

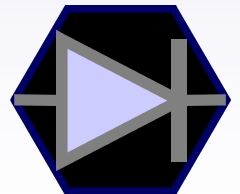
Organic Light-emitting Diodes Based on Heterocyclic Polymers

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OLED Applications

Pioneer Car Electronics Organic EL



Car Radios

CD/DVD Players

Cellular Phones

Instrumentation

Background Illumination

LCD Displays

OLED Applications

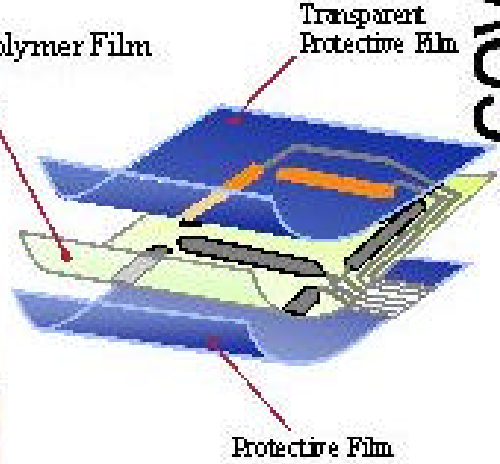
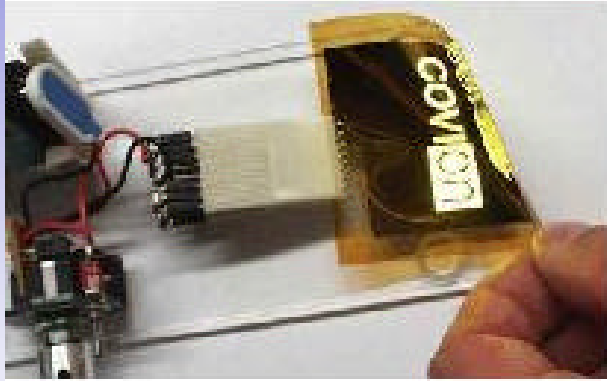
LEP- Non Planar Displays

Light Emitting Polymer Film

Transparent Protective Film

Protective Film

COVION



Covion- flexible displays

Introduction: 8 | 14 + 13

OLED Applications

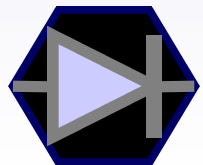


W. Riess, S. Alvarado et al.
IBM Zürich Res. Lab.,
Rüschlikon, Switzerland

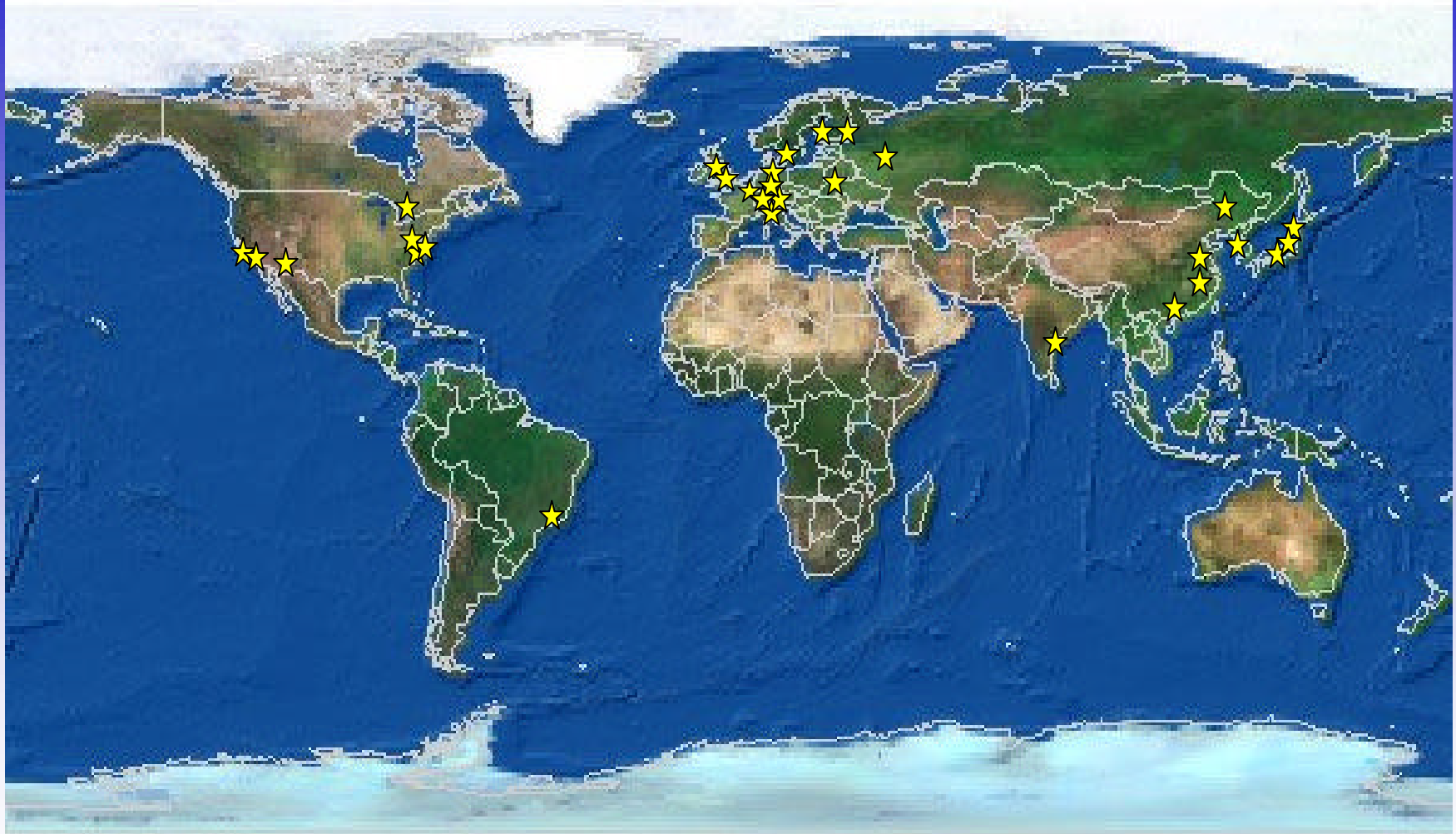


S. Schrader

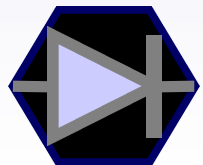
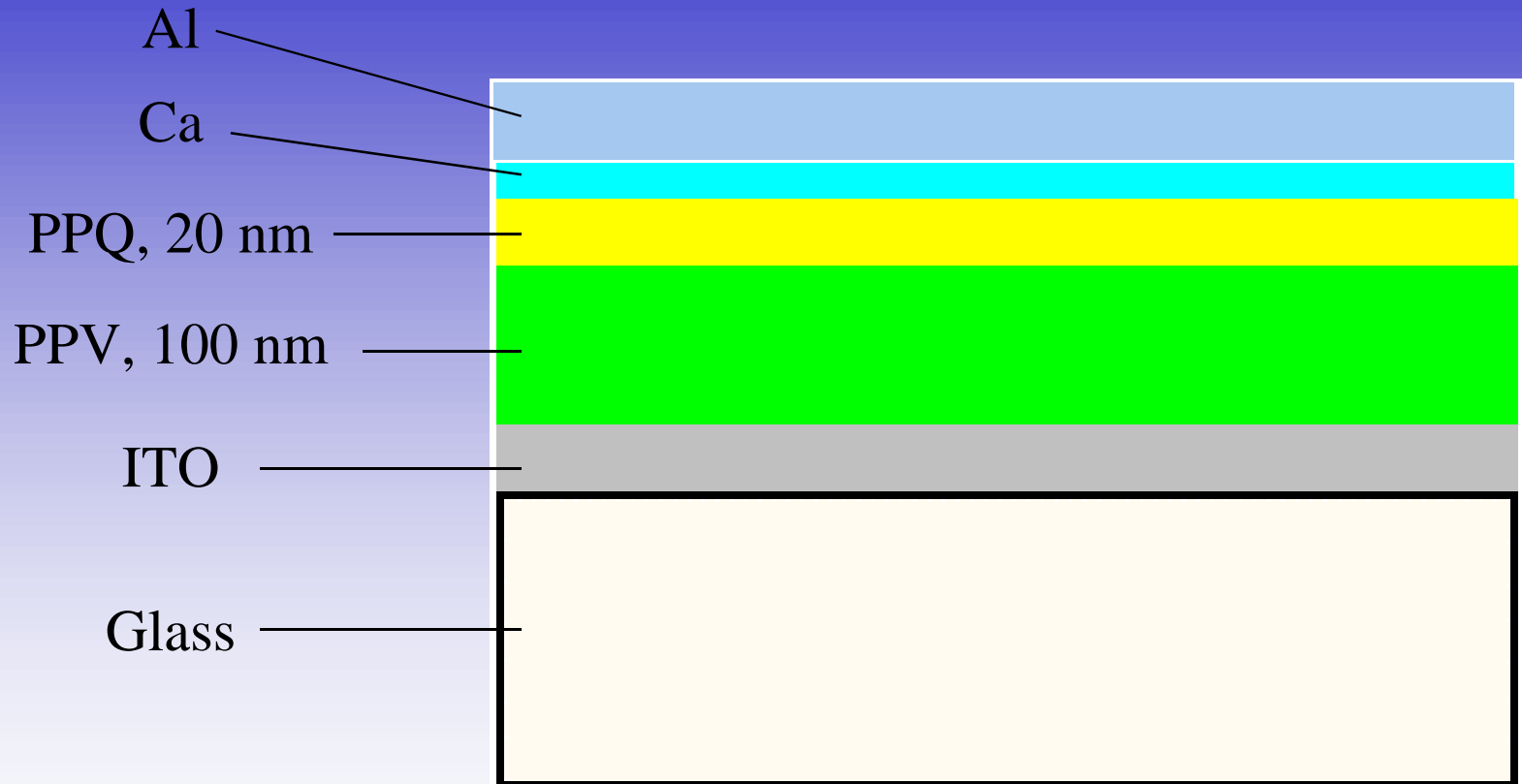
IBM Head Set



WORLD MAP OF OLED GROUPS

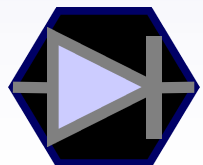


Device Structure



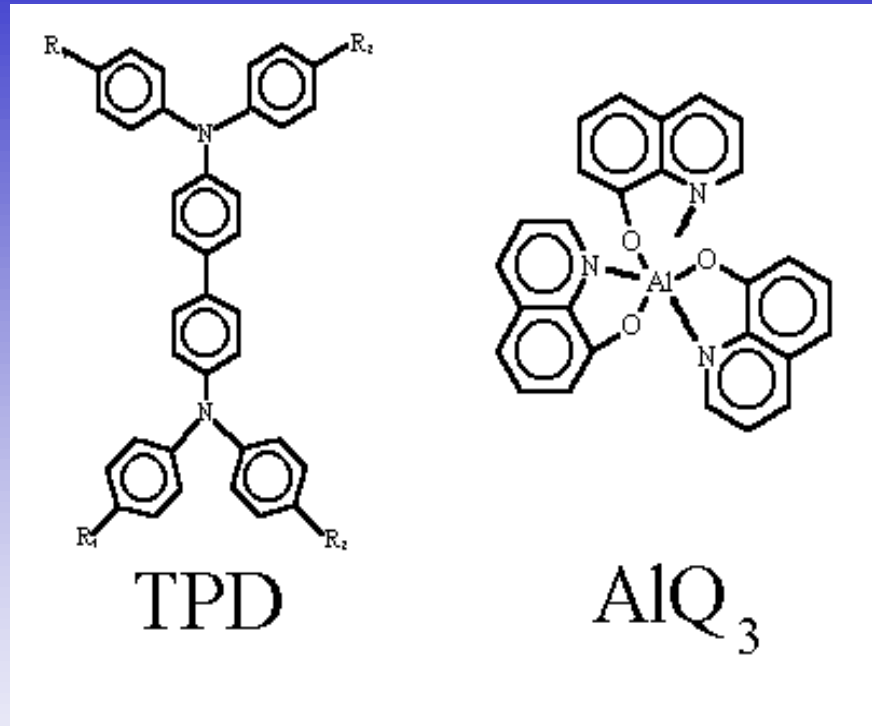
Sample Preparation

- ↓ Vacuum deposition of low-molecular organic compounds
- ↓ Vacuum deposition of reactive monomers and oligomers
- ↓ Casting from solution, doctor blading of soluble polymers or of precursor polymers
- ↓ Spincoating, Dipcoating
- ↓ Langmuir-Blodgett technique
- ↓ Deposition by self-assembly

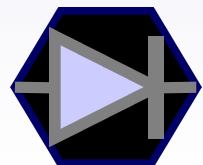


Hole Transporter

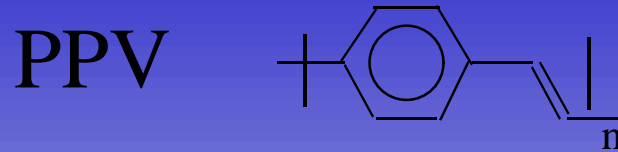
Electron Transporter



OLED Materials

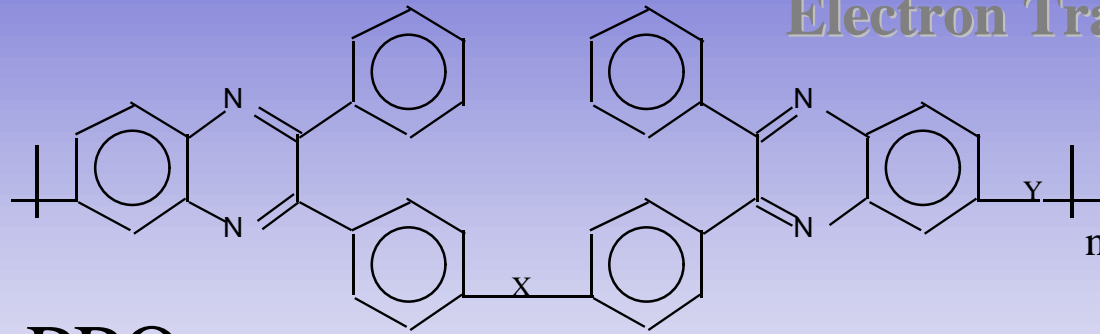


Hole Transporter



Polyparaphenylenevinylene

Electron Transporter



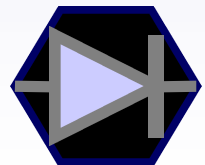
PPQ

Polyphenylquinoxaline

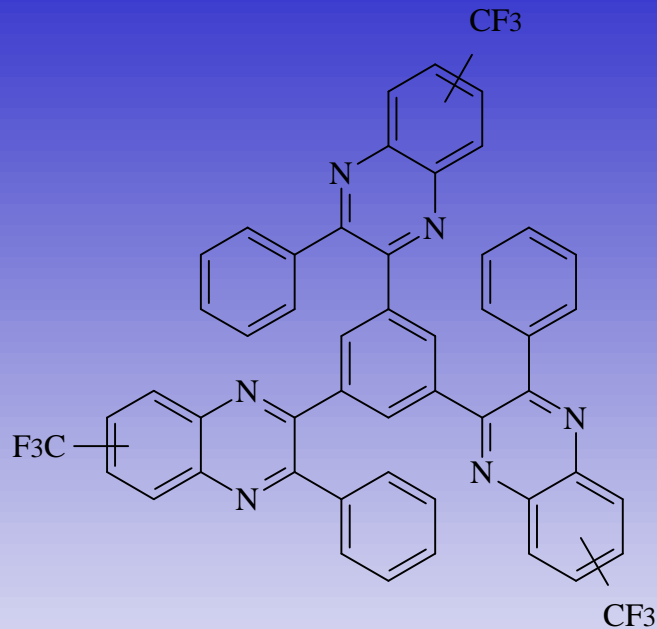
X = O, —

Y = O, —

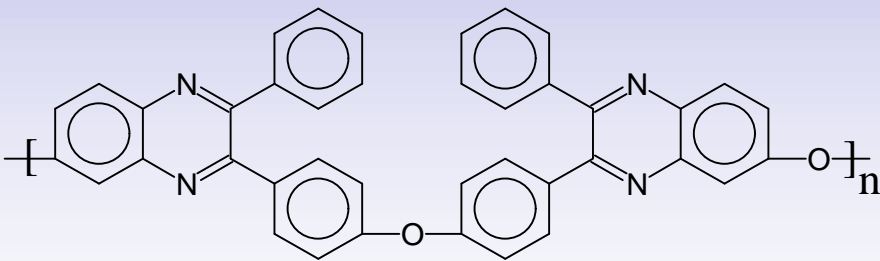
OLED Materials



Quinoxalines - Electron Transporting Materials

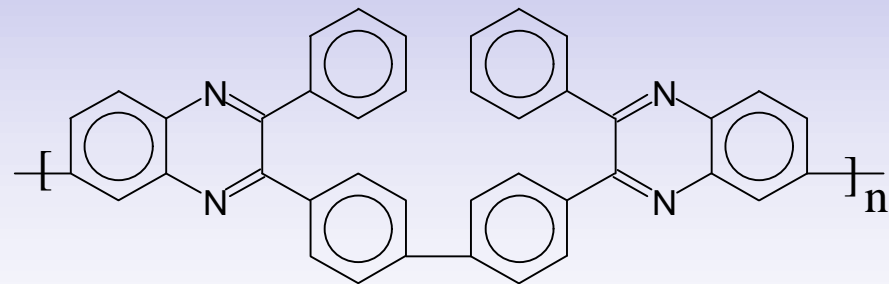


**TPQs, M. Jandke, P. Strohriegl,
Universität Bayreuth**

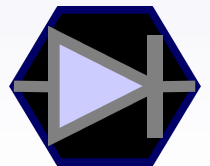


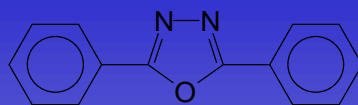
PPQ IIB

B. Falk, IDM



PPQ IA

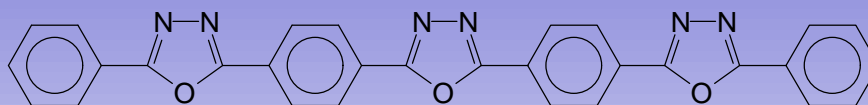




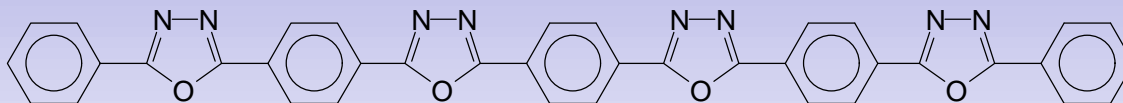
(a)



(b)



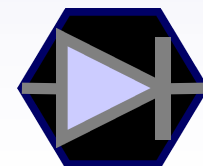
(c)

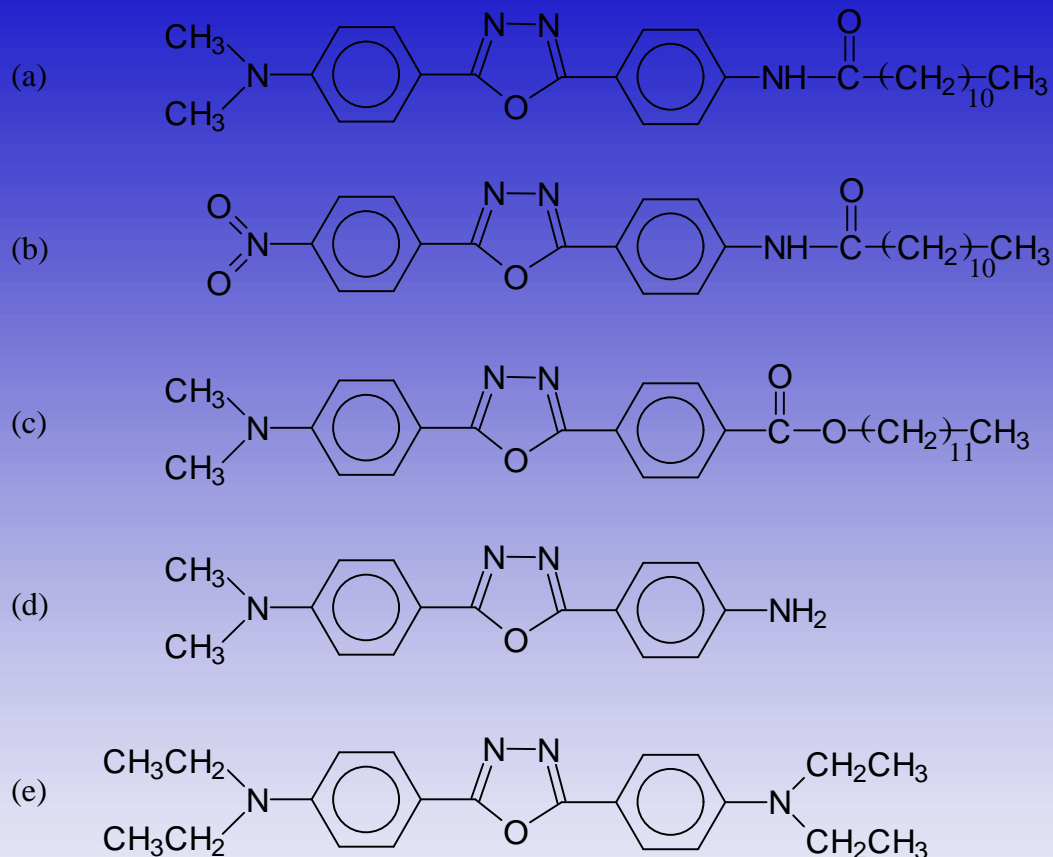


(d)

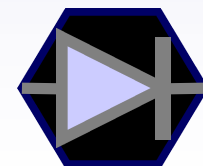
Chemical structures of phenyloxadiazole model compounds

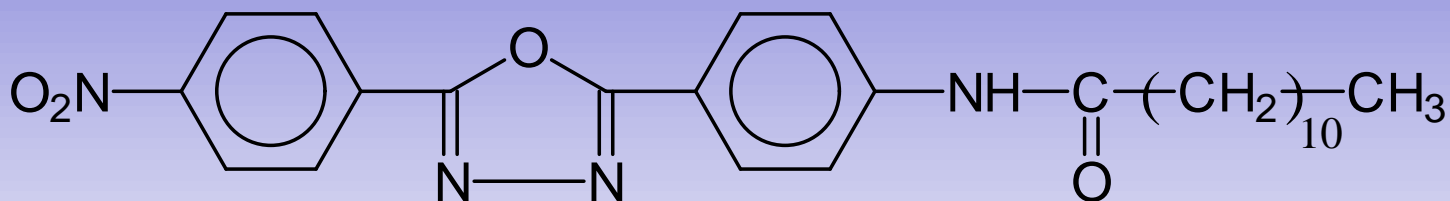
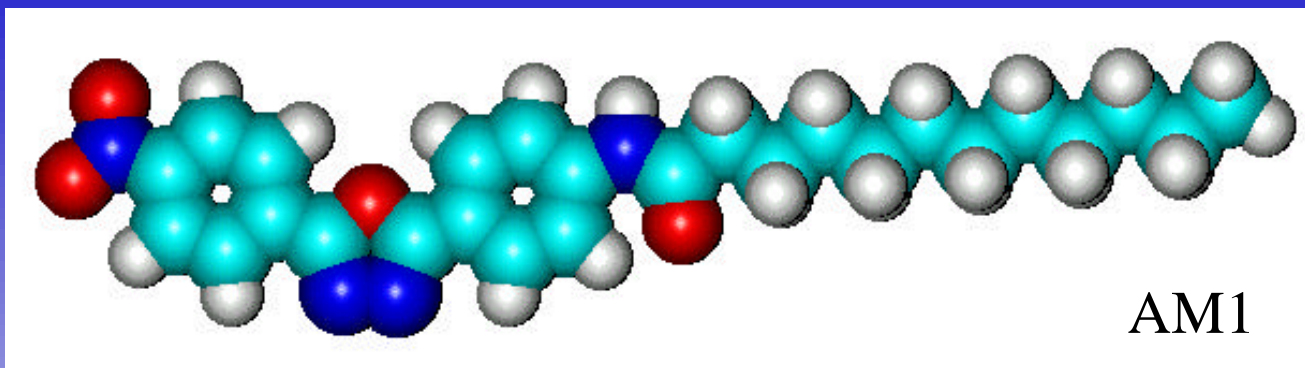
(a) 2,5-diphenyl-1,3,4-oxadiazole (POD-1), (b) POD-2, (c) POD-3, (d) POD-4.



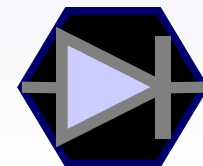


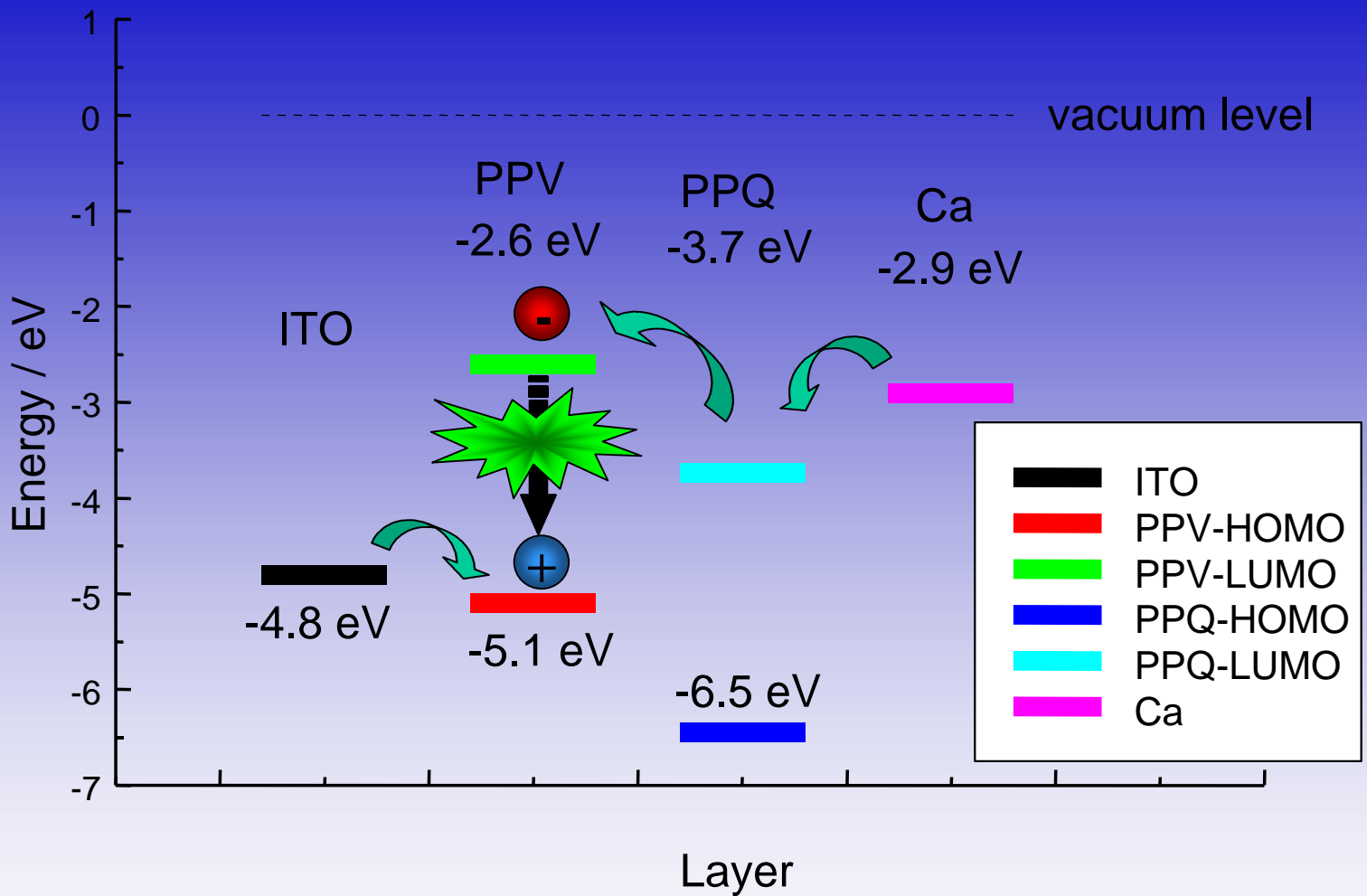
Low molecular donor- and/or acceptor-substituted diphenyl-oxadiazole model compounds: (a) Oxa-1, (b) Oxa-2, (c) Oxa-3, (d) Oxa-4, (e) Oxa-5.



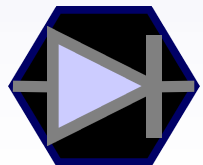


2-(p-nitrophenyl)-5-(p-undecylamidophenyl)-1,3,4-oxadiazole
(Nitro-Amino-Diphenyl-Oxadiazole: NADPO-11)

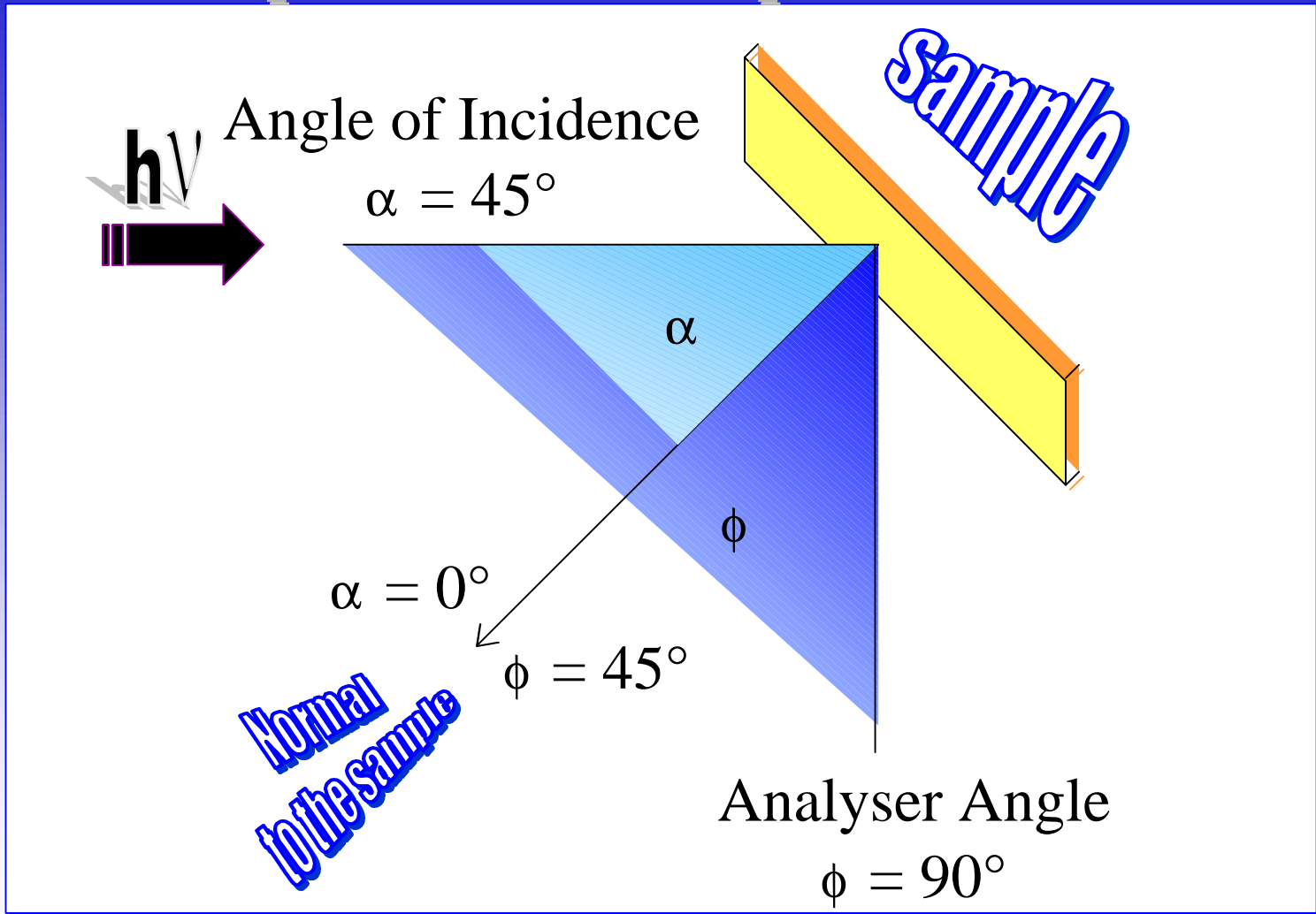


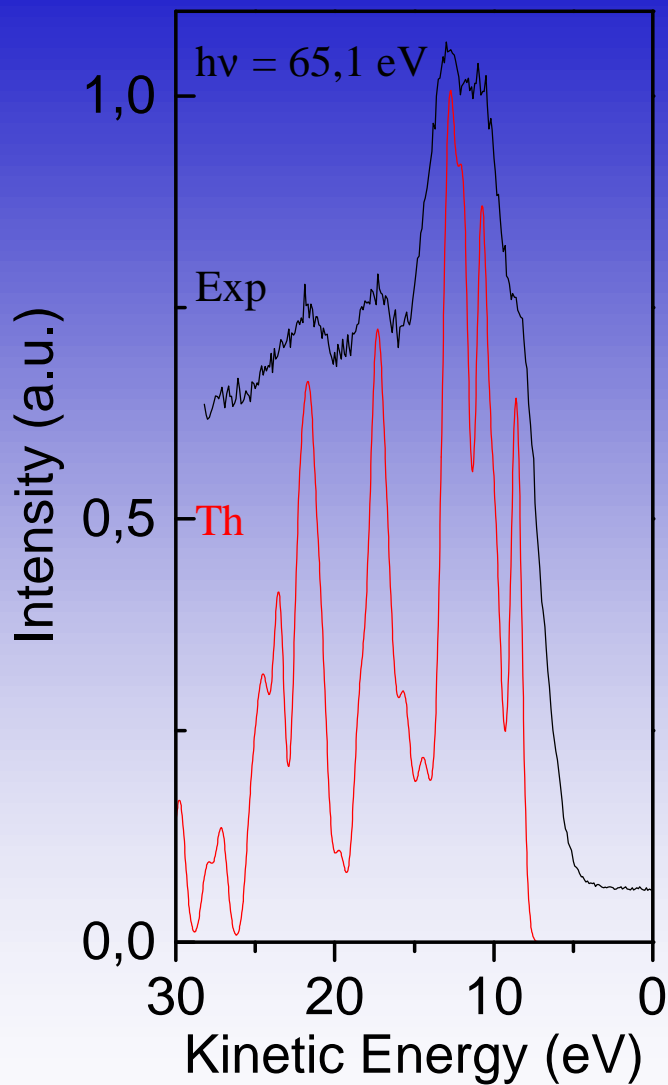
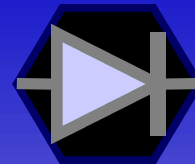


Energy Level Diagram of an ITO/PPV/PPQ/Ca/Al Device

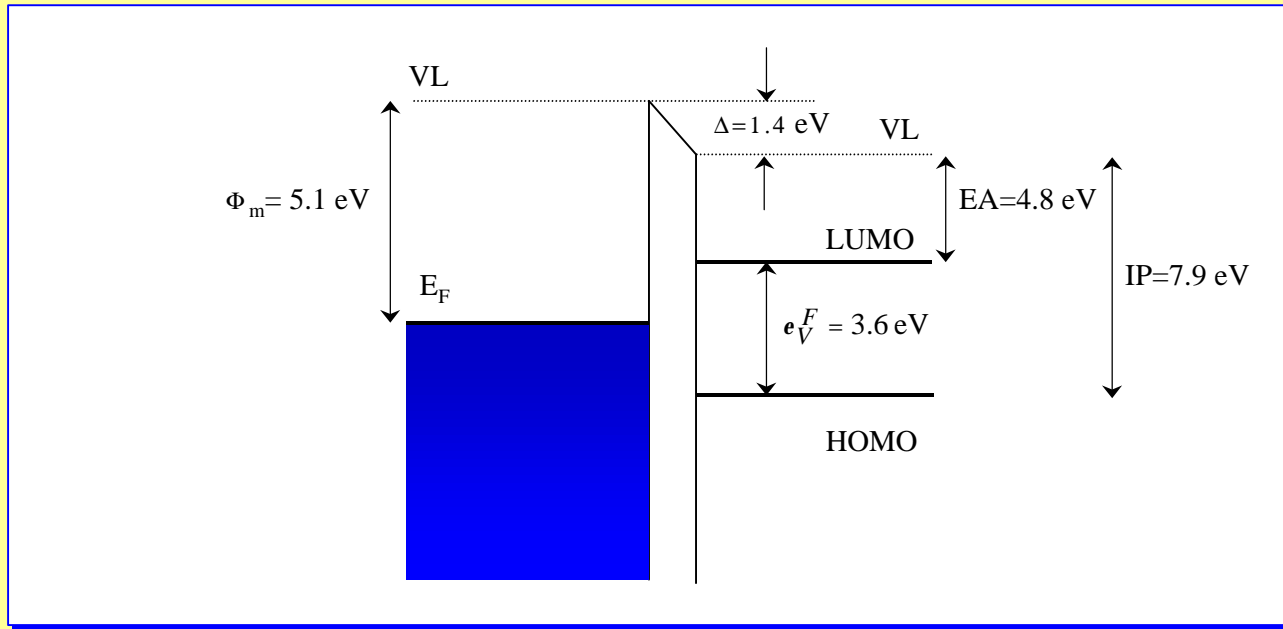


Experimental set up of ARUPS

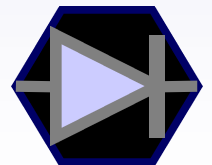




Energy diagram of the organic-metal interface.

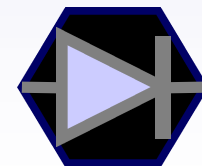
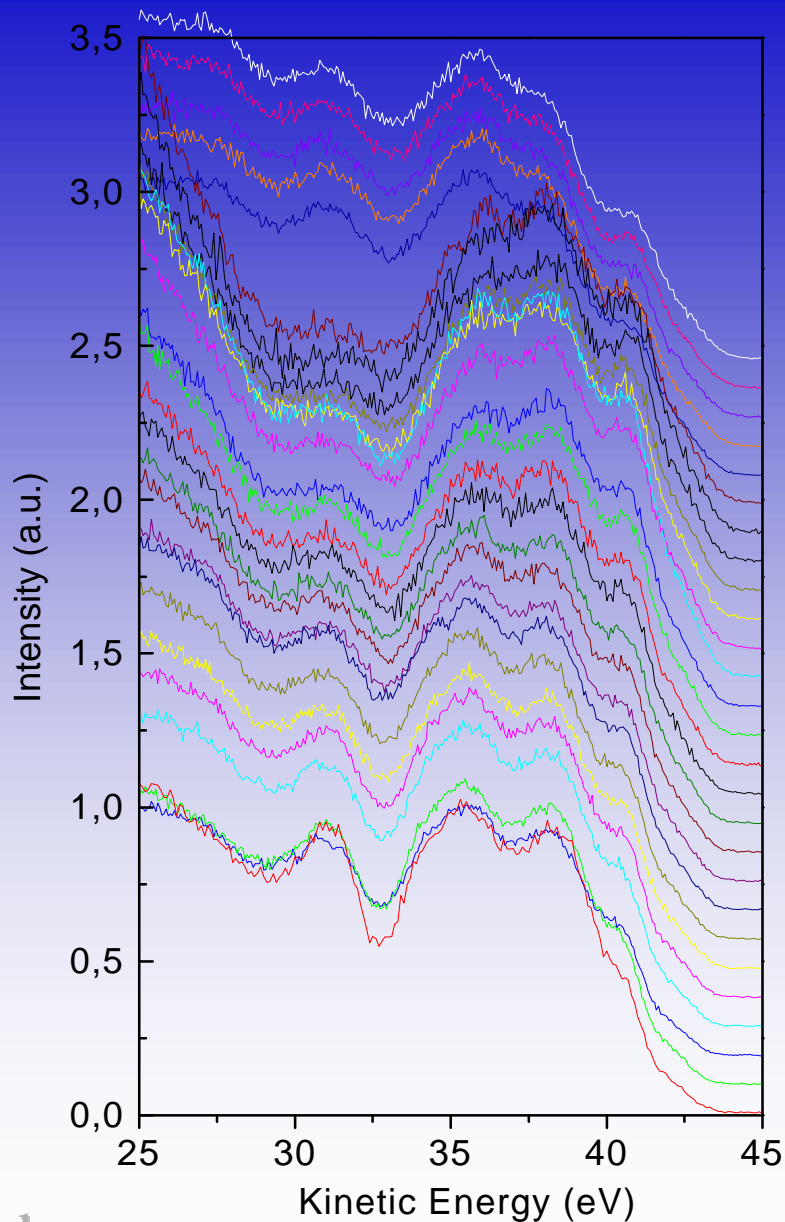


VL \Rightarrow vacuum level; **E_F** \Rightarrow Fermi level of the metal; **Φ_m** \Rightarrow work function of the metal; **IP** \Rightarrow ionisation potential; **Δ** \Rightarrow VL shift at the interface; **eV_F^F** \Rightarrow energy of the HOMO relative to the **E_F** .



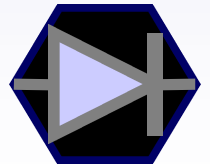
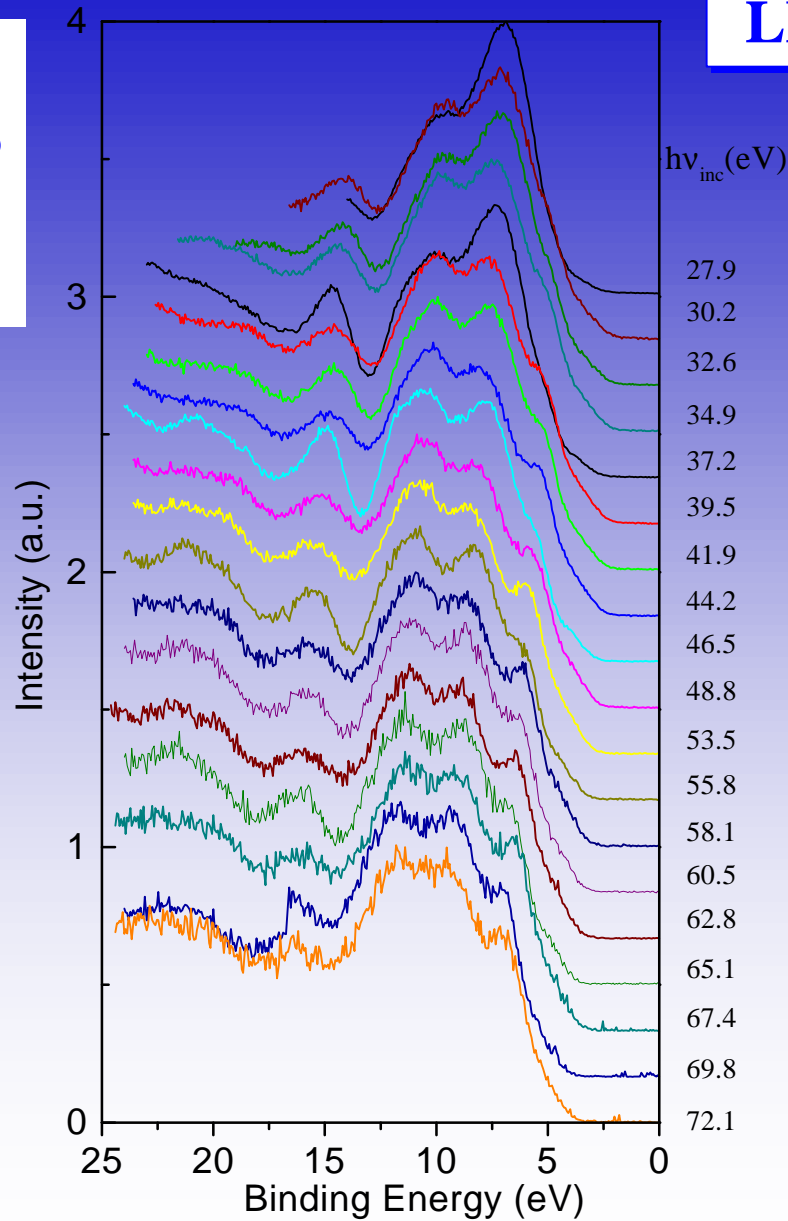
ARUPS

LB NADPO-11



The valence band is given with respect to the vacuum level set at zero

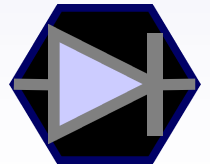
LB NADPO-11

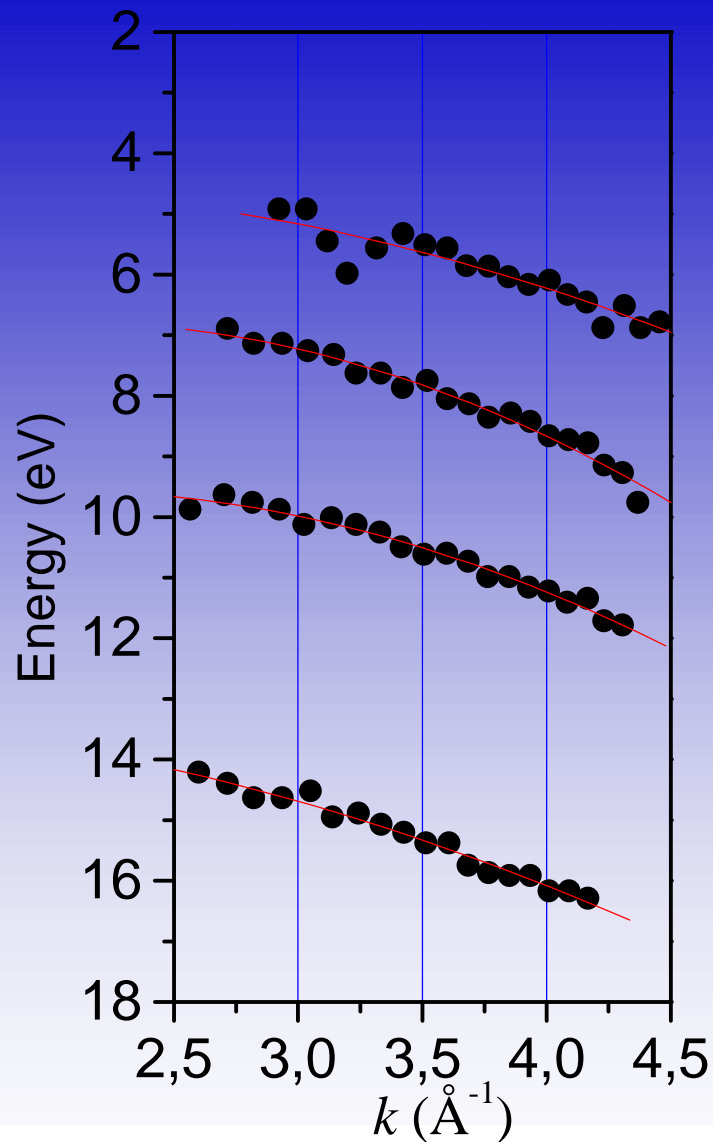


k -resolved band structure

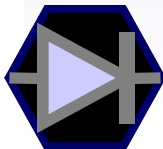
- ↓ $E_f = E_i \pm \hbar\omega \Rightarrow$ free electron final bands and direct transitions.
- ↓ $E_{kin} = \frac{\hbar^2}{2m_e} \left(k_{\perp}^2 + k_{\parallel}^2 \right)$, k_{\perp} and $k_{\parallel} \Rightarrow$ components of the momentum of the electron, perpendicular and parallel to the surface.
- ↓ In normal emission $k_{\parallel} = 0 \Rightarrow$ the momentum normal to the surface is given by

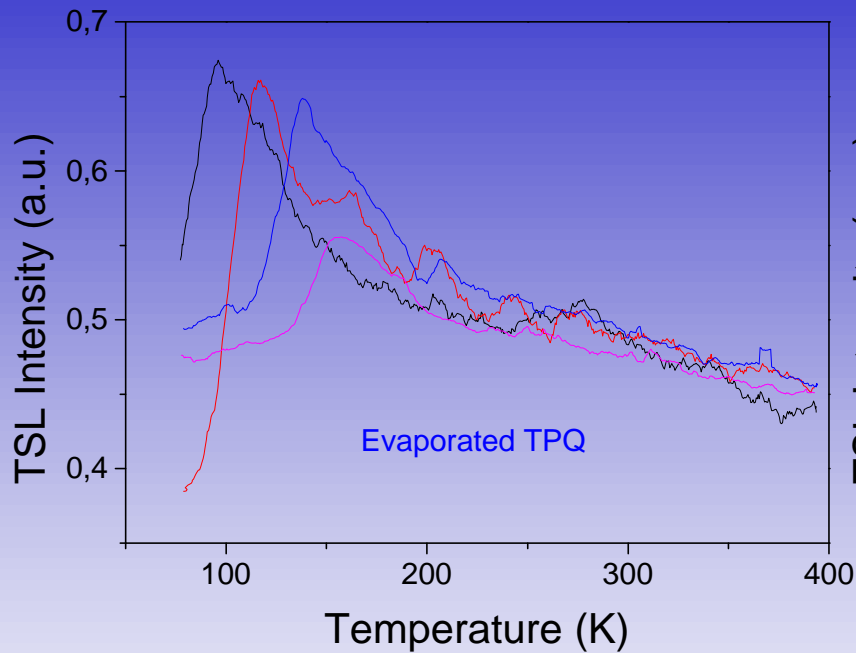
$$k_{\perp}^2 = \frac{2m_e}{\hbar^2} (E_{inc} - E_b + V_0)$$



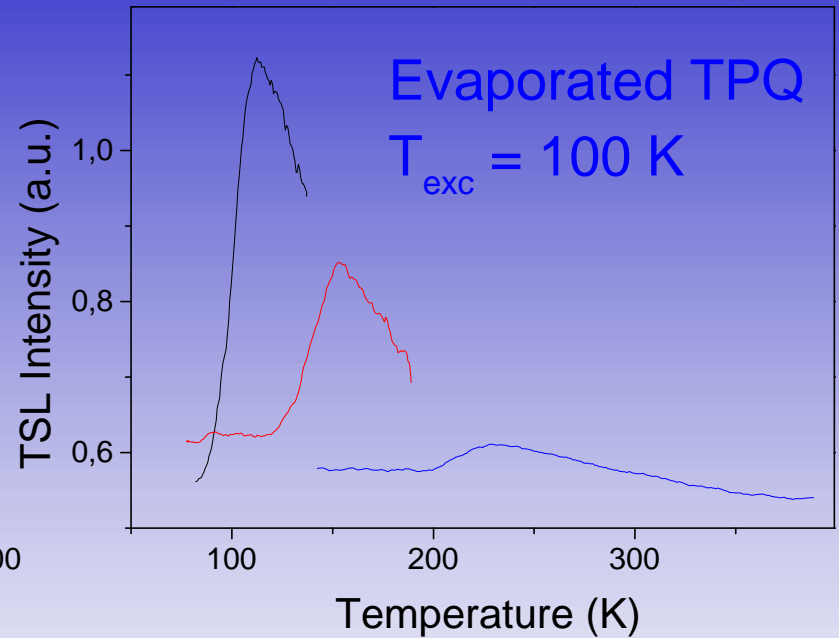


Experimentally determined band structure of LB NADPO-11 along the direction perpendicular to the surface



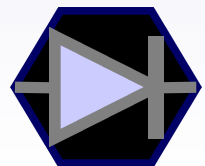


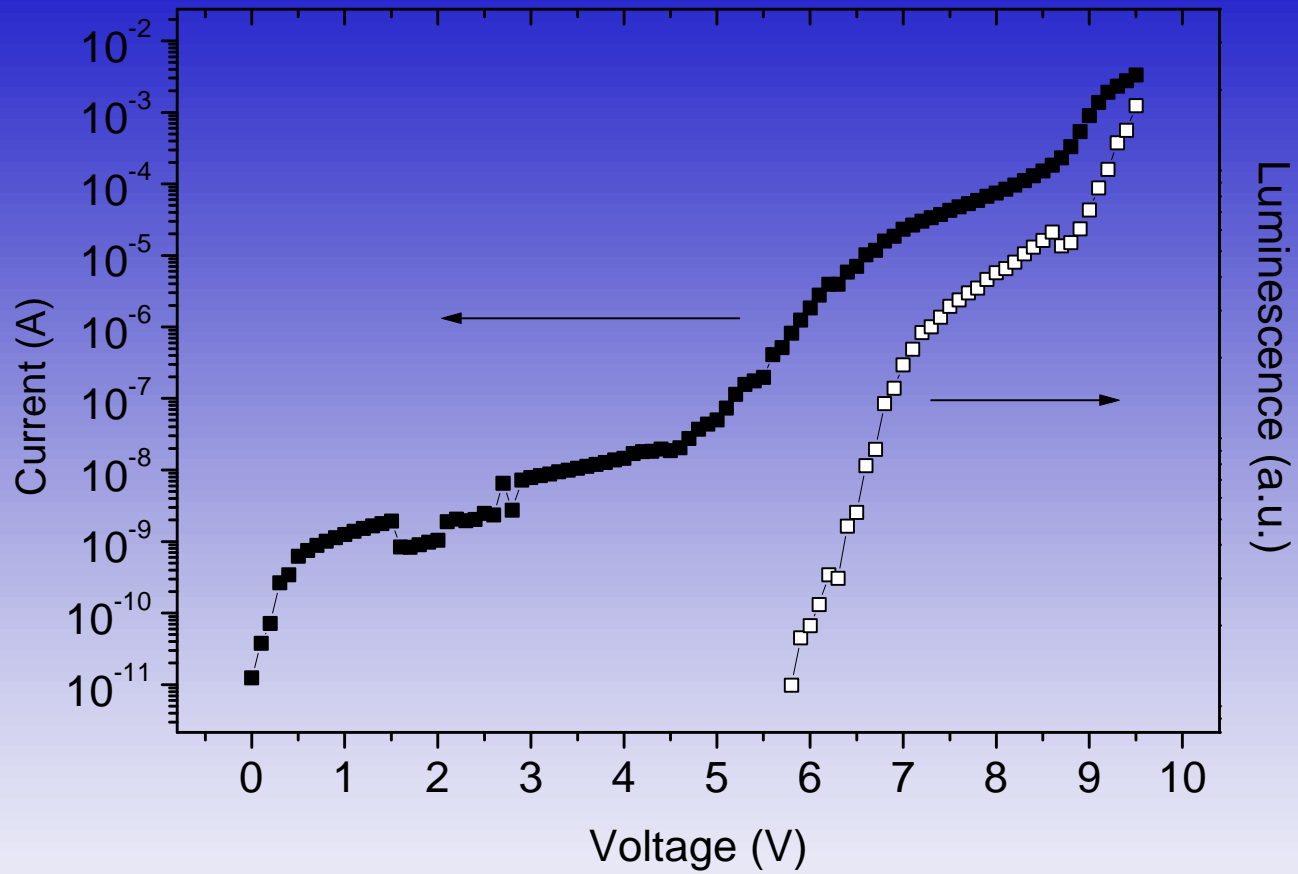
(a)



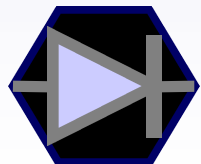
(b)

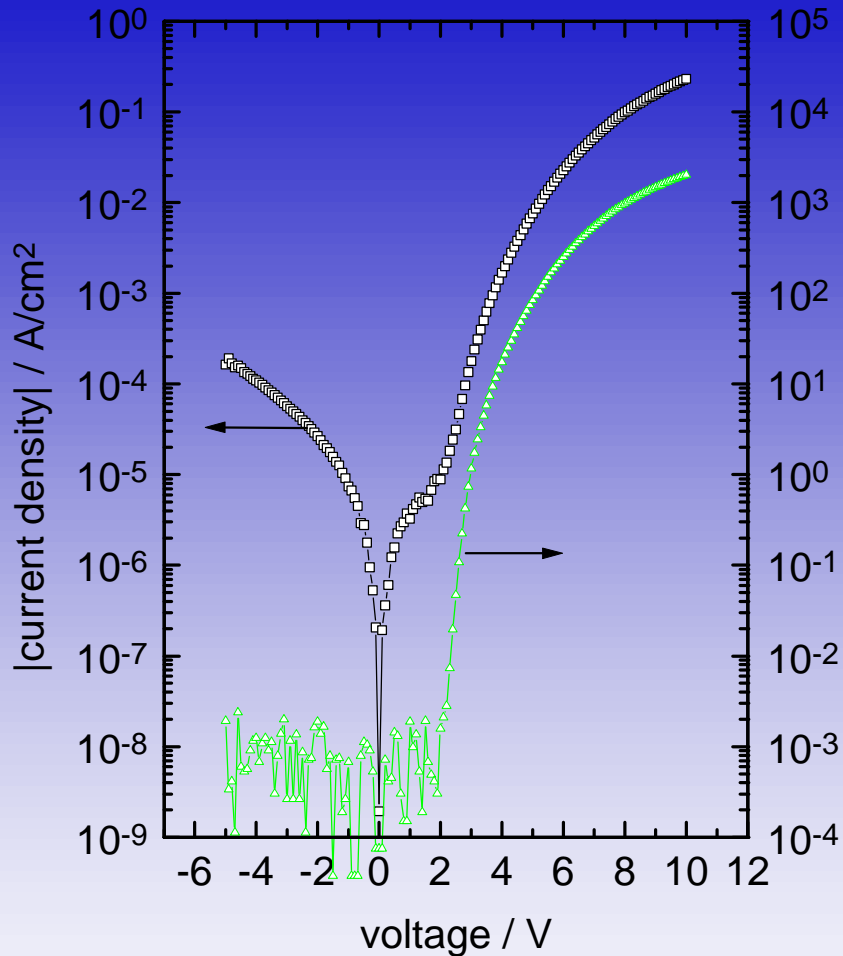
Thermoluminescence of TPQ for different excitation temperatures (a) and during partial heating (b)



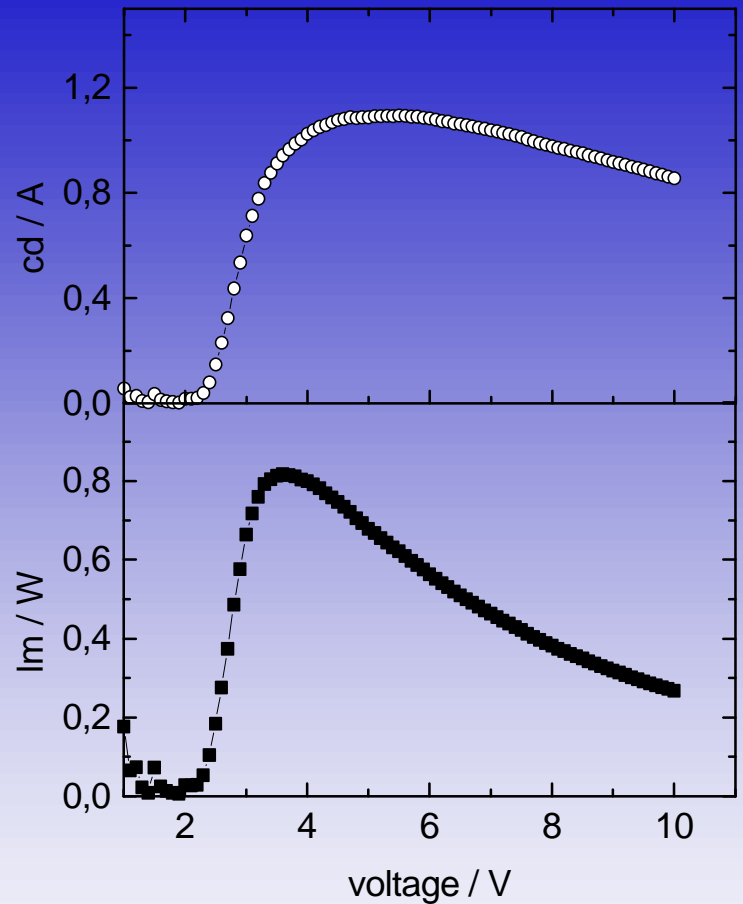


I(V)-L(V) characteristics of an ITO/ OXA-5/ Al light emitting diode

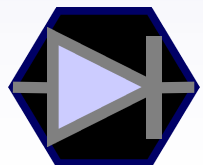




IVL-Characteristic

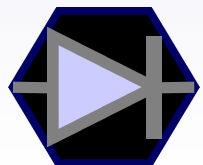


**Efficiency (cd/A) and
luminous efficiency (lm/W)**



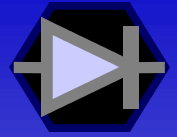
Conclusions

- ↓ Organic materials allow the fabrication of efficient light-emitting devices
- ↓ Multilayer devices are more efficient than single layer devices
- ↓ Different layers based on specially designed materials fulfil different functions, e.g. hole or electron injection/transporting layers
- ↓ Phenyloxadiazole and phenylquinoxaline compounds are promising materials for fabrication of efficient light-emitting devices
- ↓ They can serve as electron injecting/transporting materials and as hole blocker.
- ↓ While phenylquinoxalines serve as transport and blocking materials only, phenyloxadiazoles can also serve as emissive materials. in the blue/green spectral region. Their emission colour is determined by the substitution pattern of the active chromophores.
- ↓ The highest photoluminescence efficiencies are reached by donor-donor-substituted phenyloxadiazoles.





EUROLED Partners



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(LANZANI, Guglielmo)

Technische Universität Graz, Institut für Festkörperphysik, Graz, Austria
(LEISING, Günther)

International Business Machines Corporation, IBM, Zurich Research Laboratory,
Rüschlikon, Switzerland (RIESS, Walter)

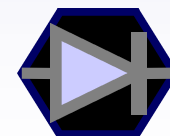
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(LOTZ, Bernard)

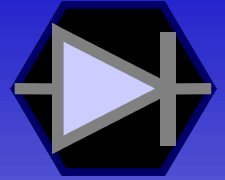
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Dr. St. Katholy, Physics; Dr. J. Reiche, Physics	
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Dr. B. Grimm, Chemistry	Microsensorics Teltow e.V. - IDM)
B. Falk, Chemistry	(IDM)
B. Dietzel, Chemistry	(IDM)





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S. Schrader