Materialien für OLEDs: Synthese, Druck und Anwendung

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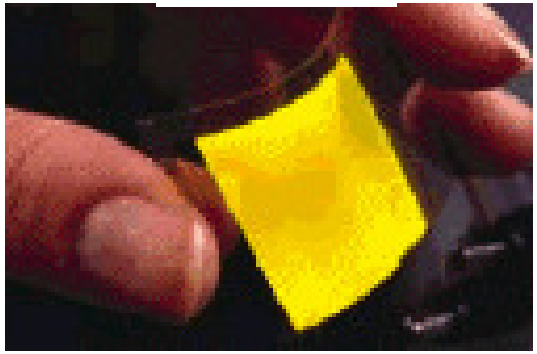
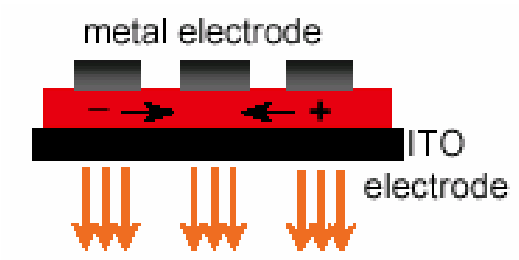
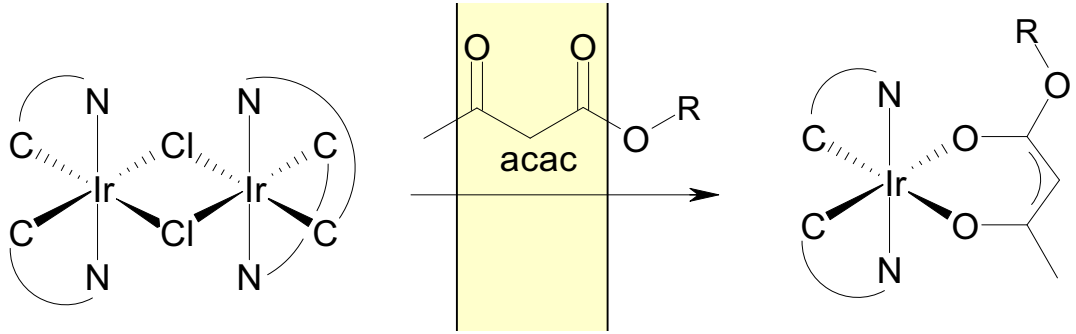
Overview

OLED

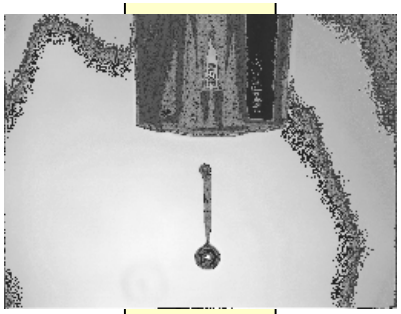




Synthesis



Inkjet printing



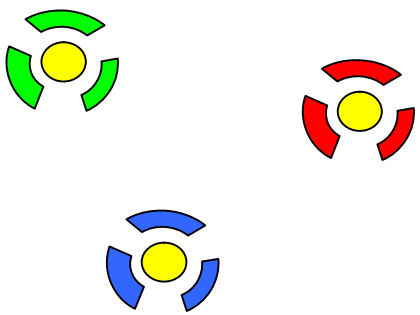
Application - device

Why iridium?

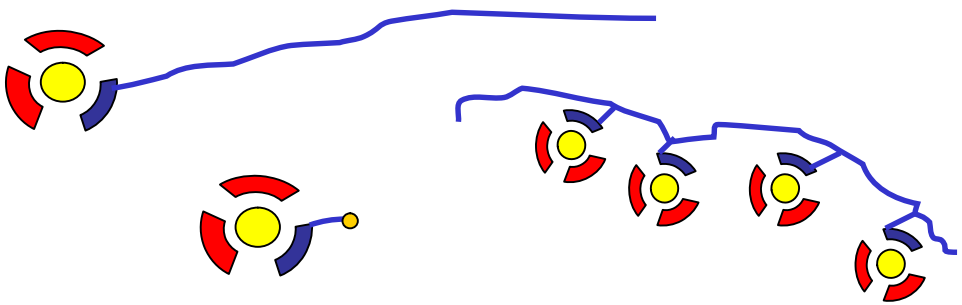
- **phosphorescence with relatively short lifetimes (few μs)**
- **high quantum yields**
- **metal-to-ligand based emission**
- **ability to change emission color**
- **can trap singlet excitones from fluorescent host molecules**
- **air-stable**

→ result in LEDs with maximum quantum efficiency, high stability, brightness and quick response on color-changes

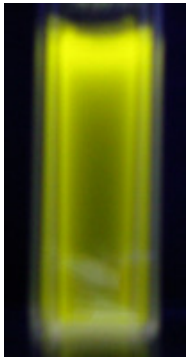
→ aim for solution processable iridium(III) complexes



ligands tune emission

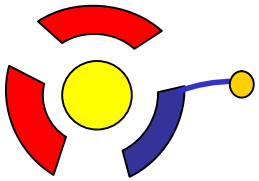


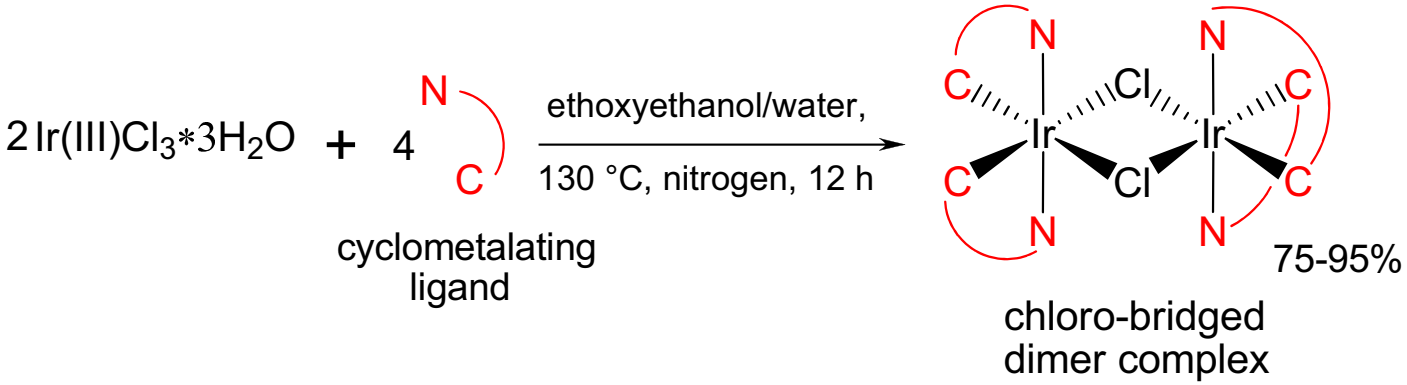
ligands with polymers/polymerizable group

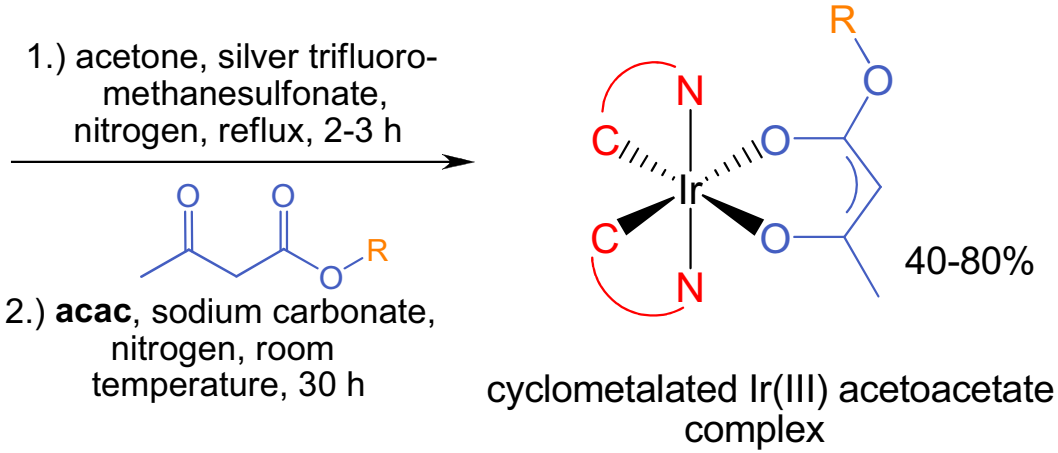


Adv. Mater. **2005**, *17*, 1109.

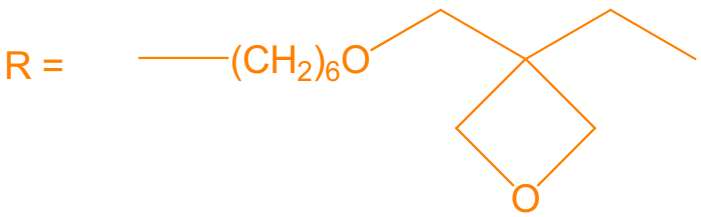
Synthesis of the iridium(III)-complexes







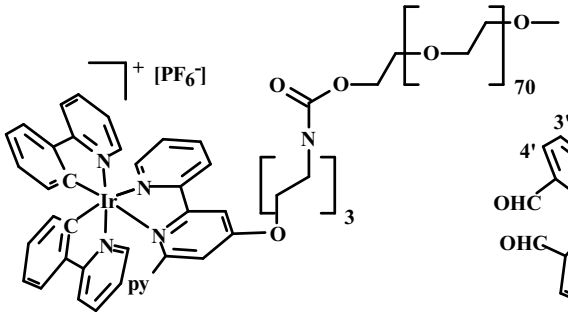
iridium(III)-complex with photo-polymerizable group



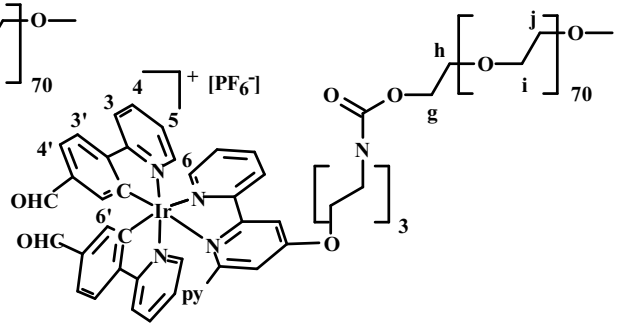
Adv. Mater. **2008**, *20*, 129.

Iridium-containing polymers

polymers with iridium(III)-complexes as end-groups



1



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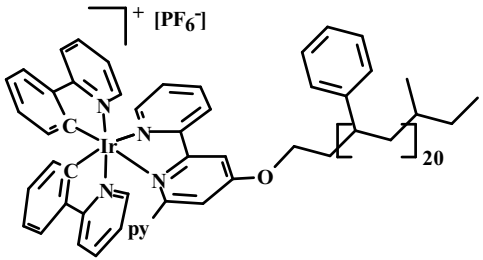

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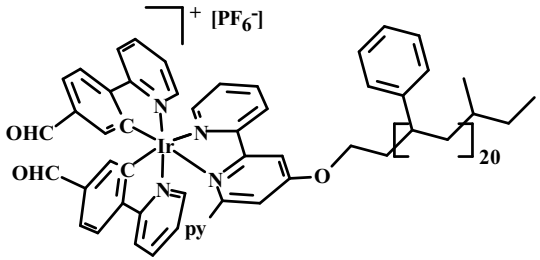

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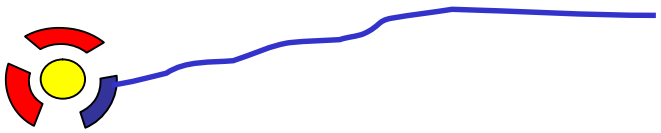
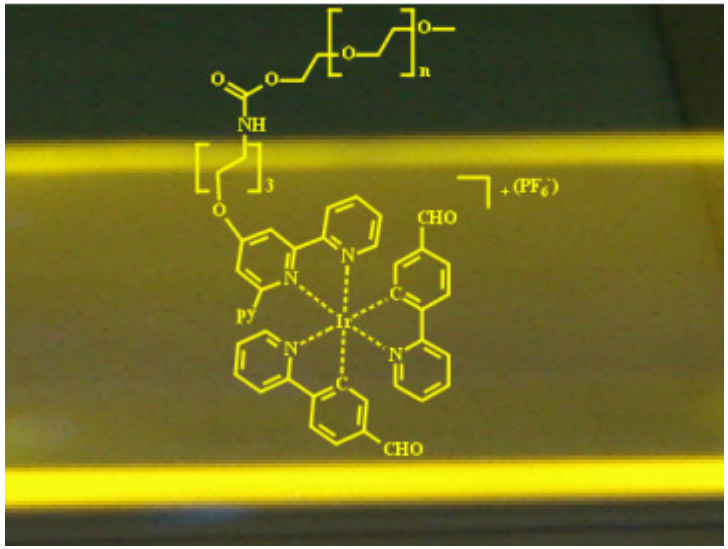




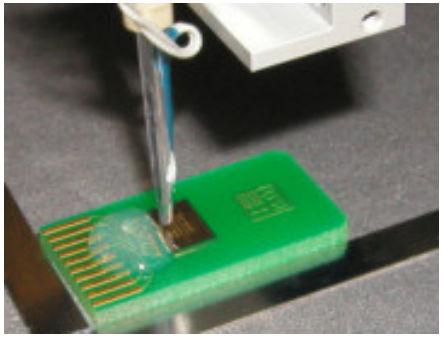
iridium(III)-complexes are processable
→ film of the polymer

Macromol, Rapid Comm. **2004**, *25*, 1491; *J. Polym. Sci.: Part A: Polym. Chem.* **2005**, *43*, 2765; *Chem. Soc. Rev.* **2007**, *36*, 618.

Inkjet deposition of polymers & materials

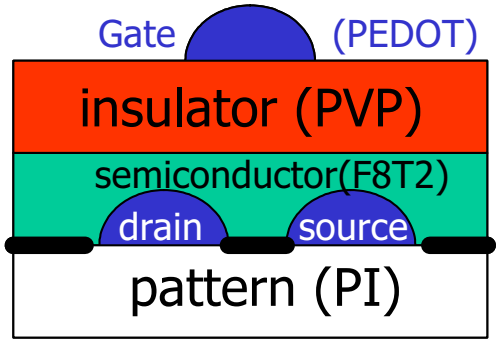
Data transfer

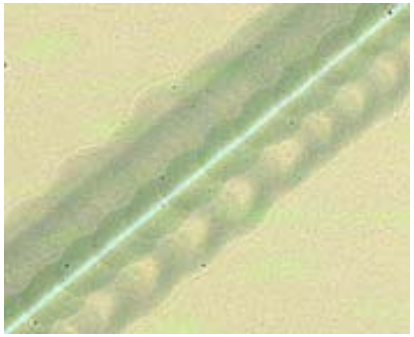
Dosing of lubricants
(www.microdrop.de)



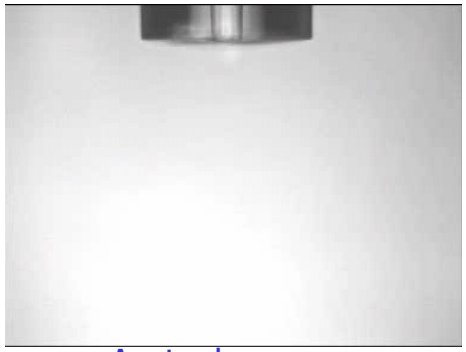
Biochip fabrication
(www.gesim.de)

Multicolor pLED displays
Courtesey of Philips Research

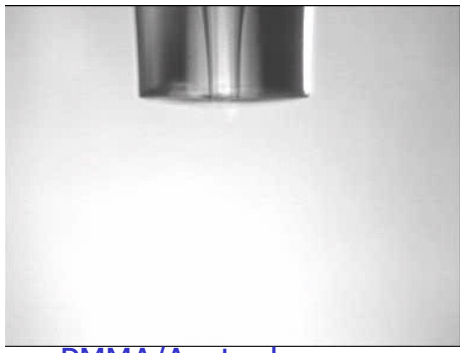




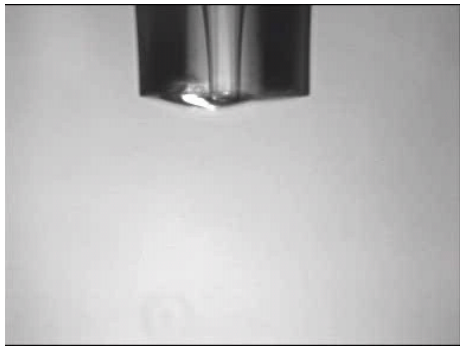
Inkjet printed all-polymer TFT
Plasticlogic / Univ. Cambridge



Acetophenone



PMMA/Acetophenone
(Mw 606 kD), 0.4% wt



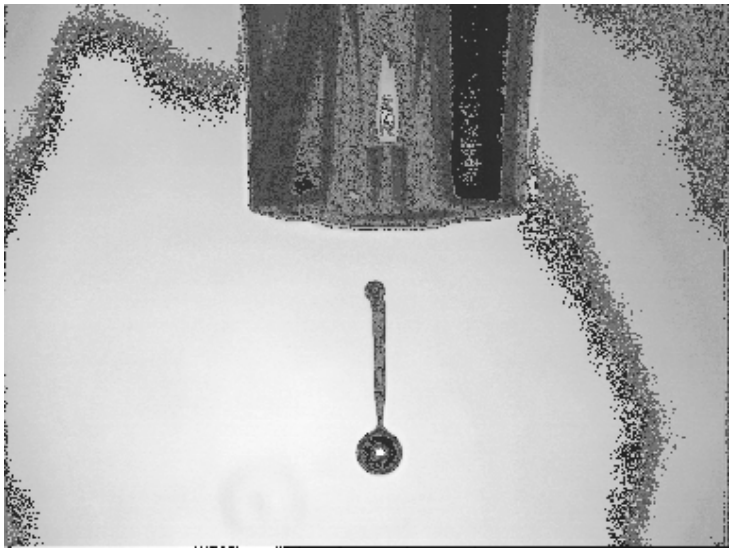
PMMA/Acetophenone
(Mw 1256 kD), 0.4% wt

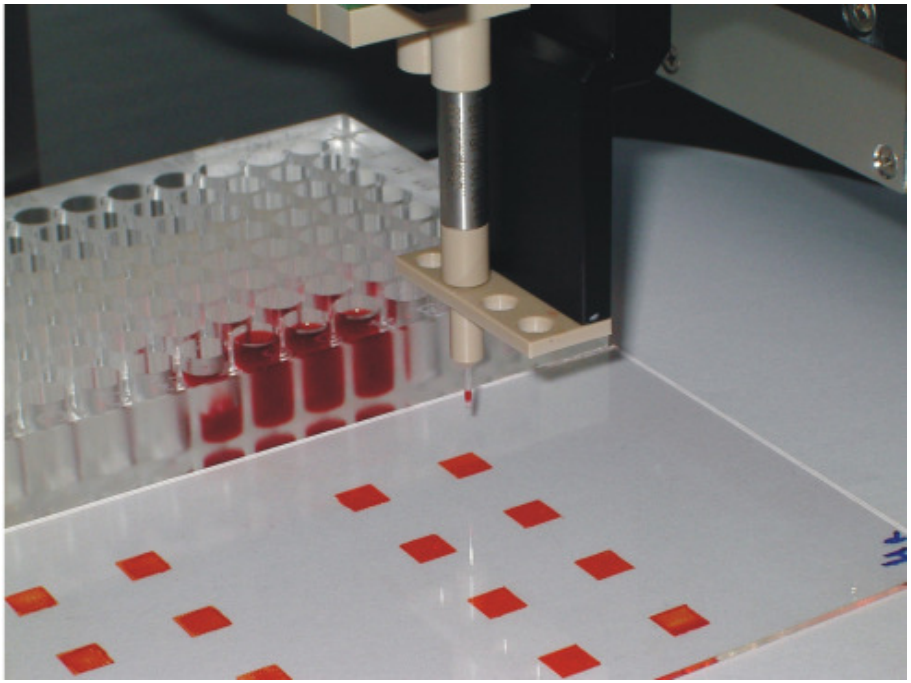
Inkjet printing 1

microdrop TECHNOLOGIES

Microdrop-Autodrop Platform

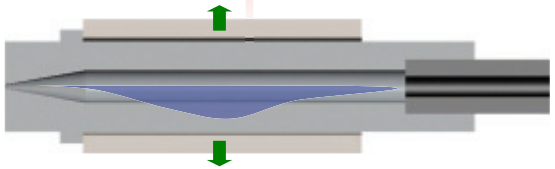
Micropipette AD-K-501



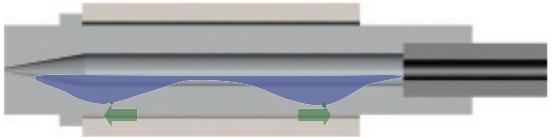


Adv. Mater. **2004**, *16*, 203; *J. Mater. Chem.* **2004**, *14*, 2627; *Soft Matter* **2008**, *in press.*

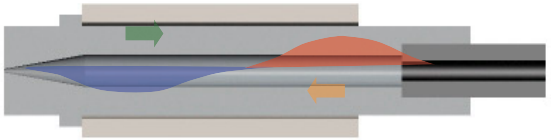
Inkjet printing 2



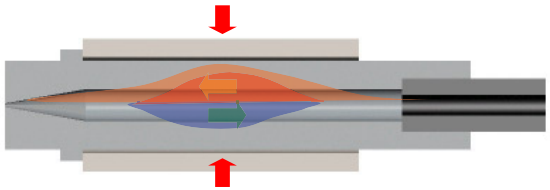
I - Piezo move outwards



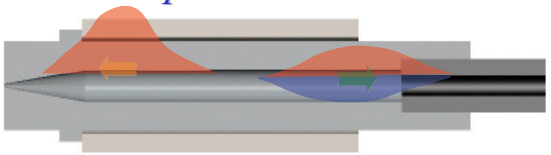
II - Negative waves travel outwards



III - Waves reflect and one reverses



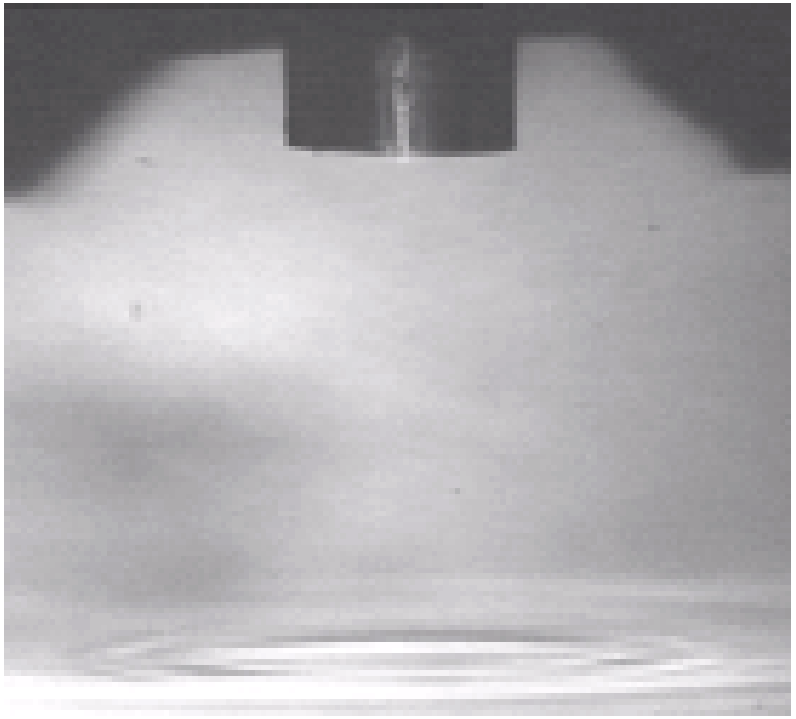
IV - Waves arrive at centre when piezo contracts



V - Wave is magnified and drop ejected

Advantages (compared to spin-coating):

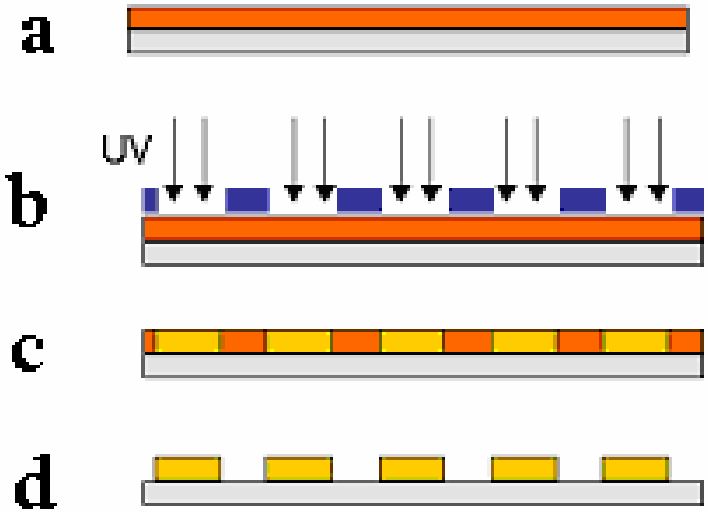
- **small amounts of solution**
- **less solution is wasted**
- **printing of defined areas**



microdrop TECHNOLOGIES

Macromol. Rapid. Comm. **2003**, *17*, 2349; *Macromol. Rapid. Comm.* **2004**, *25*, 292.

Optimization of thin films

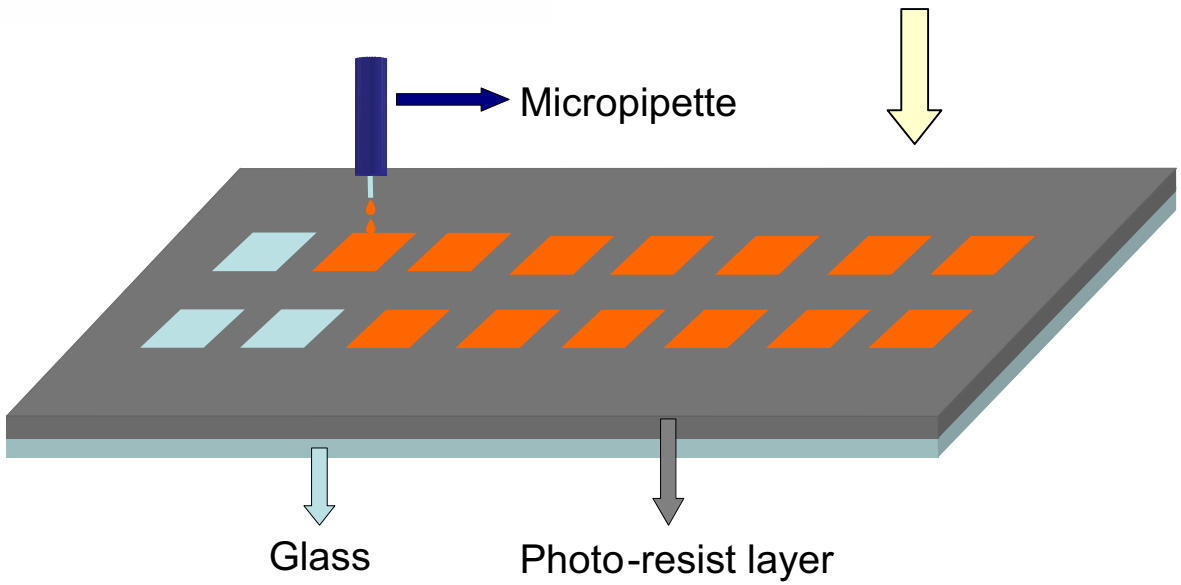


a) spin coating photo-resist

b) UV light exposure

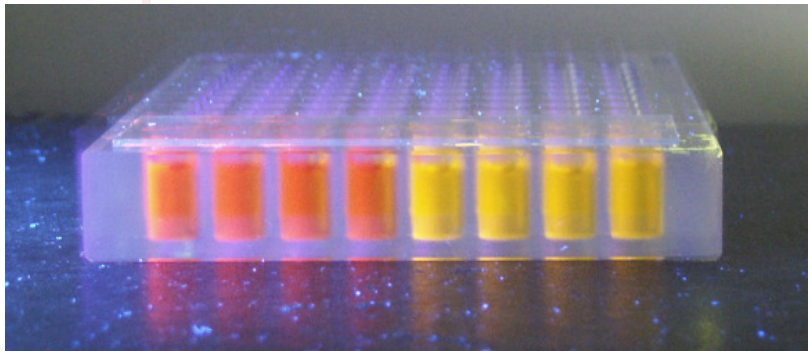
c) baking

d) developing



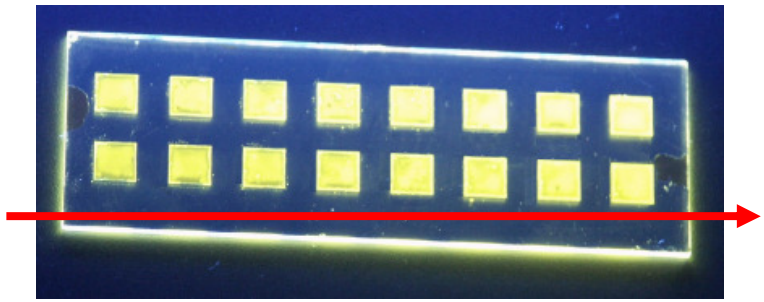
Macromol. Rapid Commun. **2005**, *26*, 293.

Inkjet printing of the iridium polymer



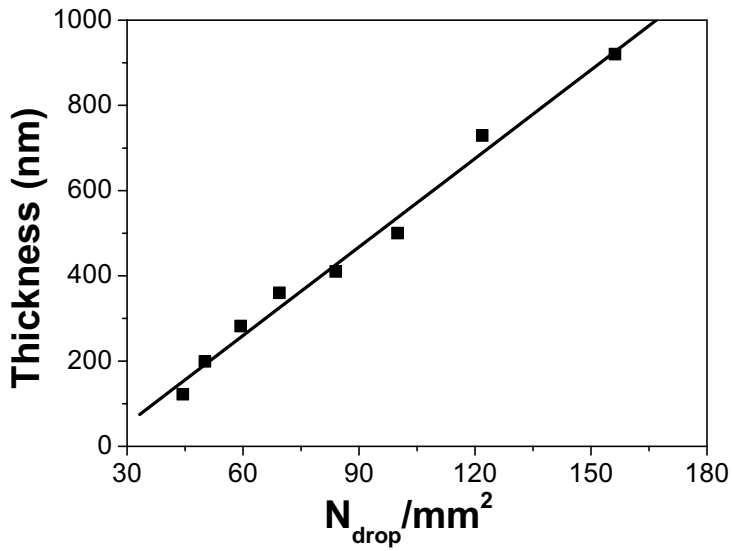
polymer solutions

inkjet printing

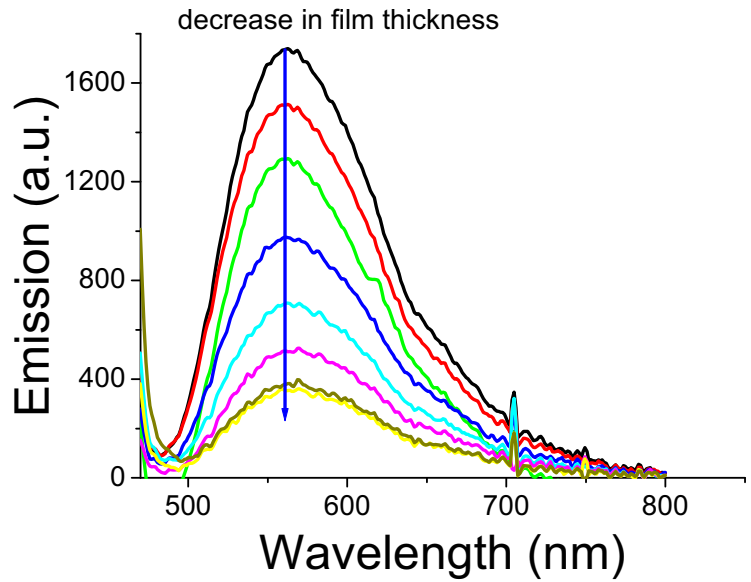


printed polymer films

increasing thickness

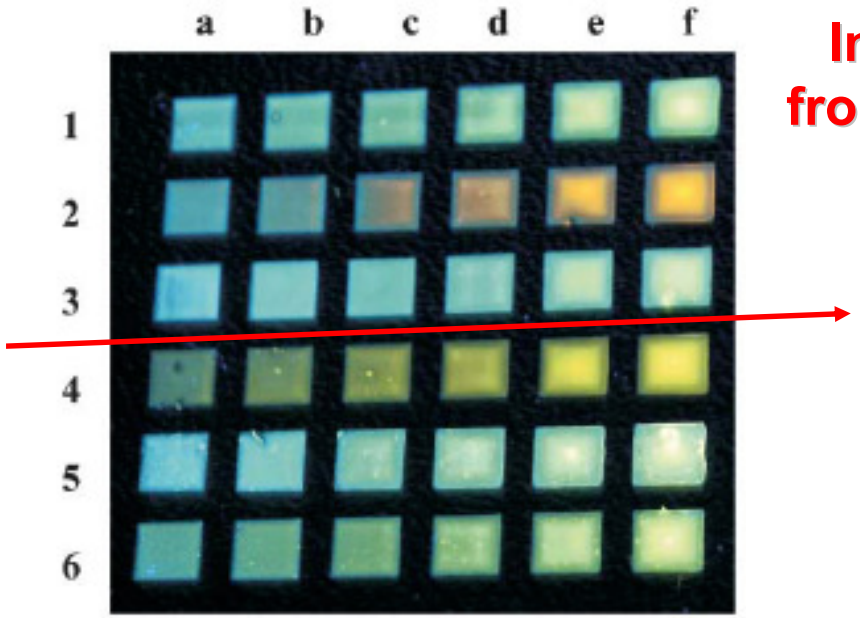


correlation of the number of printed drops with thickness and of thickness with emission

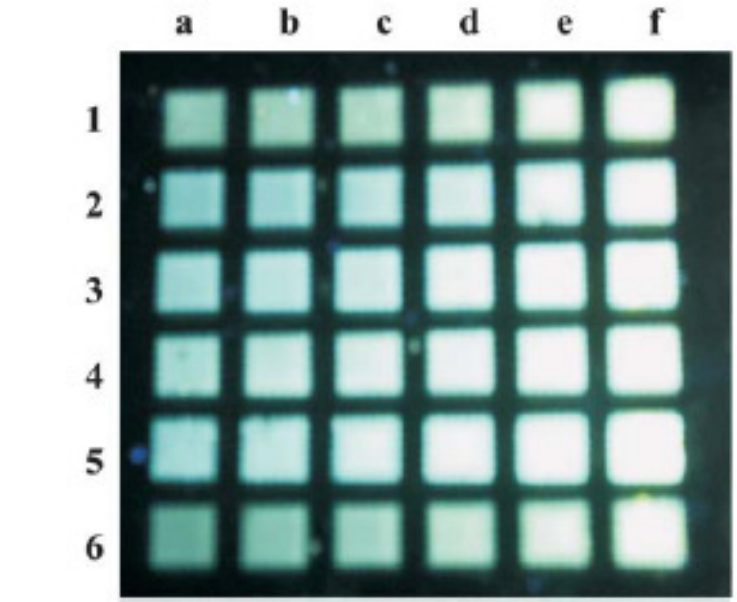


Macromol. Rapid Commun. **2005**, *26*, 293.

Inkjet printing of conjugated polymers



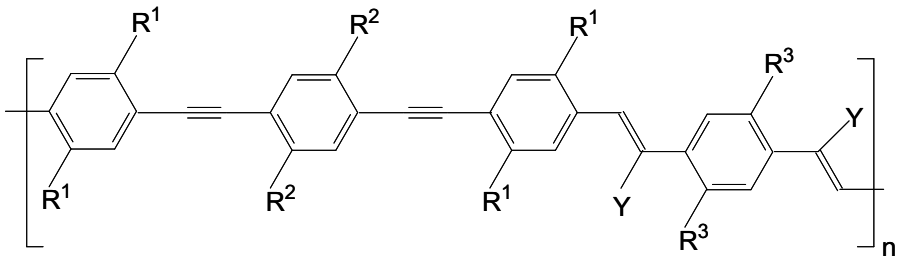
Increasing thickness from ~50 nm to ~150 nm



after annealing (70 °C, 2 h)

printed polymer films for potential application in OLEDs

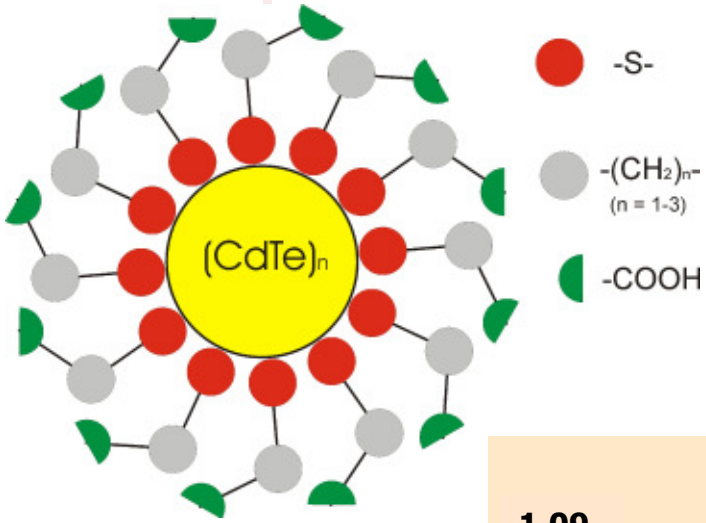
Solvent : 90% toluene - 10% dichlorobenzene,
Printed area: 6 x 6 mm Velocity: 15 mm/s,
Voltage: 74 V, Pulse width: 45 µs

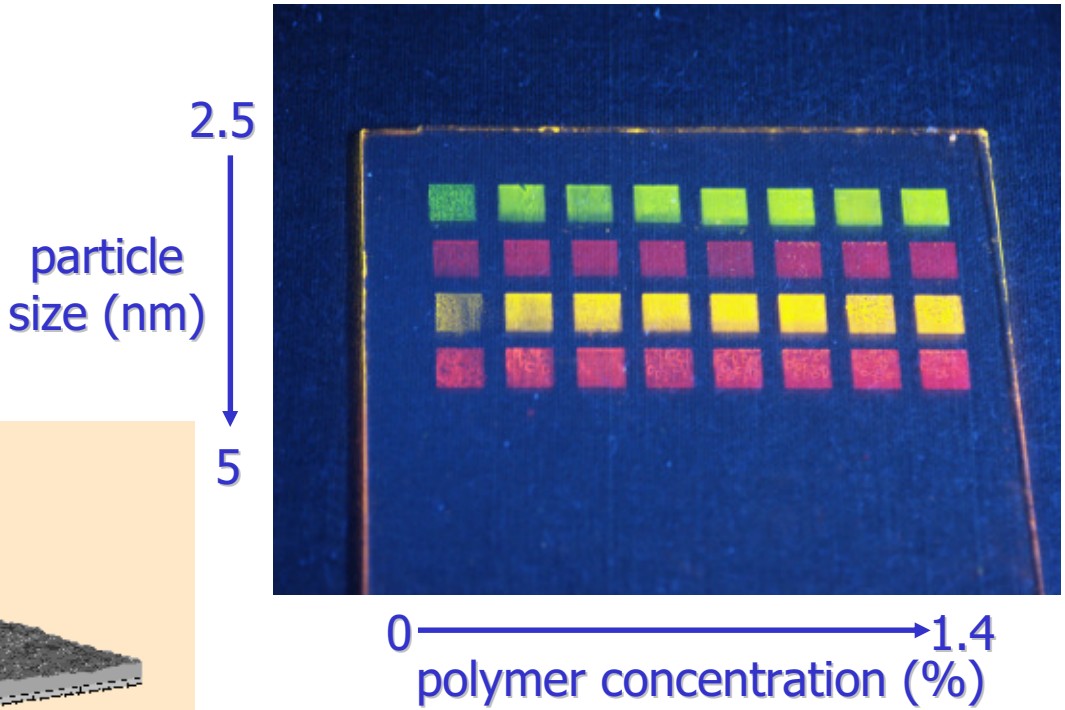


1: R^1 = H, R^2 = octyloxy, R^3 = octadecyloxy, (Mn = 50,000)
2: R^1 = H, R^2 = octadecyloxy, R^3 = octyloxy, (Mn = 38,400)
3: R^1 = H, R^2 = octadecyloxy, R^3 =heptyloxy, (Mn = 41,000)
4: R^1 = H, R^2 = octadecyloxy, R^3 =decyloxy, (Mn = 43,200)
5: R^1 = H, R^2 = octadecyloxy, R^3 =dodecyloxy, (Mn = 10,200)
6: R^1 = H, R^2 = R^3 = dodecyloxy, (Mn = 25,600)

J. Mater. Chem. **2006**, *16*, 4294; *Adv. Funct. Mater.* **2007**, *17*, 277.

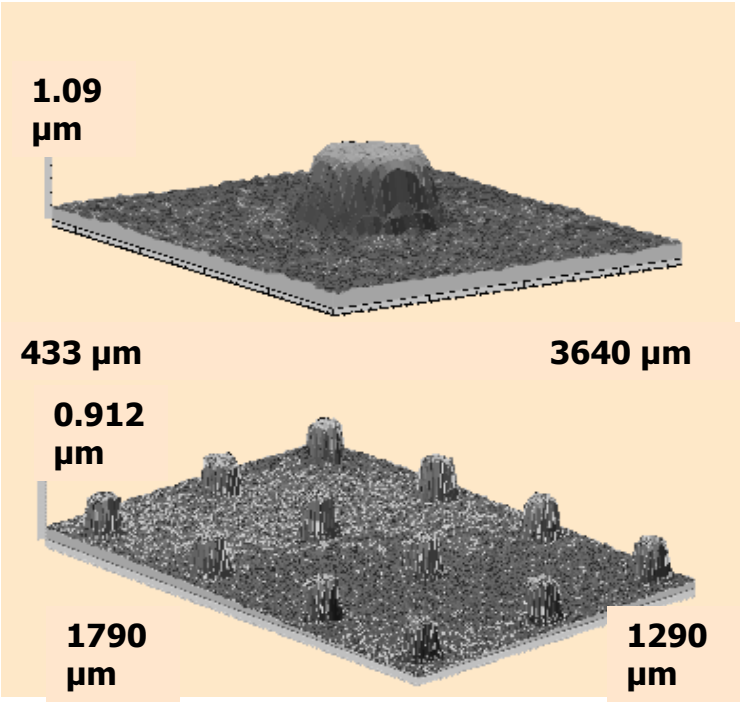
Cadmiumtelluride nanoparticles





nanoparticle library

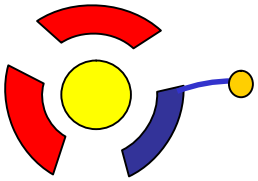
3D-profilometer image



Nanoparticle libraries including different amount of PVA (Mw: 31-50,000 g/mol, 99% hydrolyzed). Films were printed from water on heated substrates (75 °C). Dot spacing: 0.08 mm

Adv. Funct. Mater. **2007**, *17*, 23.

Iridium complex based OLED I



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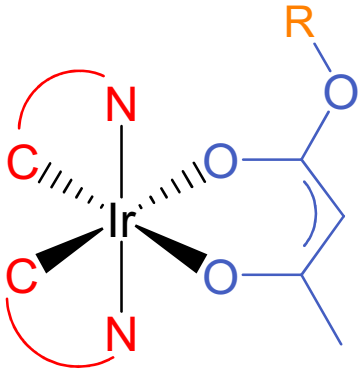
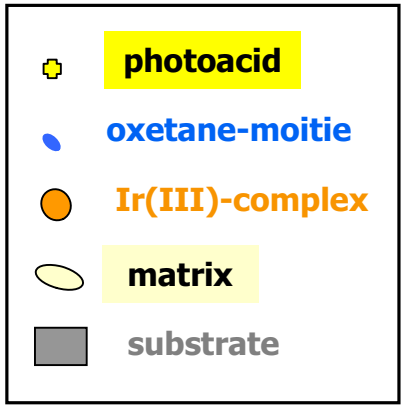




solution-processing

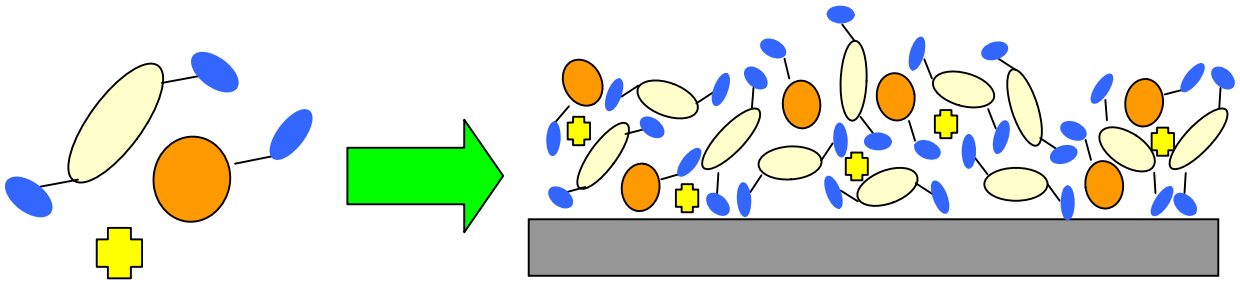
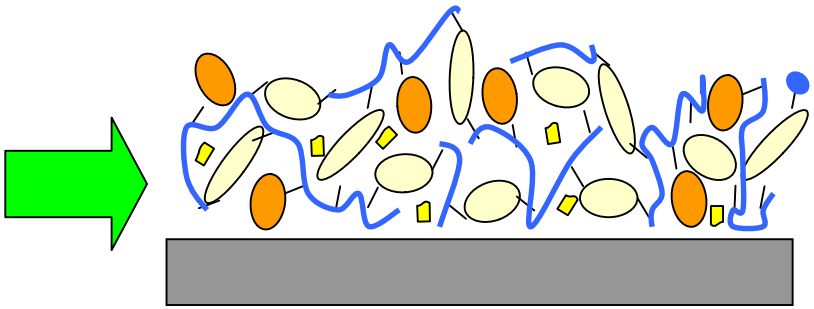
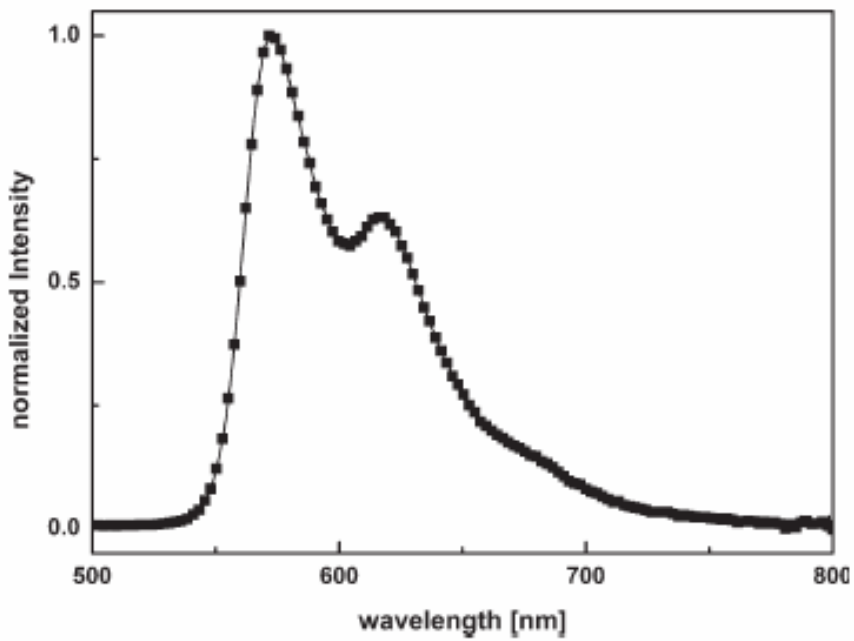


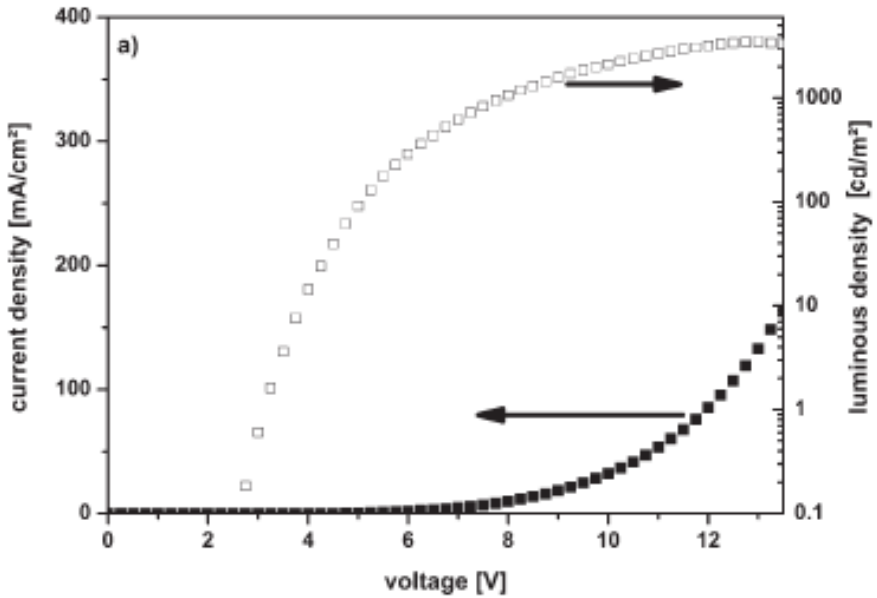
photo-crosslinking



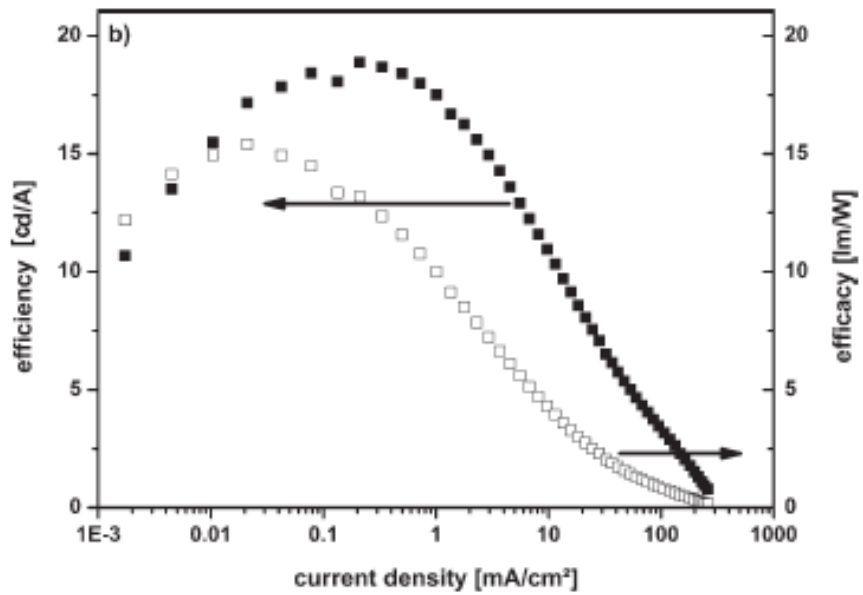
Cooperation with K. Meerholz, Universität Köln: *Adv. Mater.* **2008**, *20*, 129.

Iridium complex based OLED 2





electroluminescence



Best device: 18.4 cd/A
Max. power efficiency [lm/W]
performance @ 100 cd/m^2
18.4 cd/A @ 5V
@1000 cd/m^2
15 cd/A @ 8V

Cooperation with K. Meerholz, Universität Köln: *Adv. Mater.* **2008**, *20*, 129.

Conclusions

The pathway to OLEDS

Synthesis Printing Device

- functionalization of iridium(III)-complexes with polymerizable groups
- endfunctionalization of polymers with iridium(III)-complexes
- printing of polymers containing iridium(III)-complexes
- printing of CdTe-nanoparticles
- printing of conjugated polymers
- device containing photocrosslinkable iridium-complex

Acknowledgement

Info's under
http://www.schubert-group.com

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FCI

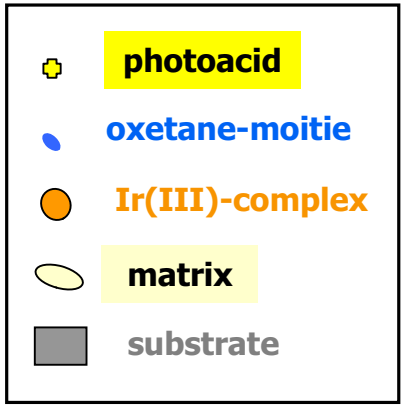
NWO

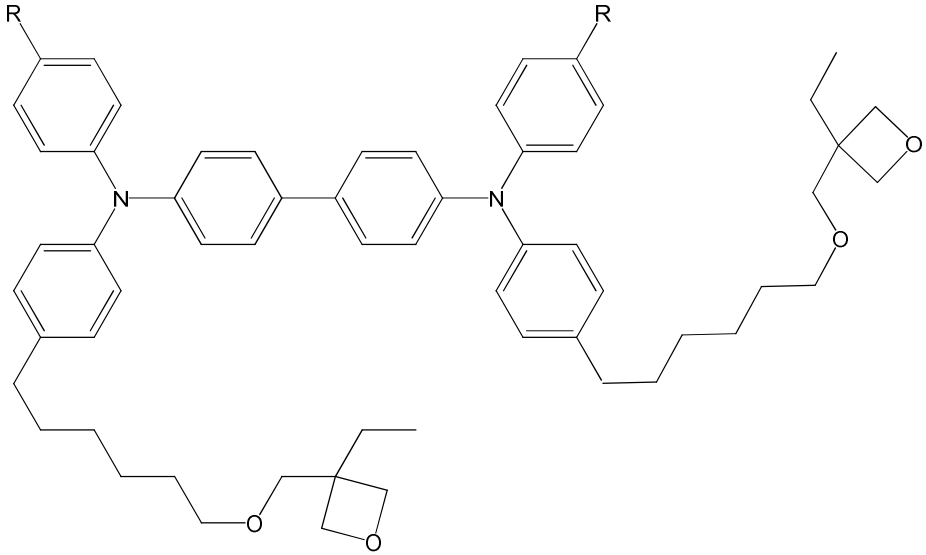
DPI DUTCH POLYMER INSTITUTE

Thüringer Kultus-ministerium

Iridium complex based OLED III

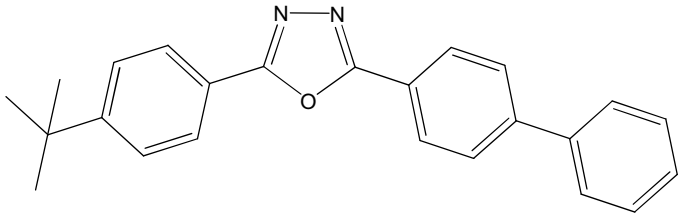
Supporting information



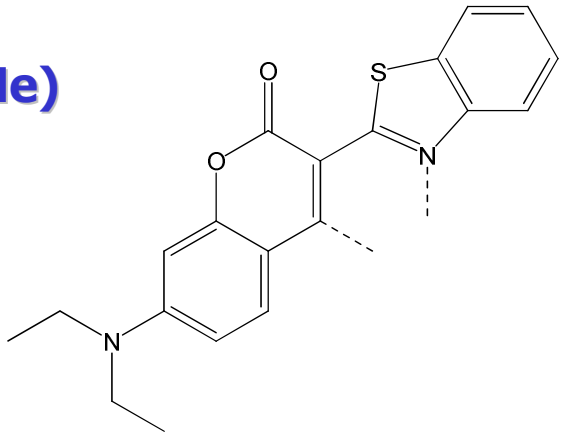


substrate:
ITO-coated glass

matrix: OTPD (R = H)
hole-transporting material: QUPD (R = OMe)



electron-transporting material: PBD



ligand: coumarine-type