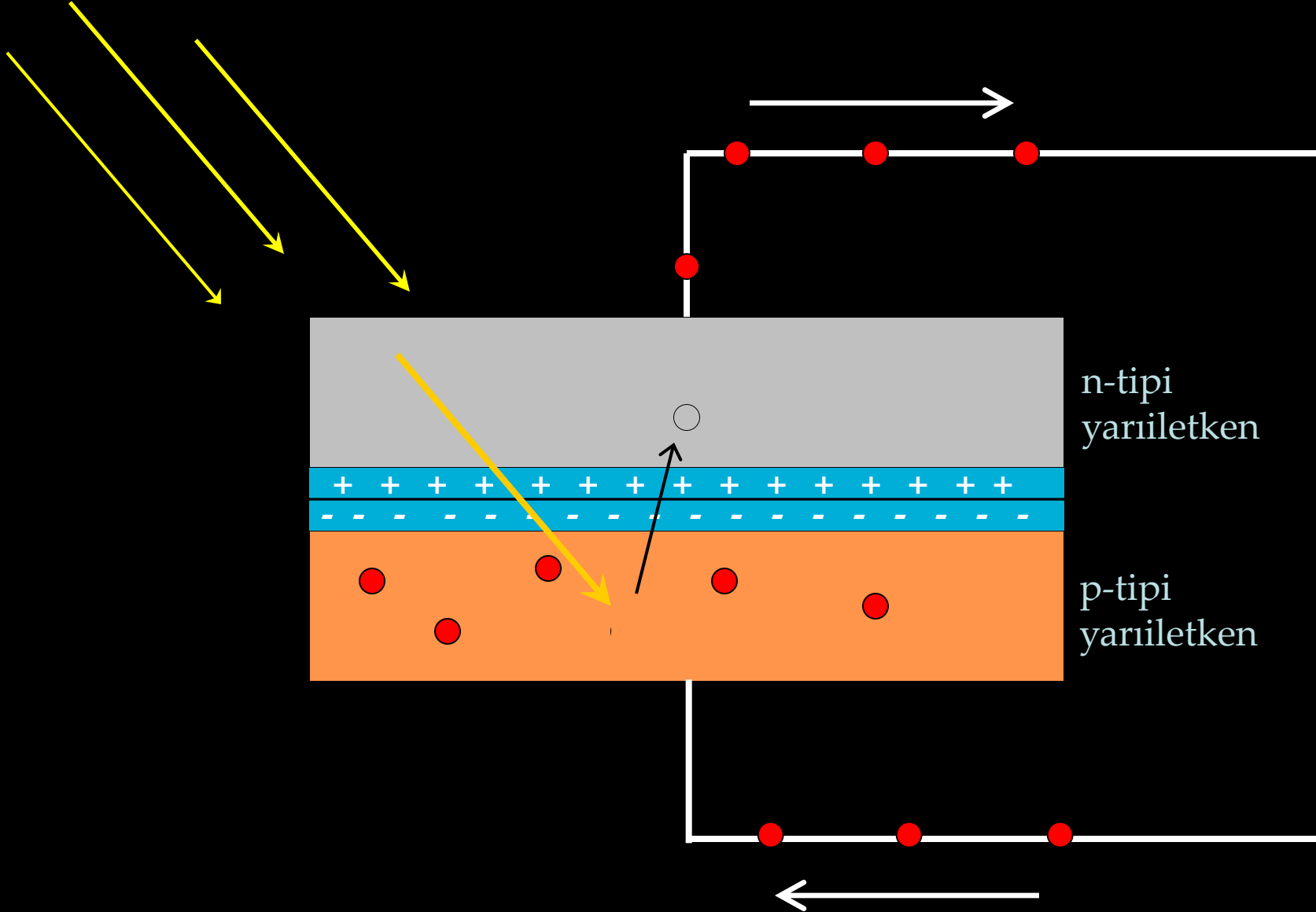
# HOW DOES AN OLED WORK?

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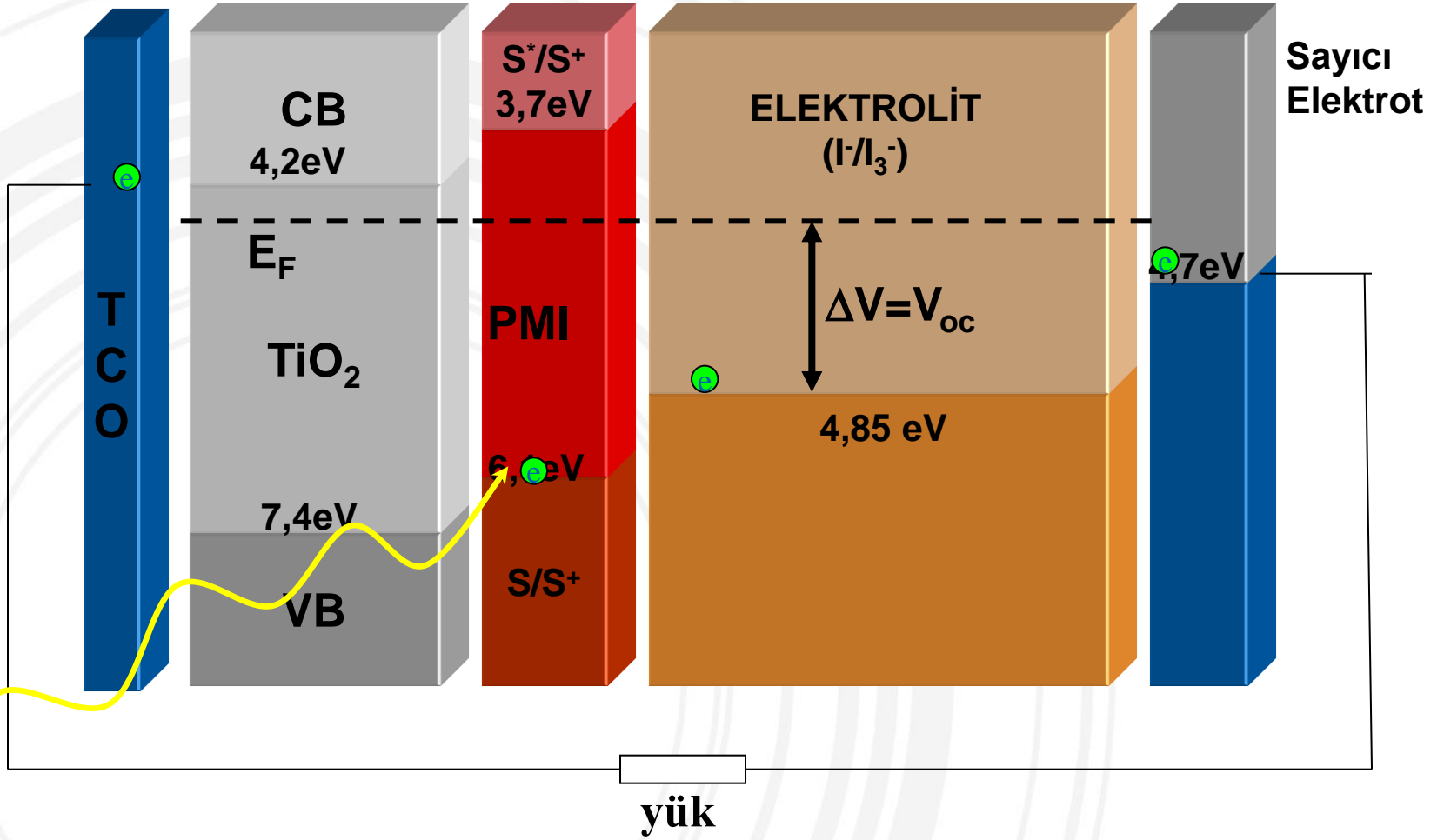




# Fotovoltaik Kayanağın Fiziği

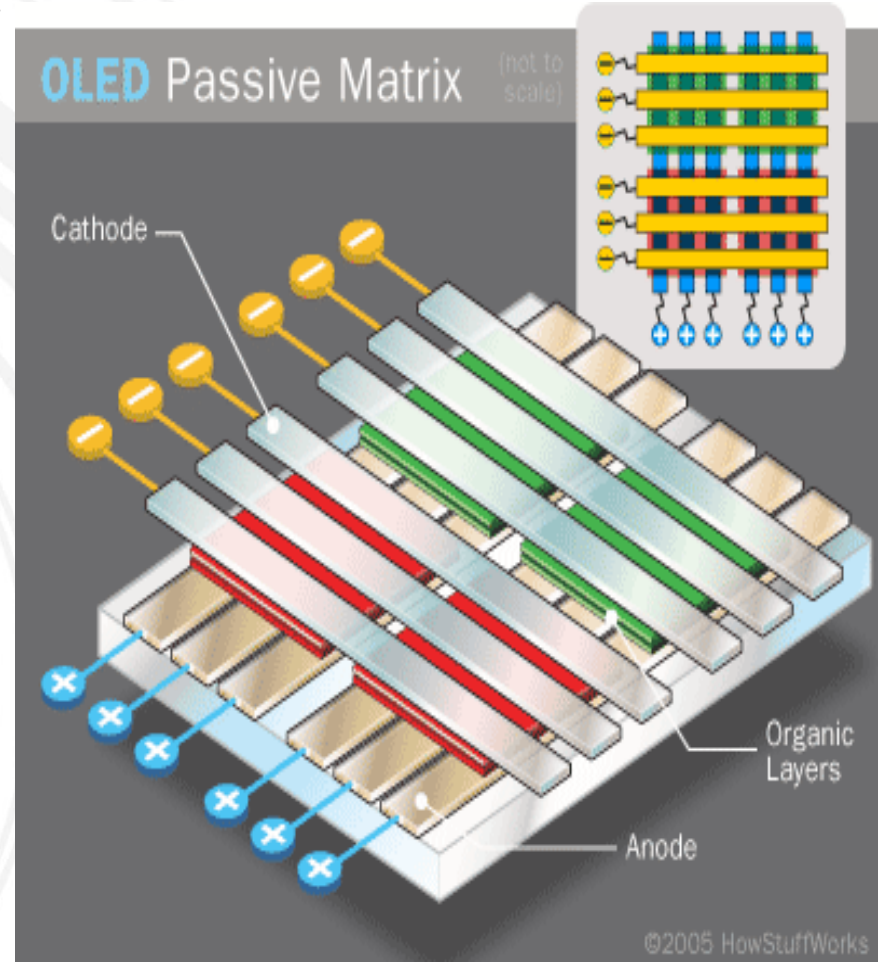


# ORGANİK BOYA ESASLI GÜNEŞ PİLİ NASIL ÇALIŞIYOR ?



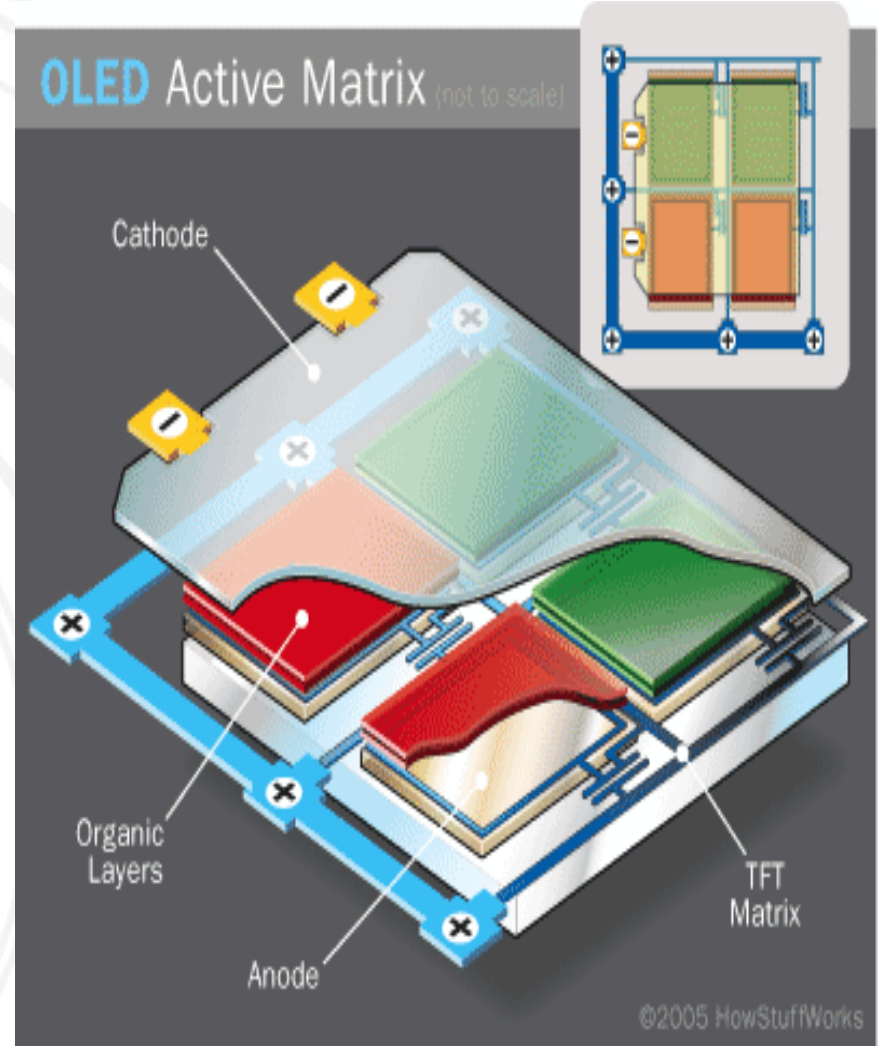
# 1- Pasif Matrix Oled (PMOLED)

- *Katot şeritlere organik tabakalara ve anot şeritlerine sahiptir.*
- *Anot şeritler katot şeritlere dikey ayarlanır. Katot ve anodun kesişme noktası, ışığın yayıldığı yer olan pikselleri meydana getirir.*
- *Dışardan gelen devre hangi piksellerin açık kalacağını ve hangi piksellerin kapalı kalacağını belirleyerek seçilmiş olan anot ve katot şeritlerini akıma katar.*
- PMOLED lerin yapılması kolaydır. Ancak OLEDlerin diğer çeşitlerinden daha fazla enerji tüketirler.
- bunun temel sebebi dış devre için gerekli olan güçtür. PMOLED ler en çok yazı ve şekillerde verimlidir.
- Daha çok mp3 oynatıcı, PDA lar ve cep telefonları gibi küçük ekranlı aletlerde kullanılır.



## 2- Aktif Matrix Oled (AMOLED)

- *İnce film transistor düzenlemesine sahiptir.*
- *Bu düzenleme hangi piksellerin görüntü vermek için açık kalacağını belirleyen devredir.*
- *AMOLED ler PMOLED lerden daha az güç tüketirler. Çünkü ince film transistor sergisi dışarıdan gelen devreden daha az güç gerektirir. Bu yüzden onlar büyük görüntüler için verimlidir.*
- *AMOLED ler aynı zamanda video için uyumlu daha hızlı canlandırma oranına sahiptir. AMOLED lerin en iyi kullanımı bilgisayar ekranlarında, dev ekran televizyonlarda, elektronik işaret ve reklam panolarındadır.*





A close-up photograph of a person's hand holding a small, rectangular yellow card. The card has the word "Teşekkürler" (Thank you) written on it in red, stylized Turkish script. The card is held between the thumb and index finger. On the left side of the card, a red cable and a black cable are plugged into a port. The background is a blurred ceiling with a grid of square light panels in shades of white and light green.

**Teşekkürler**