MULTILAYER STRUCTURES FOR OPTOELECTRONICS

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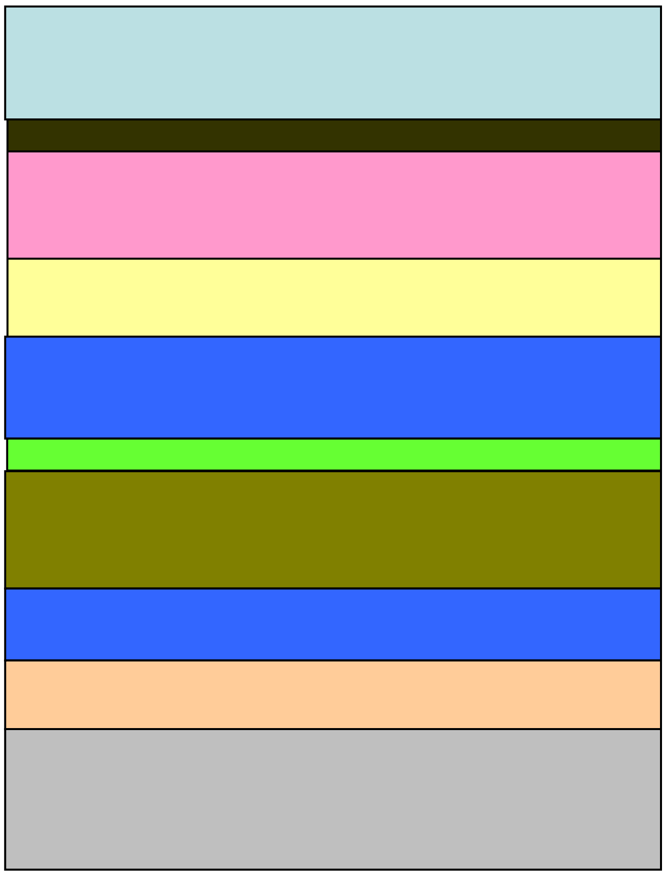
Printed Electronics

One of the ultimate goals in electronics is the ability to directly write electronic components and circuits. Advancing materials chemistry and developing print head technology is bringing this goal closer to reality. However, requiring the integration and optimization of many factors from print fluid formulation to print head design and print platform engineering to process design there remains some way to go.

In this presentation two multilayer optoelectronic organic systems which are ready for application of printing technologies are discussed.

Organic light-emitting diode (OLED)-structure

9 functional nano-sized layers



AL (cathode)

LiF (electron injection layer) **1нм**

Bphen (electron transport layer) **20нм**

BCP (hole blocking layer) **8нм**

DPVBi (light-emitting layer) **20нм**

NPD (electron blocking layer) **7нм**

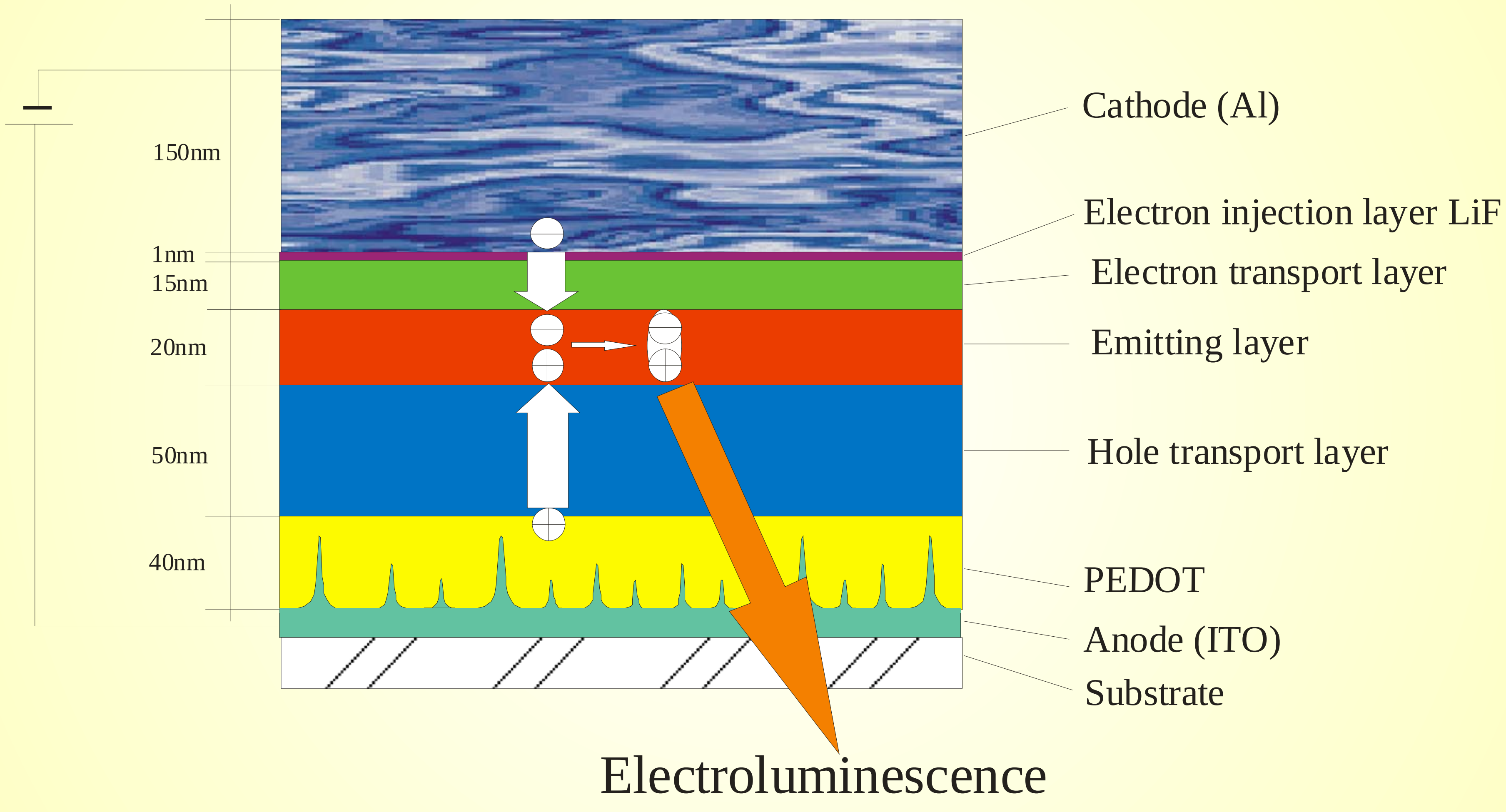
2-TNATA (hole transport layer) **40нм**

CuPc (hole injection layer) **5нм**

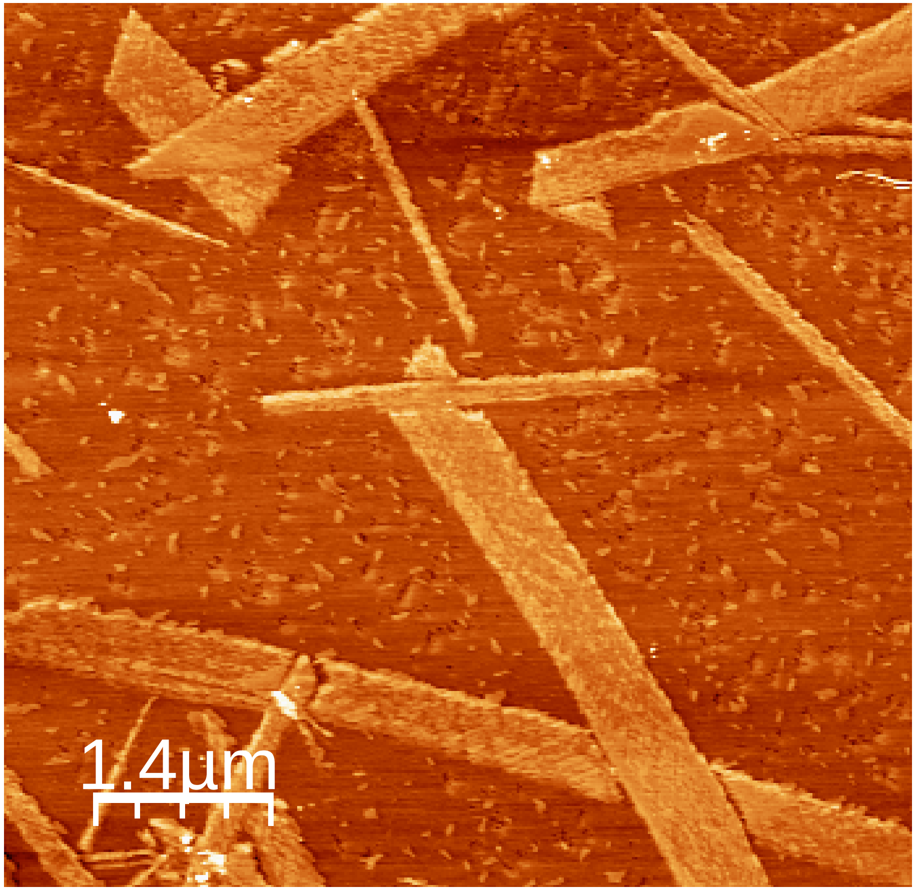
ITO (anode)

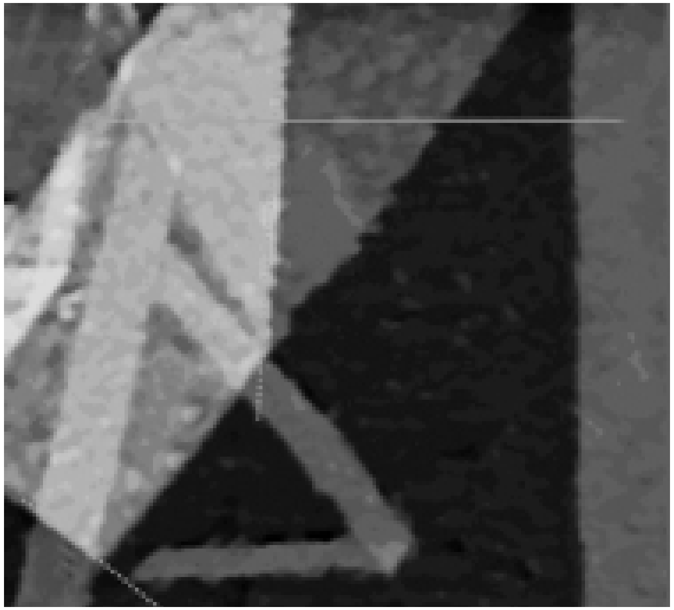
Glass (substrate)

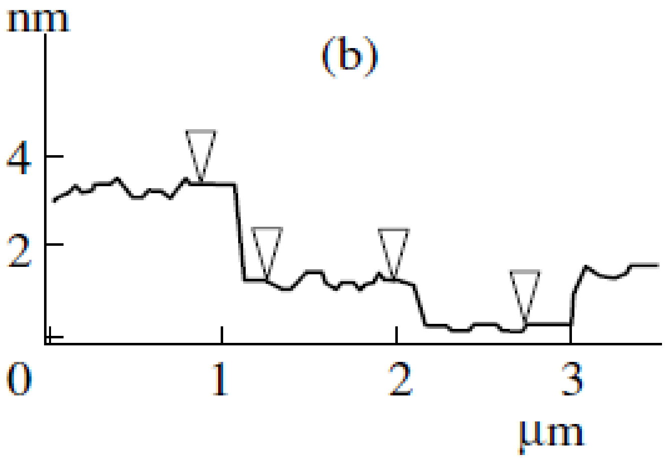
Electroluminescence in OLED structure



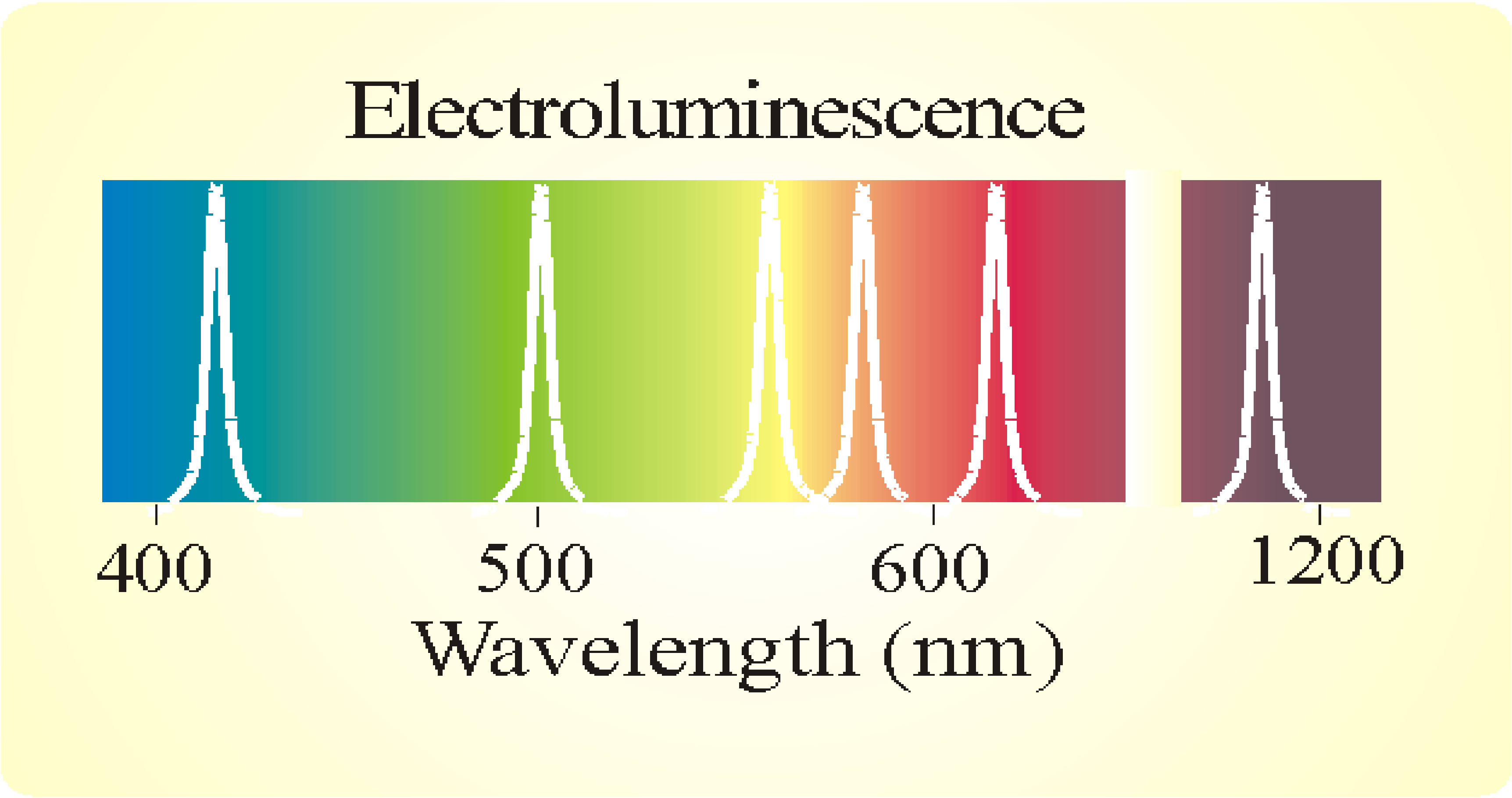
AFM images of J-aggregates of cyanine dye





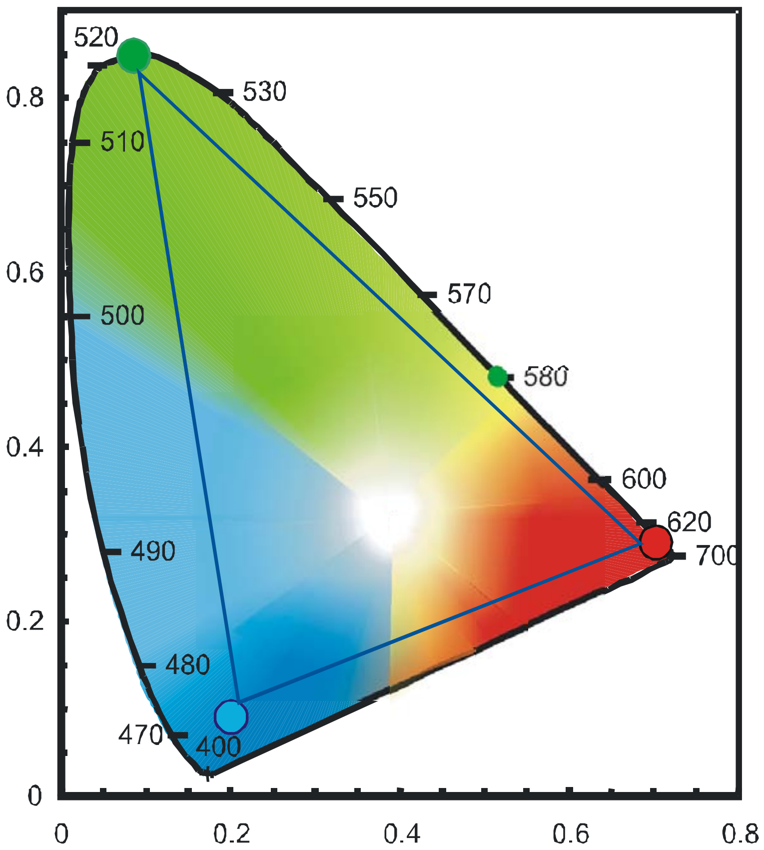


Polymer nanocomposites based on J-aggregates of cynine dyes



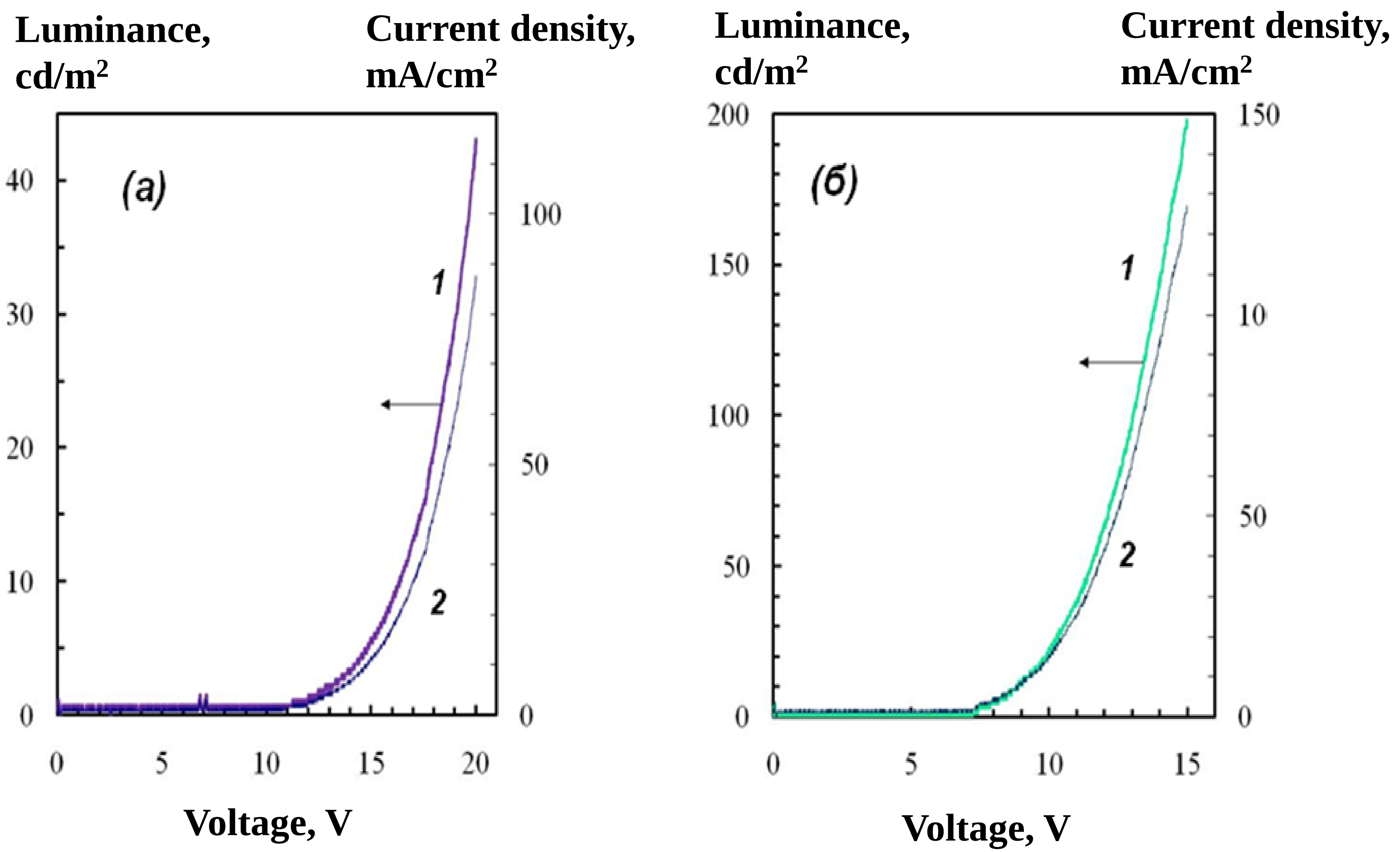
CIE CHROMATICITY DIAGRAM

Electroluminescence of cyanine dye J-aggregates



- Red – cyanine dye containing sulfur heteroatom
- Green – cyanine dye containing oxygen heteroatom
- Blue – cyanine dye in water-soluble polyaniline matrix

Electroluminescent characteristics of organic light-emitting diodes

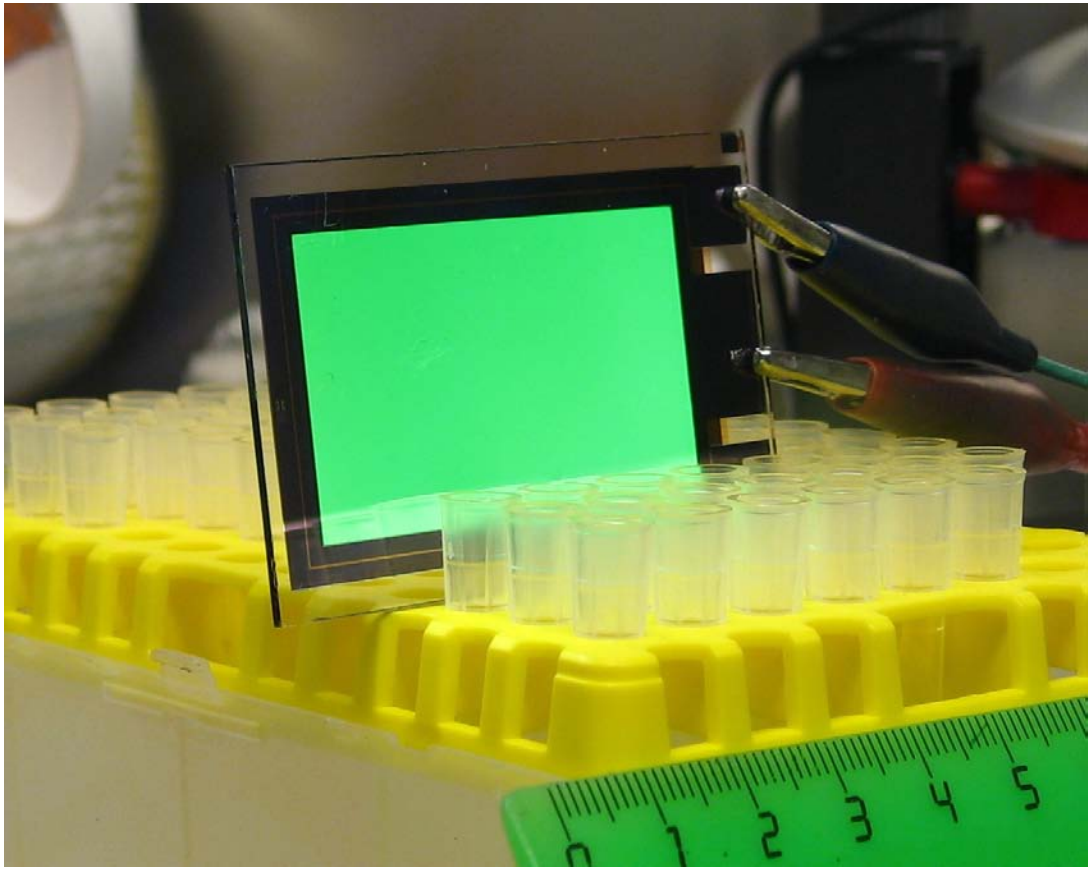


(a) – blue OLED and *(б)* – green OLED

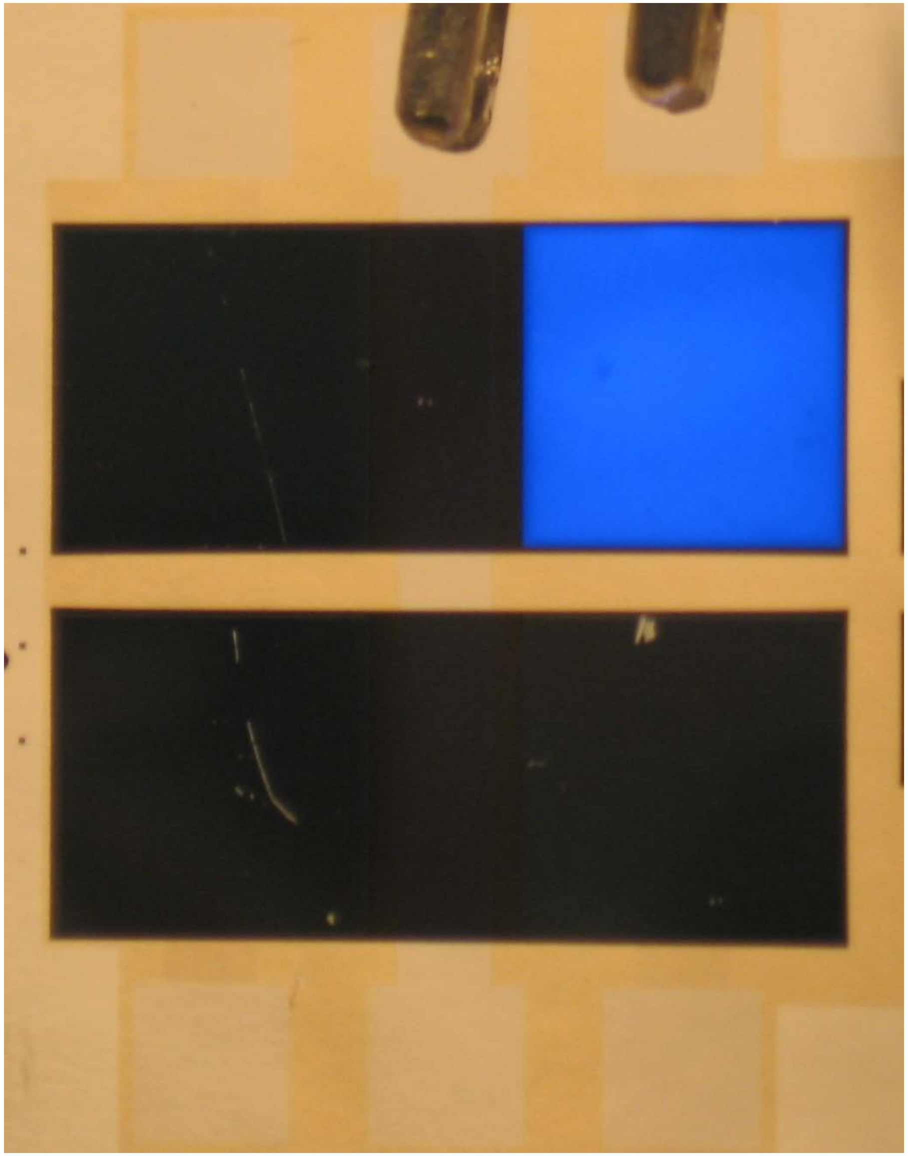
G

OLED-structure with diagonal 5 cm

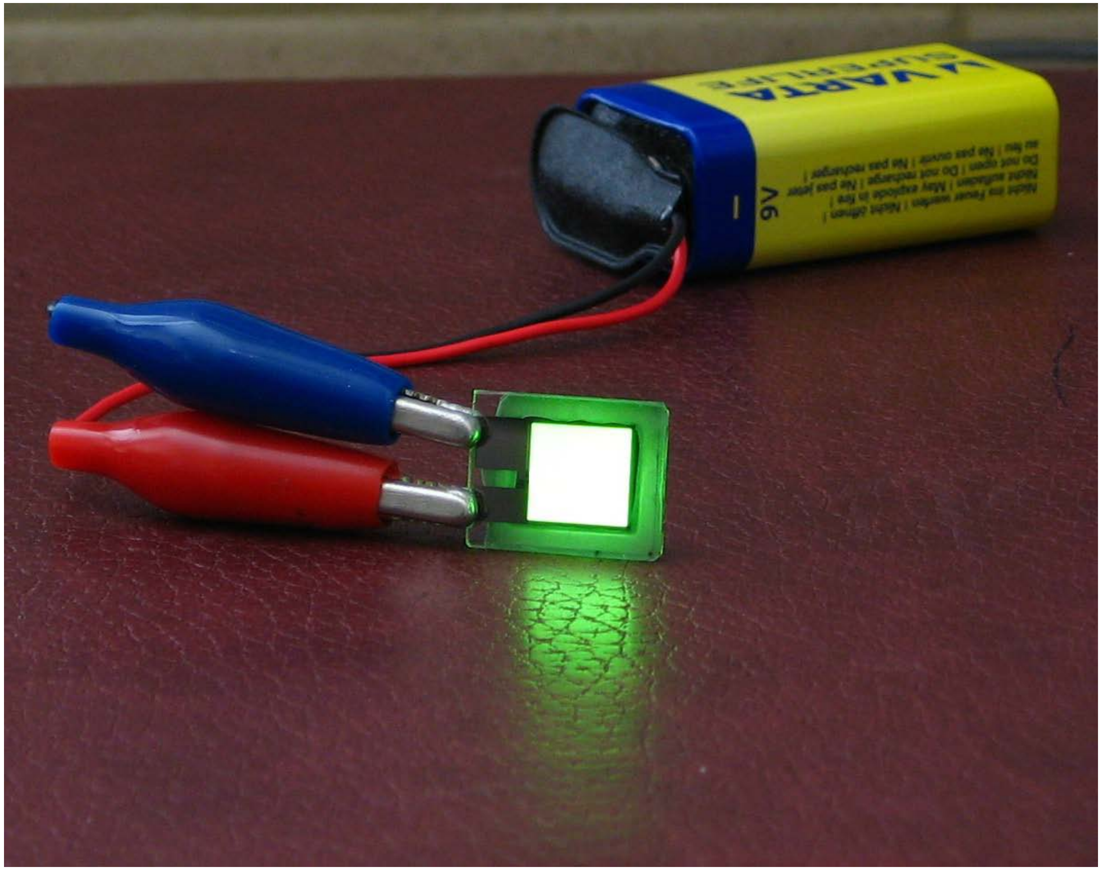
Coordinates: X = 0.302, Y = 0.605



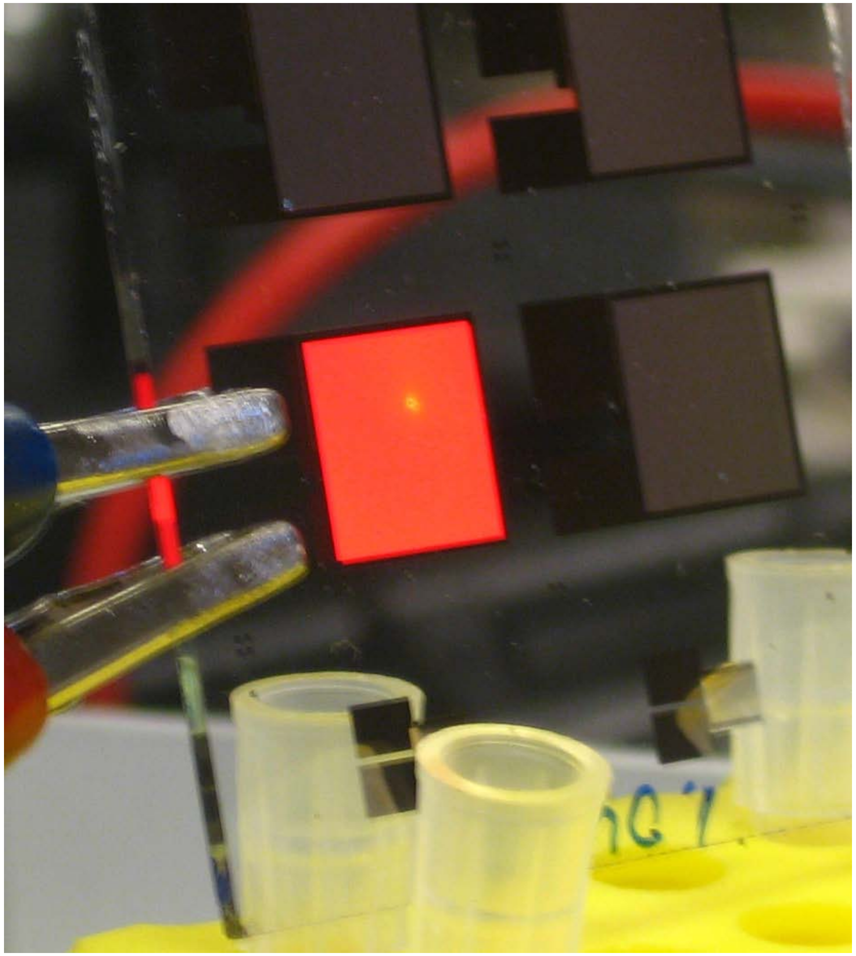
B



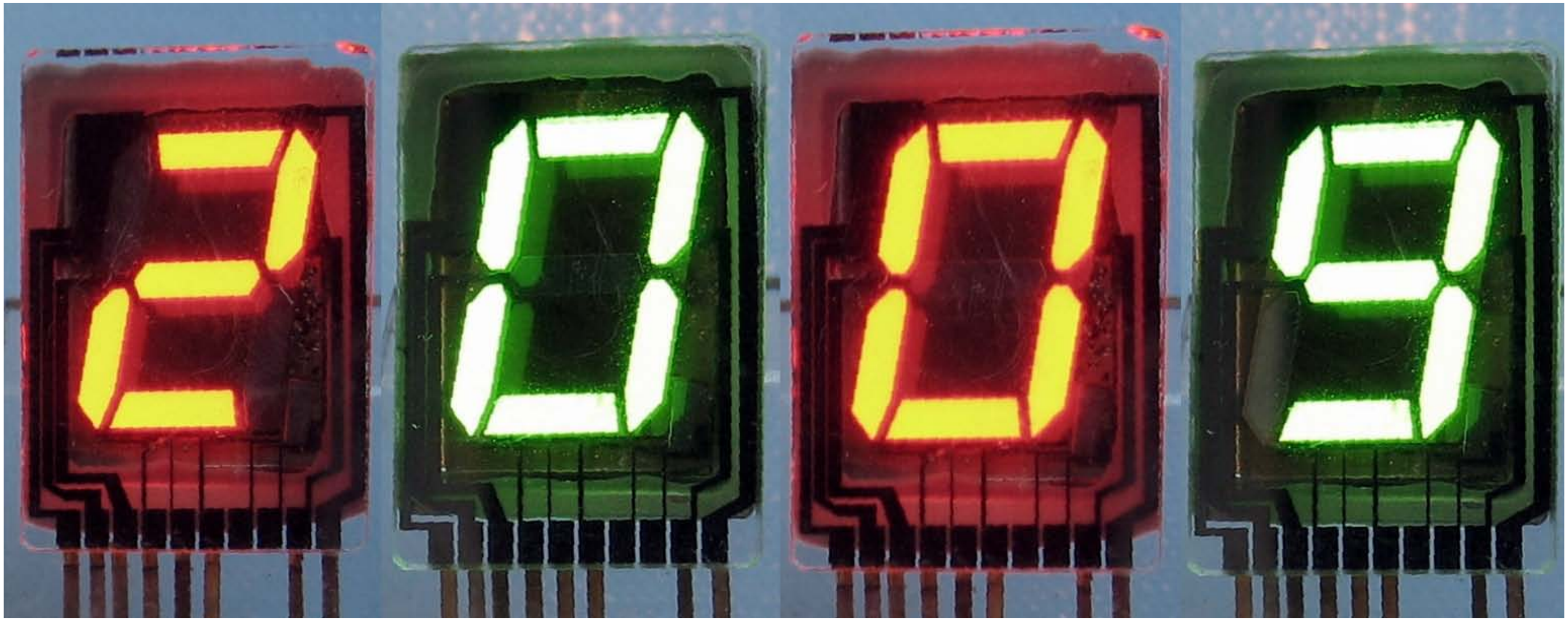
W



R



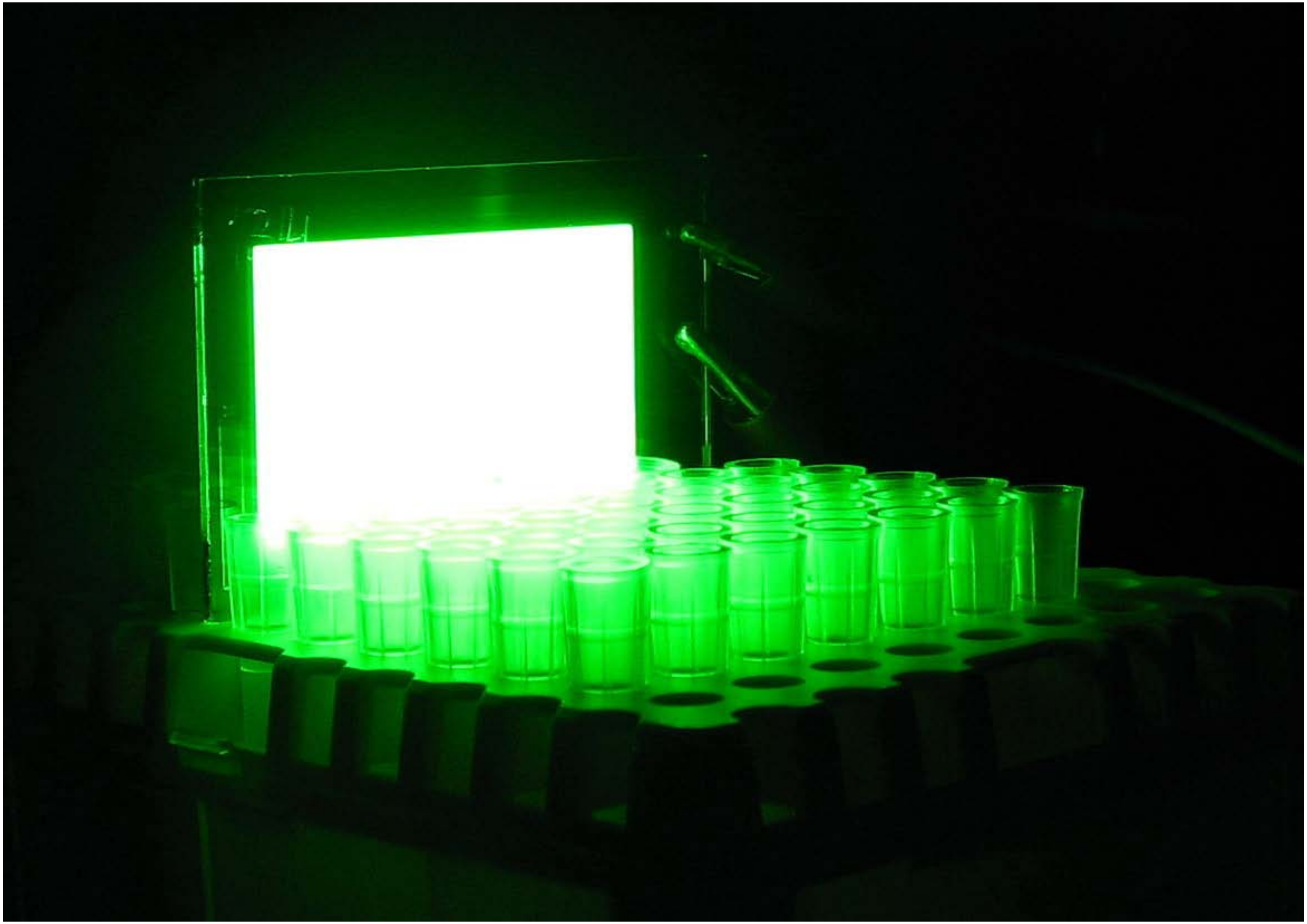
SEGMENTED DIGITAL IMAGE



W

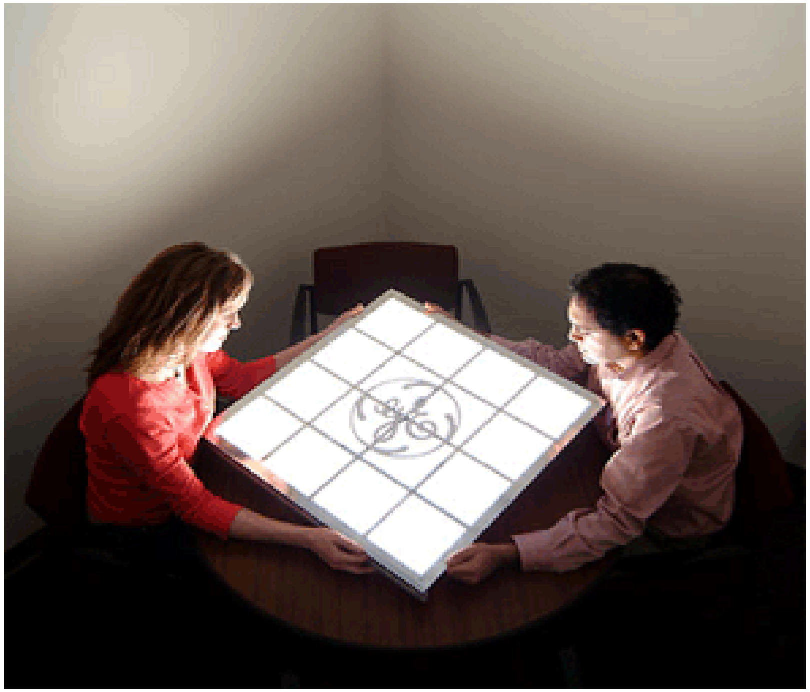
OLED-structure with diagonal 10 cm

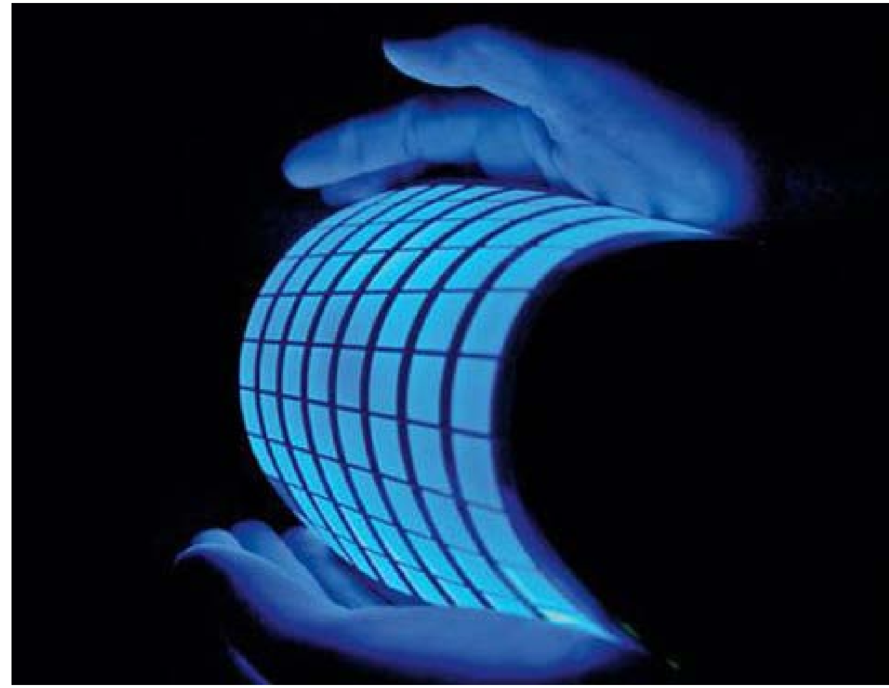
Efficiency 60 lm/W, luminance 900 cd/m²

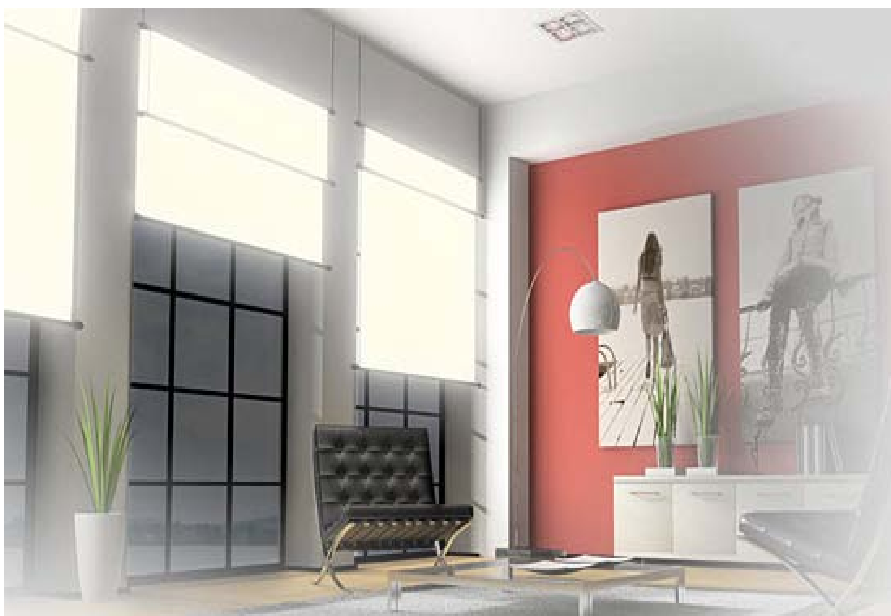


In usual incandescent lamps light is generated due to heating of metallic filament within the glass balloon. Therefore energy is emitted mainly in the form of heat (infra red radiation) and at best 12% in the form of light. OLEDs allow to increase this efficiency up to 75%.

EXAMPLES OF OLED PANEL EMPLOYMENT

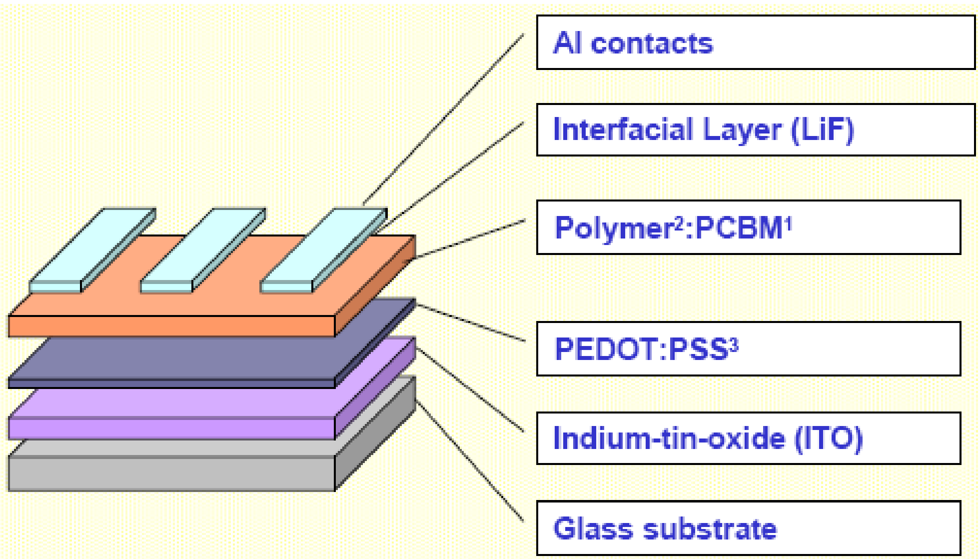




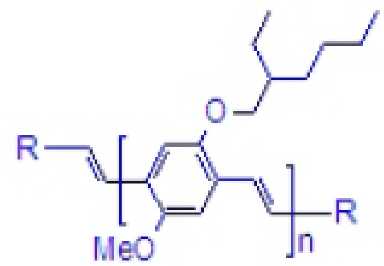




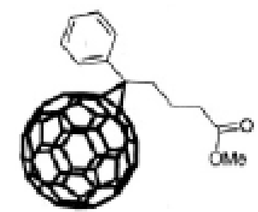

STRUCTURE OF POLYMER SOLAR CELL



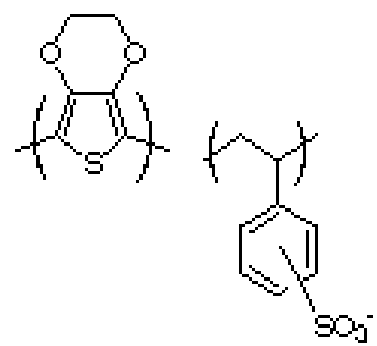
MEH-PPV



PCBM



PEDOT:PSS



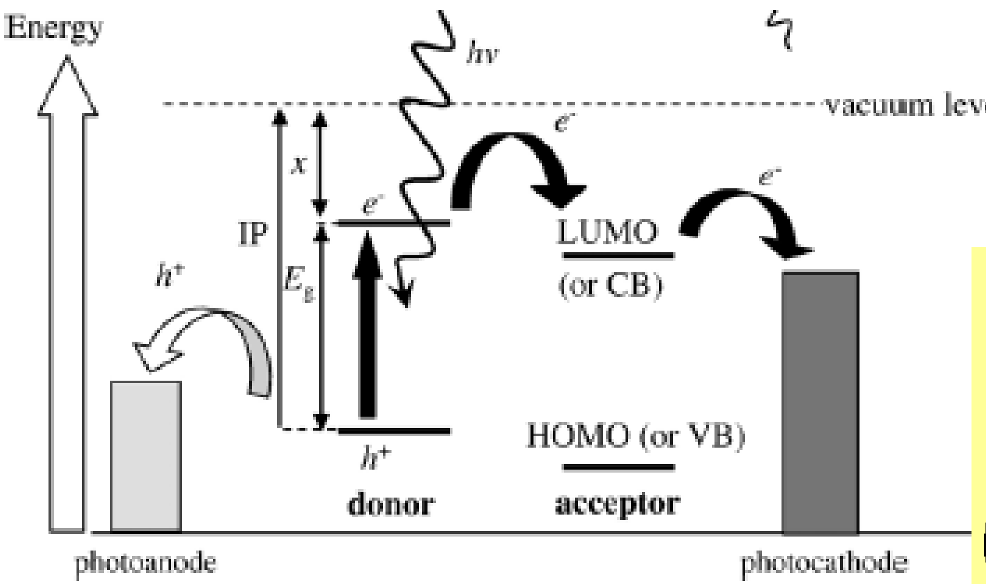
1 **PCBM – Phenyl-C61-butiric acid methyl ester – electron acceptor**

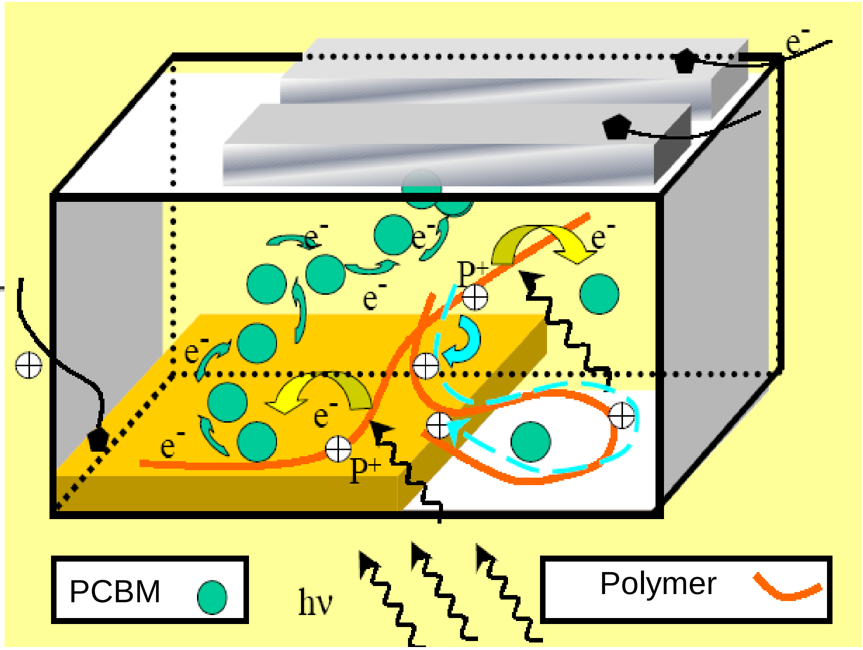
2 **MEH-PPV – Poly[5-(2’-ethyl-hexyloxy) phenylene vinylene], photo-conducting polymer – electron donor**

3 **PEDOT:PSS – Poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate – electro-conducting polymer**

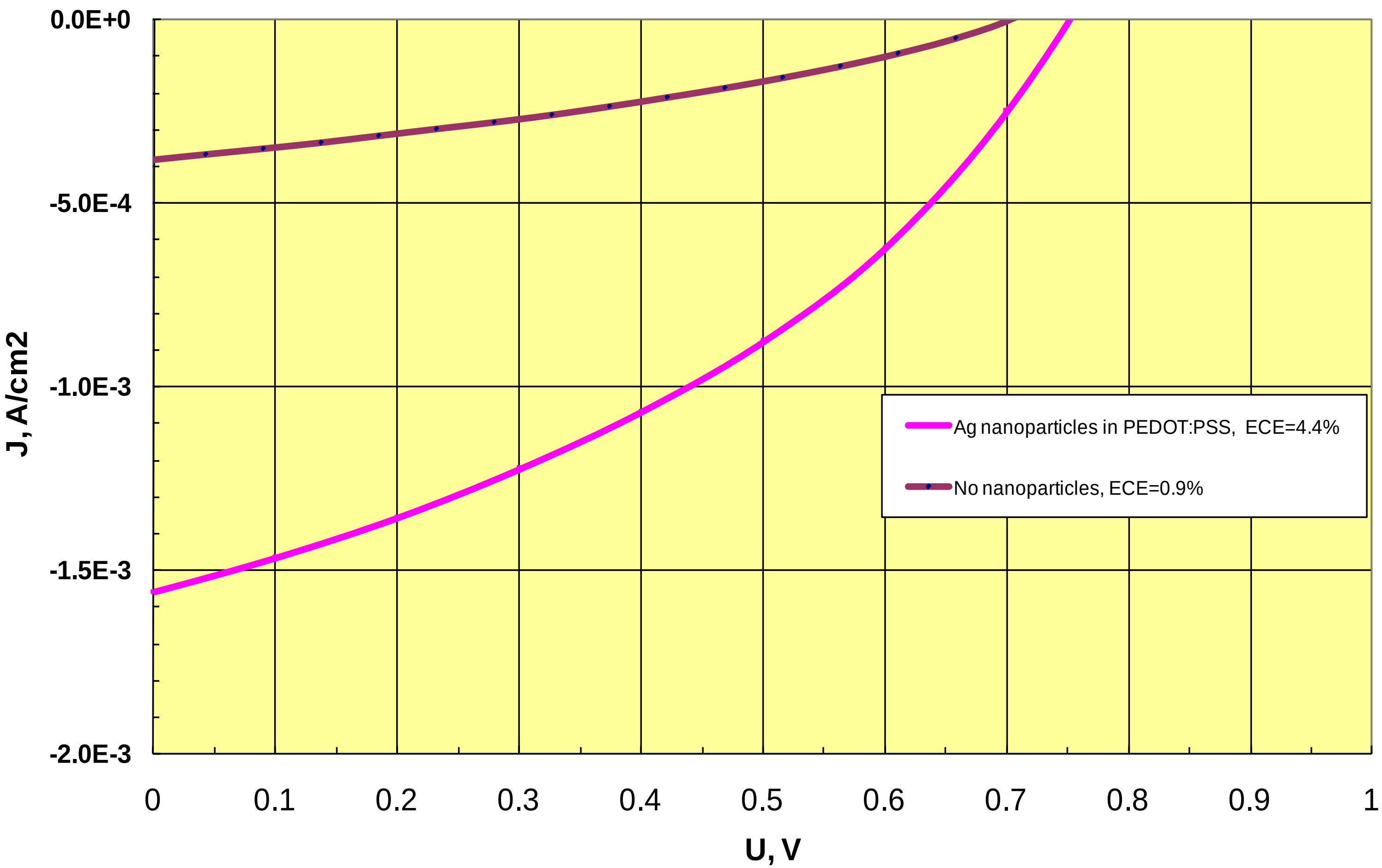
The layers thickness is within 0.8 - 200 nm

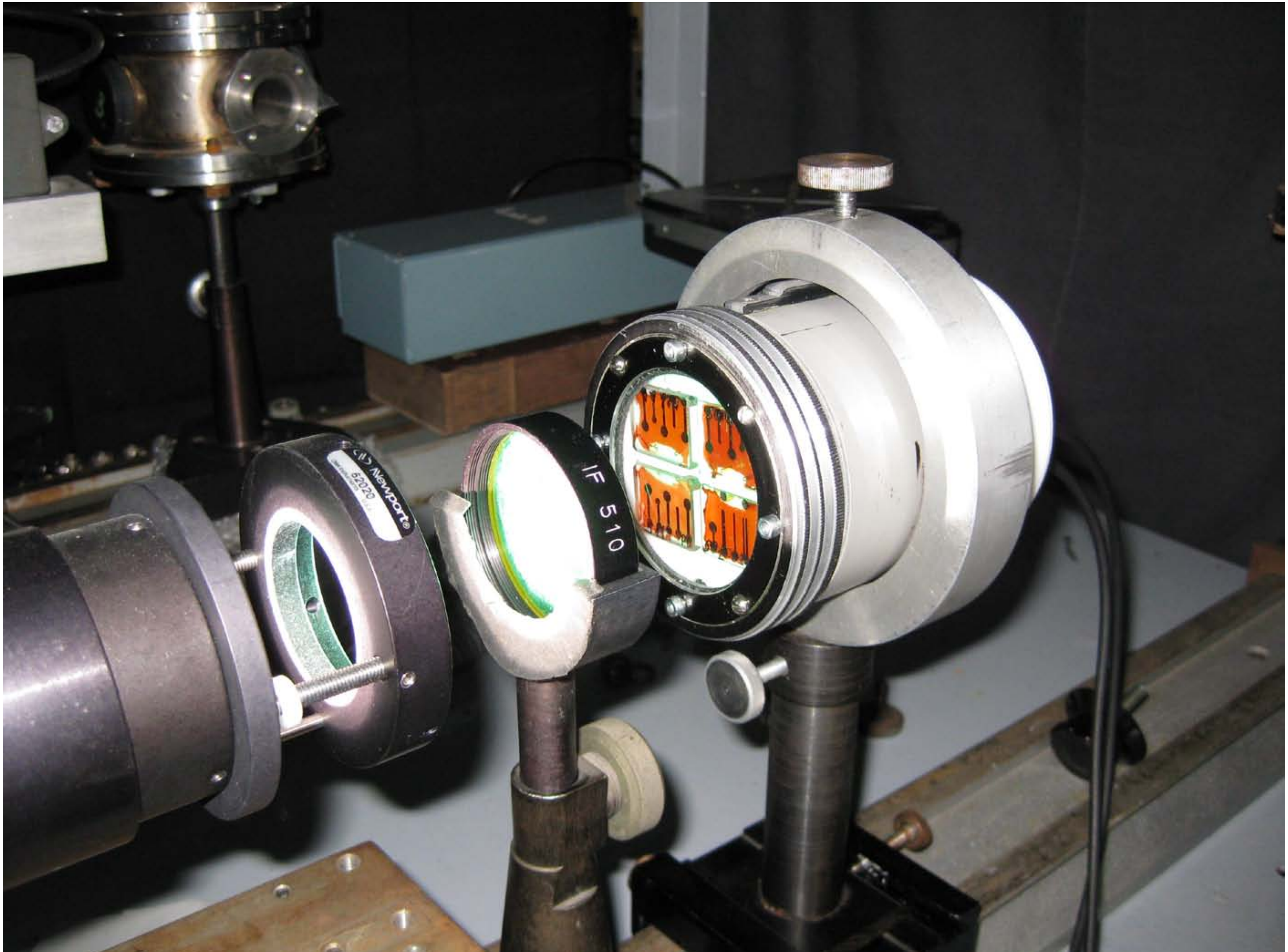
Donor-Acceptor Bulk Heterojunction (BHJ)





V-I CHARAKTERISTICS OF SOLAR CELLS ITO/PEDOT:PSS/MEH-PPV:PCBM(1:5)/LiF/Al (top curve) AND THE SAME STRUCTURE CONTAINING NANO-PARTICLES Ag (d~30 нм) IN THE LAYER PEDOT:PSS (low curve); Efficiency equals 0,9% и 4.4%, accordingly.

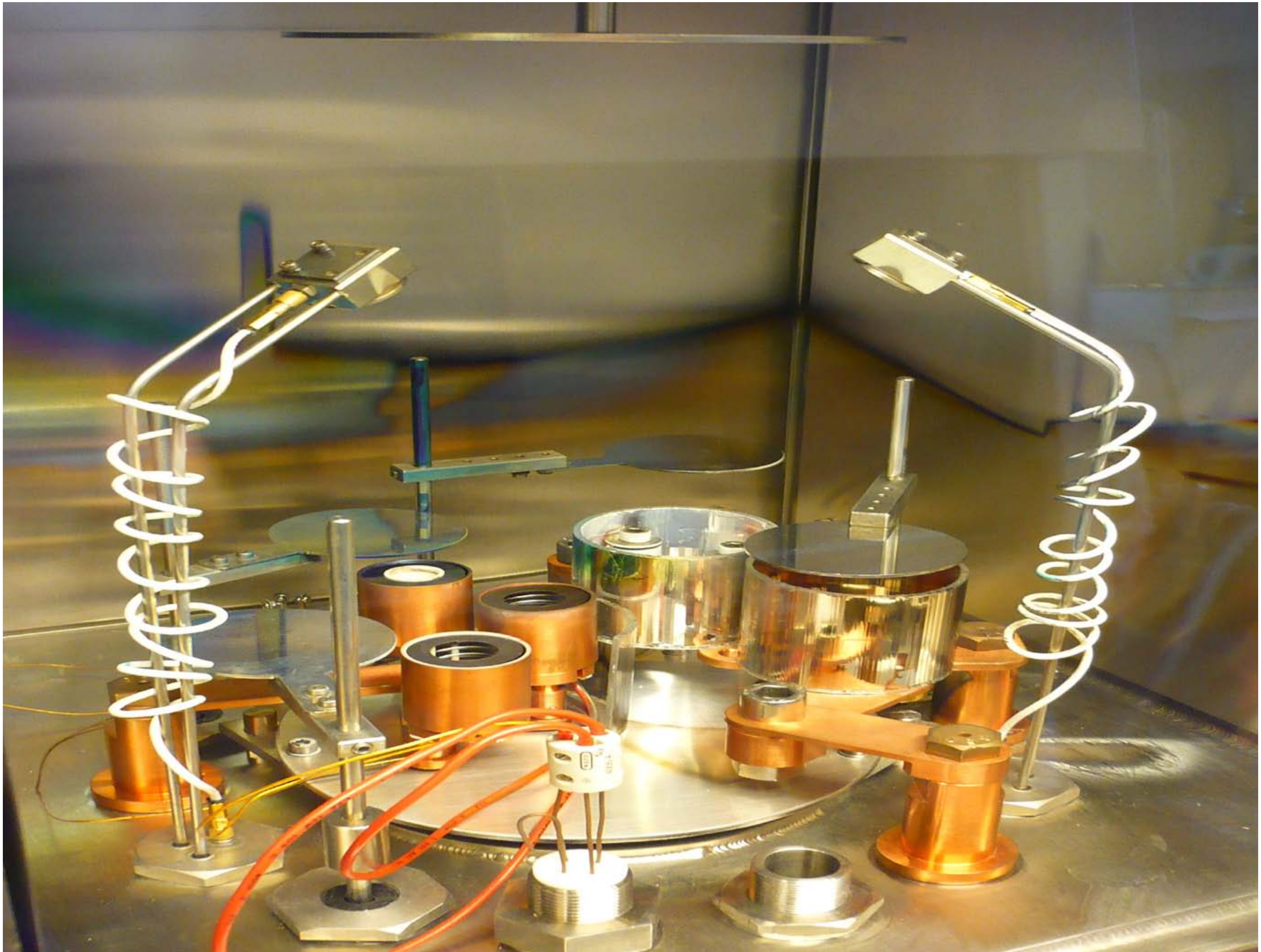



Newport
IF 510

Preparation and Characterization of Organic Optoelectronic Devices

Glove Box MBraun
Ar atmosphere/ Vacuum Unit

All layers of the presented devices can be prepared by printing technologies

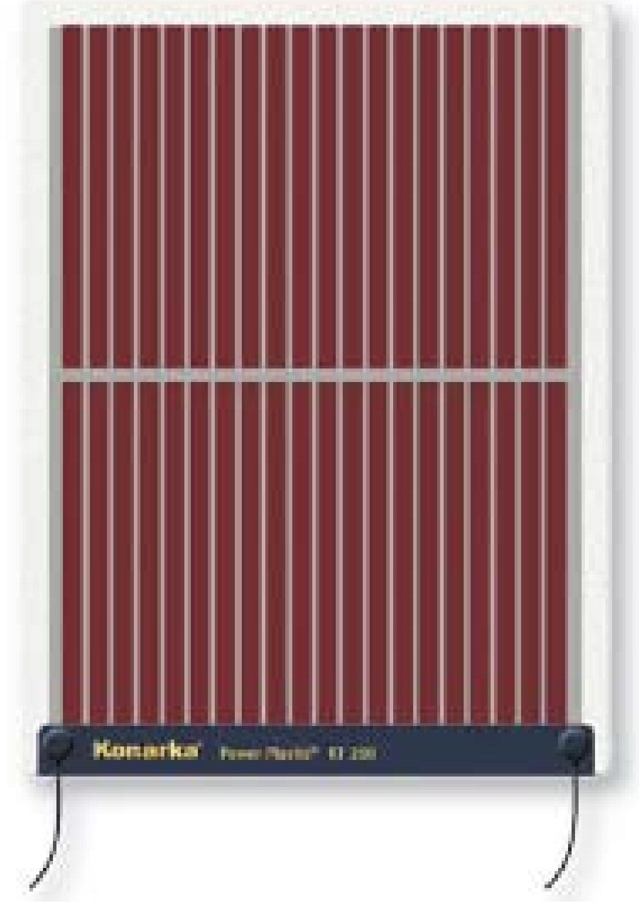


Konarka's solar panels
Output power range: 2W/8V … 26W/16V

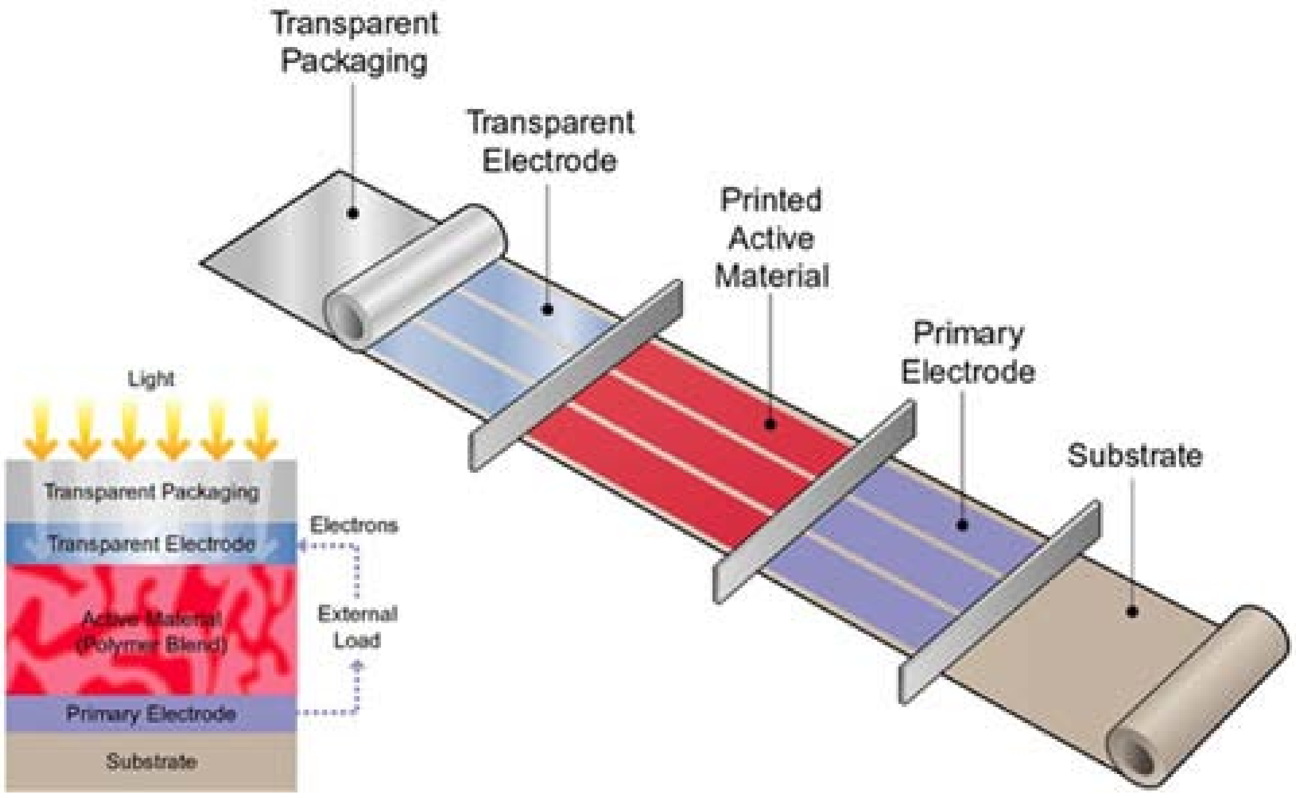
Construction Characteristics for 2W/8V panel:

• Dimensions:
Length: 464mm (18.3"),
Width: 352mm (13.8"),
Depth: 0.5mm (.020")
• Weight: 149g (5oz)
• Material thickness: 0.5mm+/-0.05mm
• Operating temperature range:
-20°C to 65°C
• Weatherproof materials
• User friendly design: easily mountable
• Laminate encapsulation:
high-light transmissive polymer

Efficiency ≈ 2%



Konarka Technologies, Inc.:
Roll to Roll Manufacturing Process



Using inkjet printing as a manufacturing method

MANUFACTURING (at least partially, low-cost devices)

- electronics: passive components, circuit manufacturing
- MEMS devices
- displays
- RFID components
- solar cells
- optics: micro lenses
- diagnostics: DNA synthesis, medical research and development
- medical science: dosing, sorting, DNA and tissue preparation, laser surgery
- CTP plate making
- smell generation

SUITABLE JETTING MATERIALS

- solders and epoxies
- optical polymers
- conductive and semi-conductive polymers
- metal particles and metal nano-particles
- transparent conductors
- dielectric and resistor materials
- ferrite materials
- reagents
- optical absorbents
- biomedical materials

Printers for inkjet printed electronics

2000

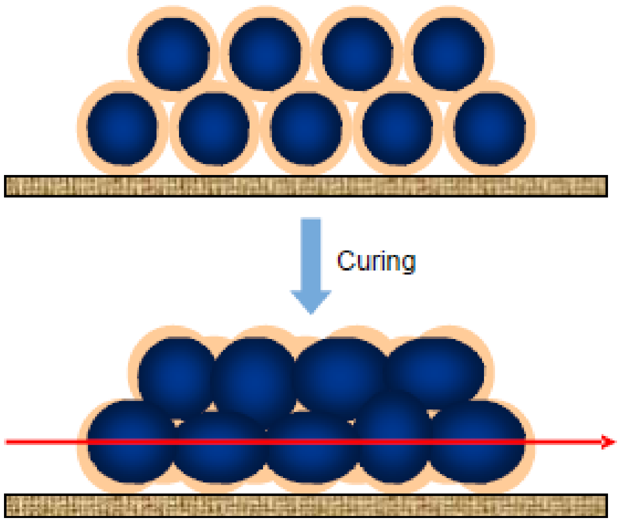
2005

From 20 cm x 20 cm printing area to 2m x 2 m

Technologies enabling inkjet printed electronics

- Nano technology
  - nano-particles enable small particles required in inkjet inks
- Conductive polymers
  - conductive materials suitable for ink components
- Development of inkjet printheads
  - increasing speed, jetting reliability and accuracy
  - decreasing drop size

Series application of layers produces multilayer optoelectronic device



Principle of nano-particles at inkjet printed metal layers

THANK YOU!