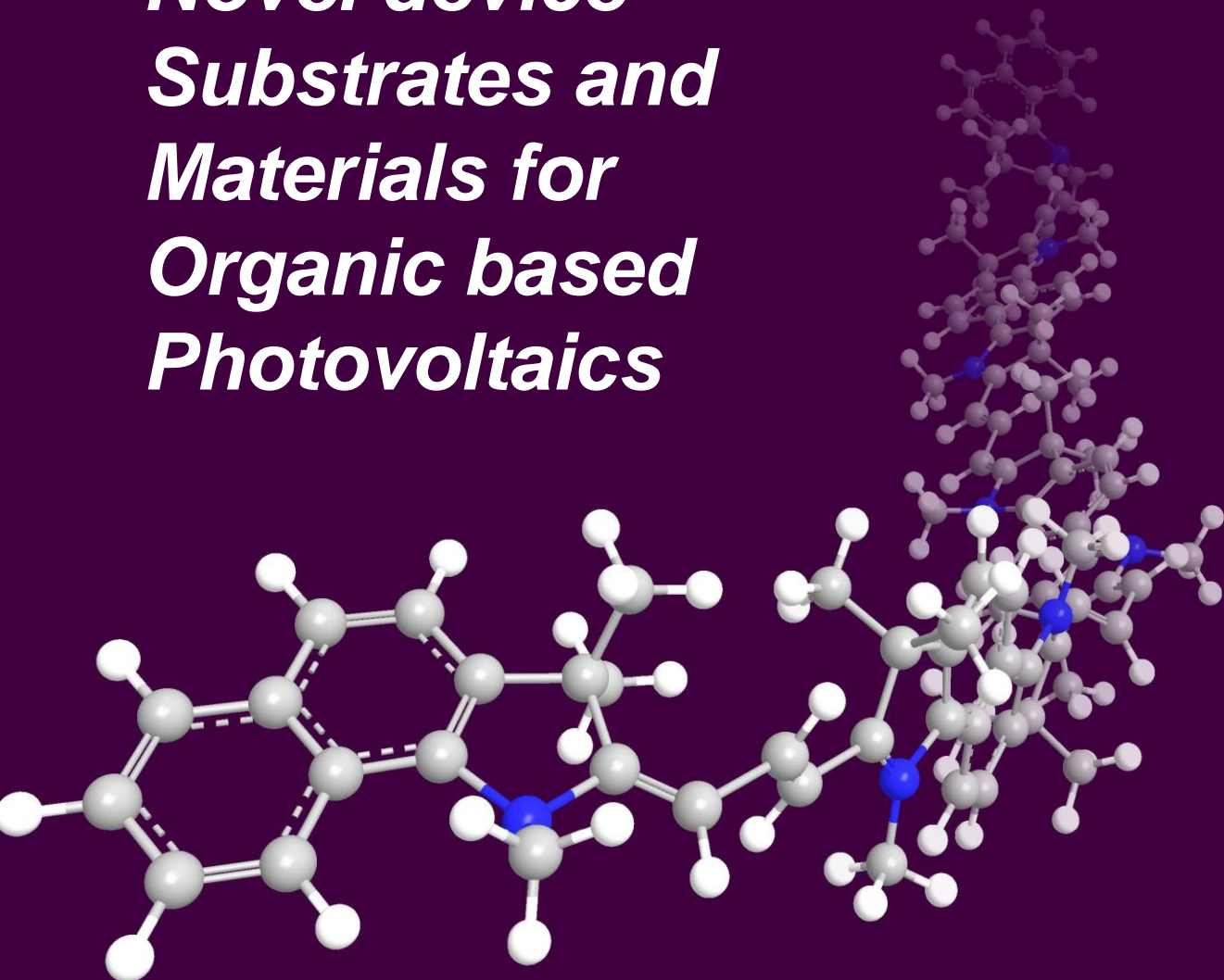


***Novel device
Substrates and
Materials for
Organic based
Photovoltaics***



Frank Nüesch

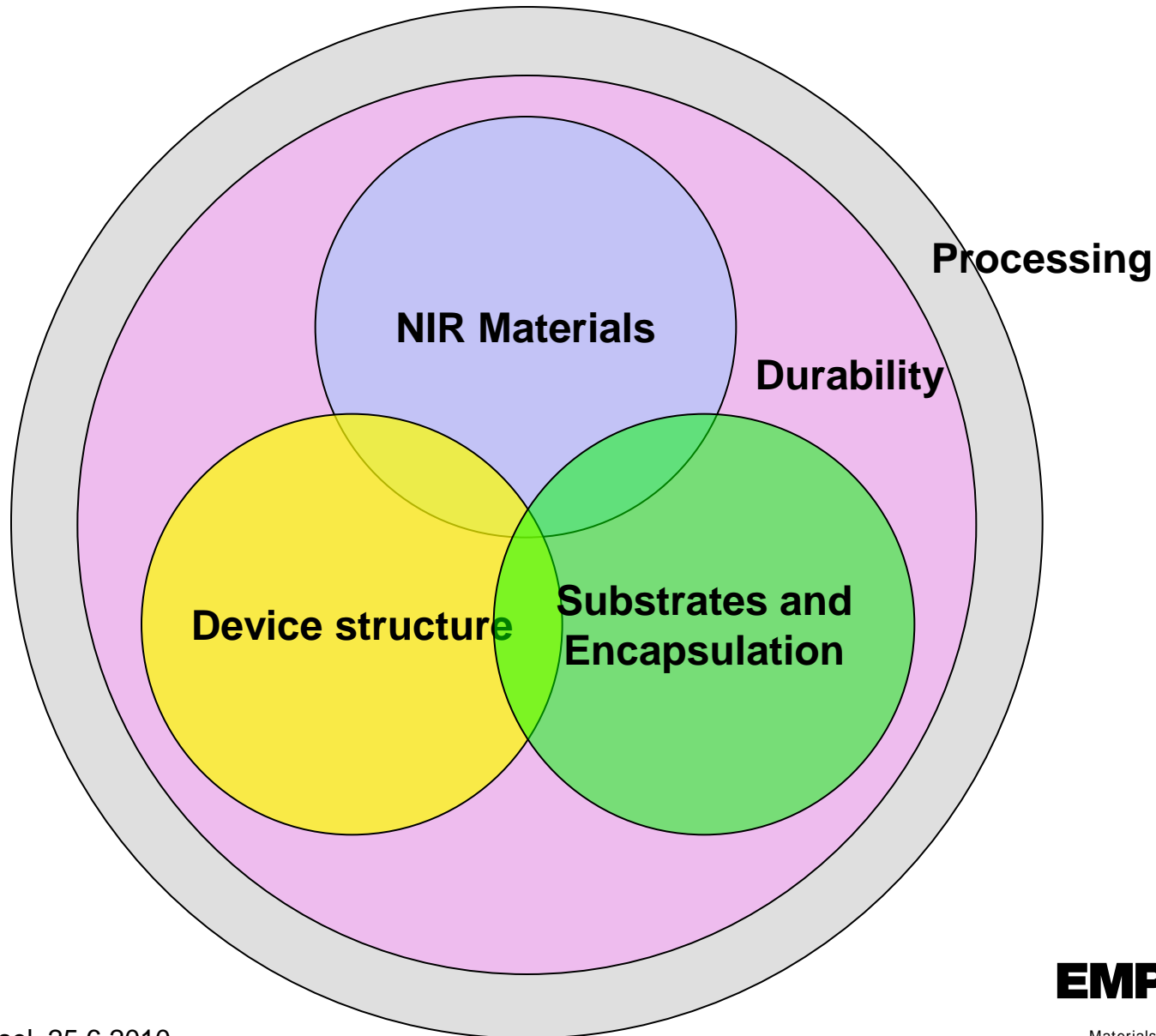
*Laboratory for
Functional Polymers*

*Empa –
Materials Science and
Technology
Überlandstrasse 129
8600 Dübendorf*

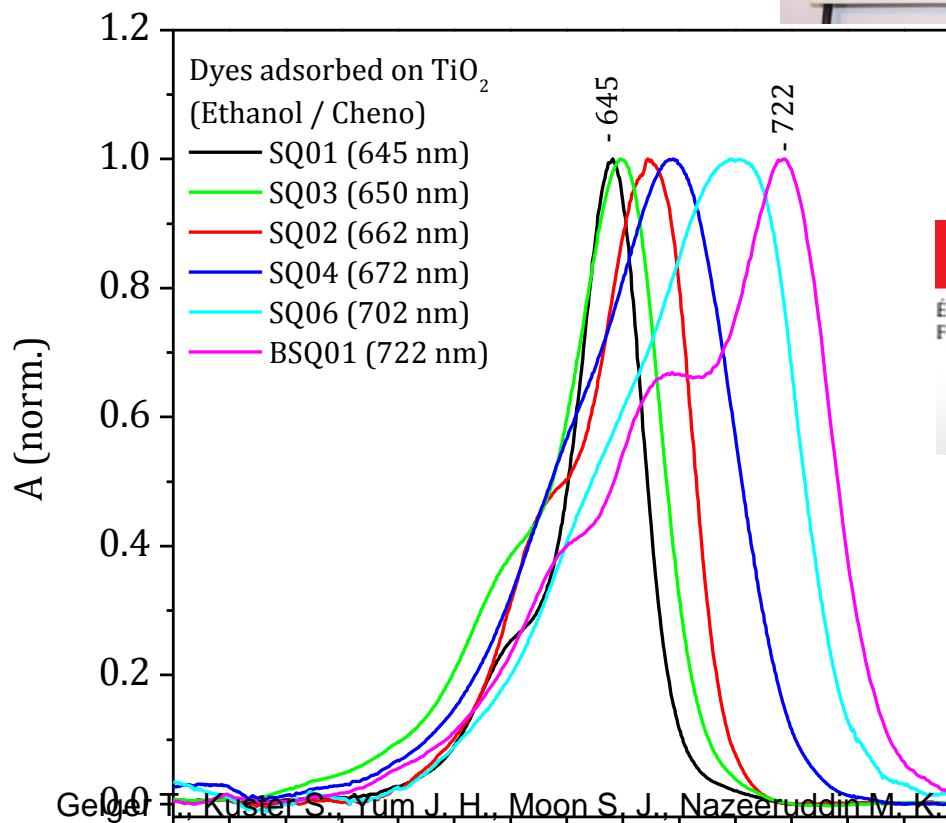
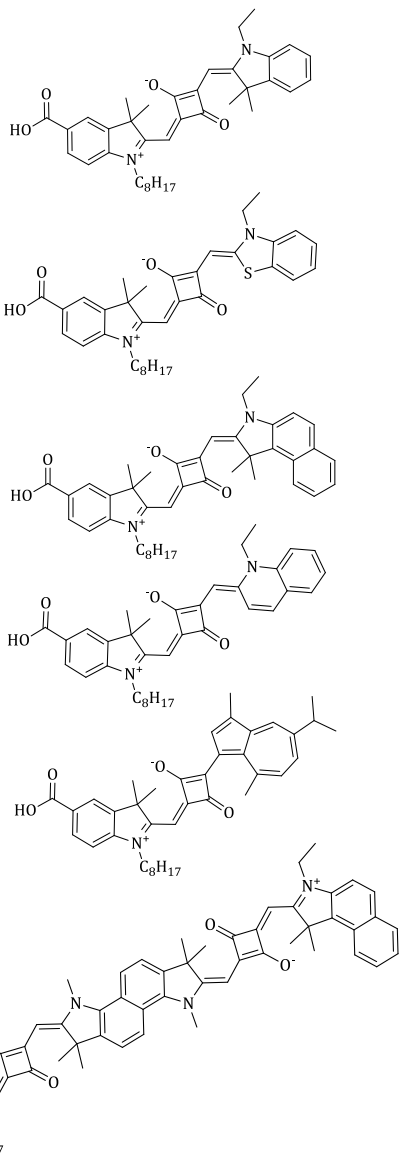


Materials Science & Technology

Big challenges in organic based PV



Squaraine dye synthesis



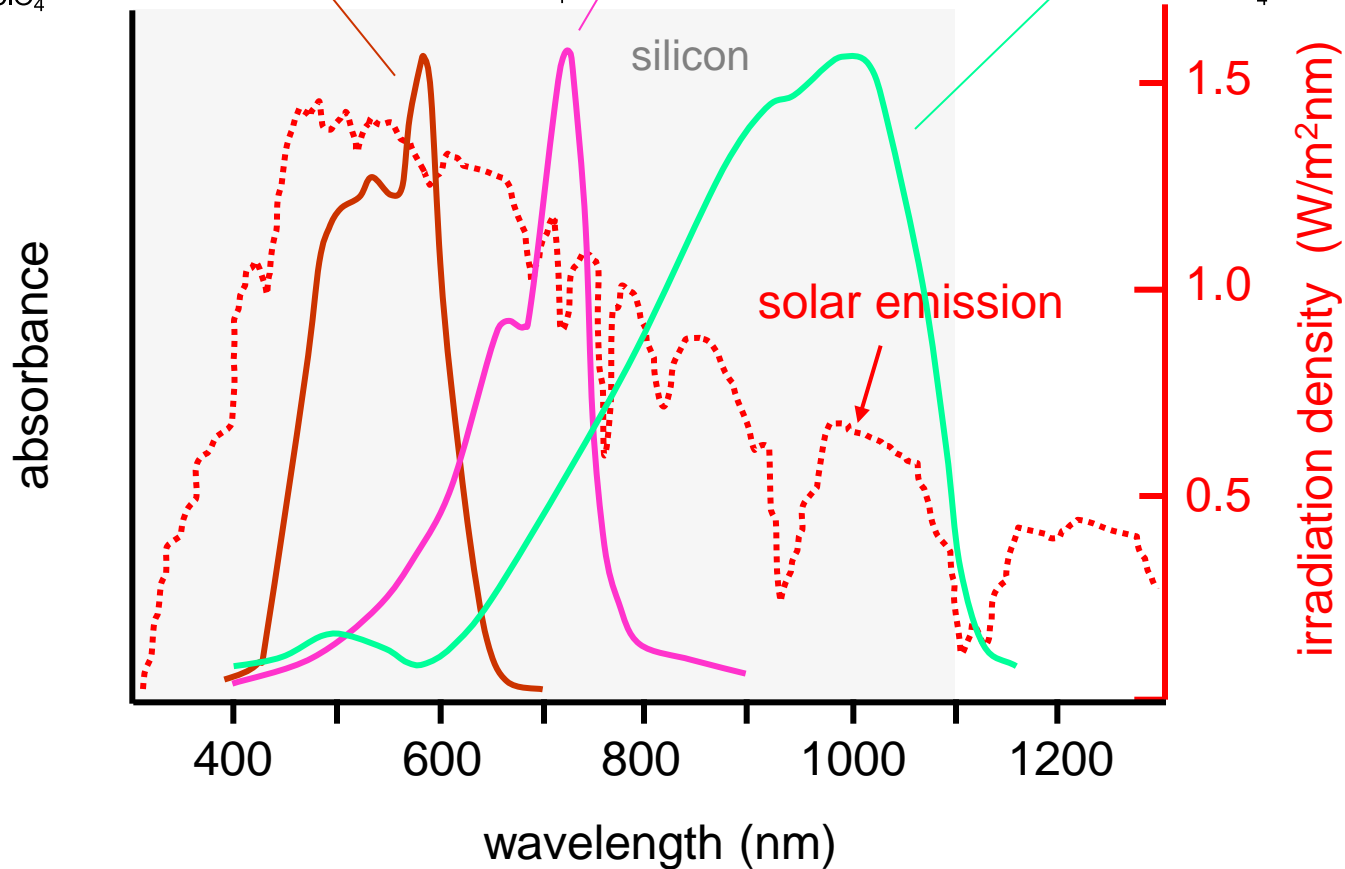
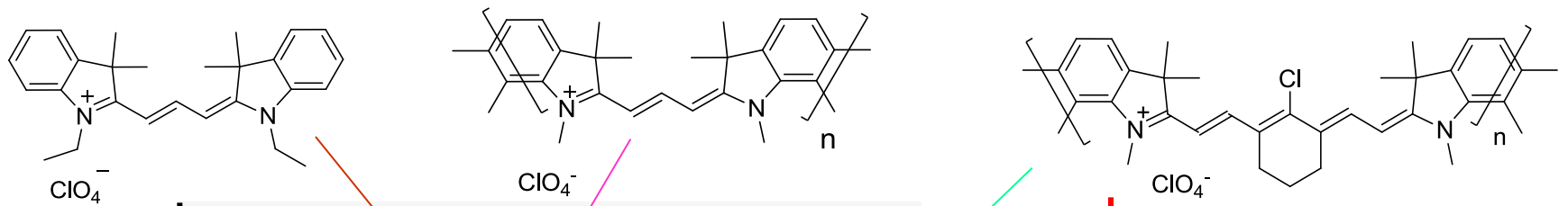
EMPA 
Materials Science & Technology

EPFL
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

 **SOLARONIX**
"in sun we trust"

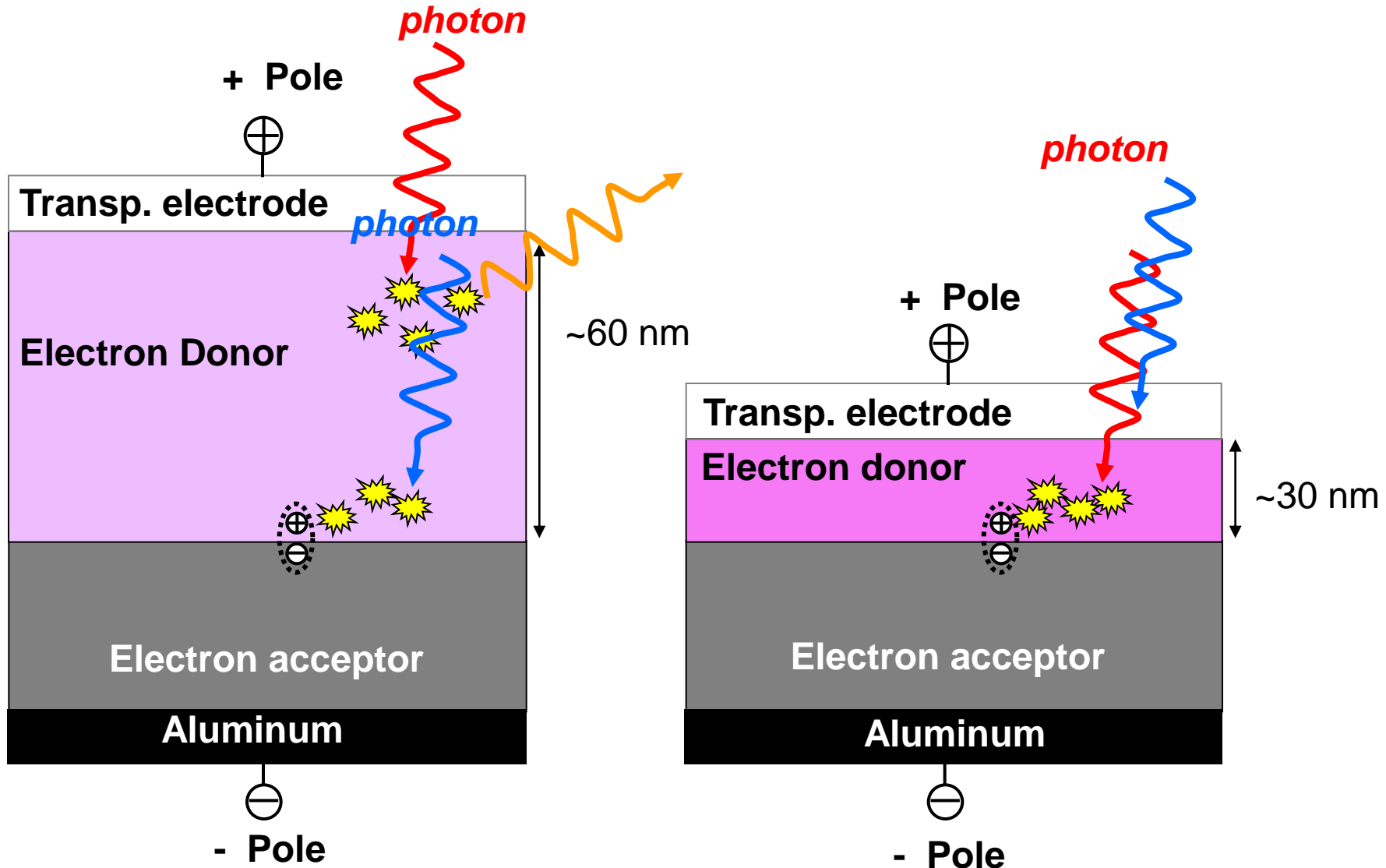
Geddes T., Kuster S., Yum J. H., Moon S. J., Nazeeruddin M. K., Gratzel M., Nuesch F., *Adv. Funct. Mat.*, 2009, 2720-2727

Cyanine dye synthesis

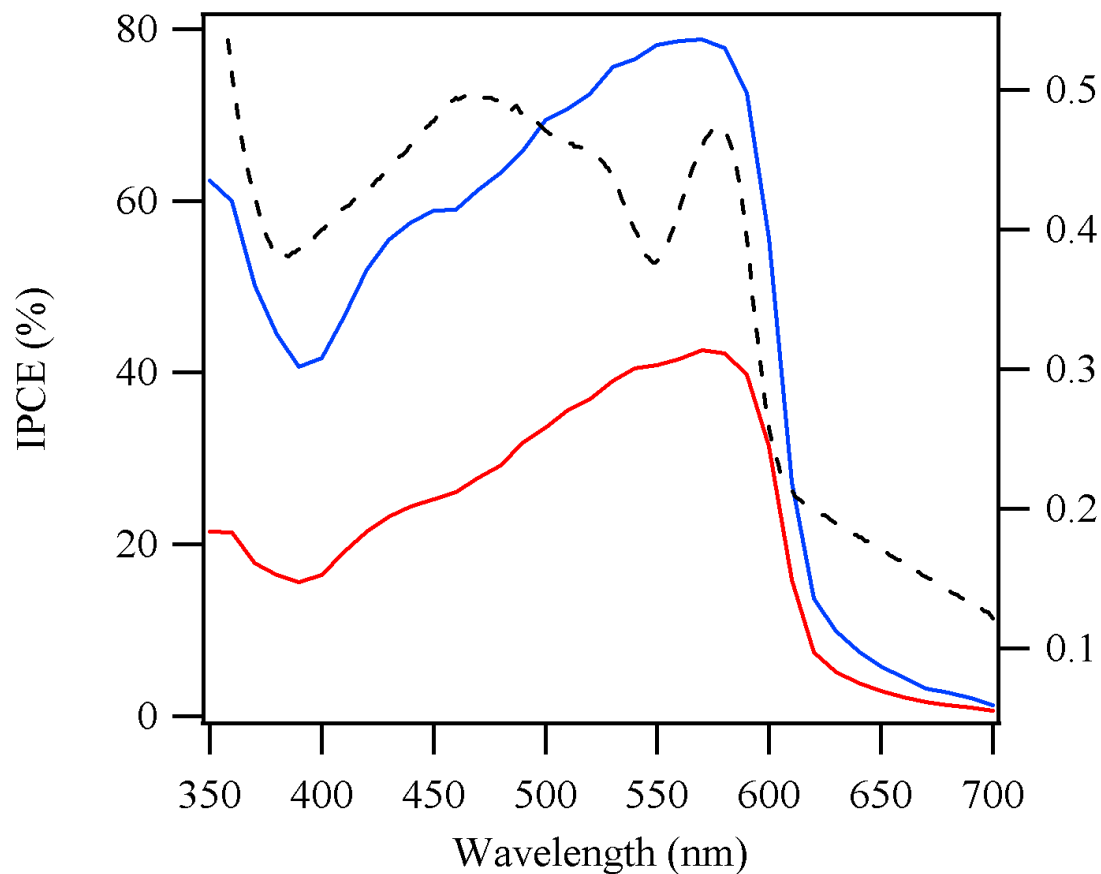


T. Geiger, H. Benmansour, B. Fan, R. Hany, F. Nüesch, *Macromol. Rapid Commun.*, 2008, 29, 651-658

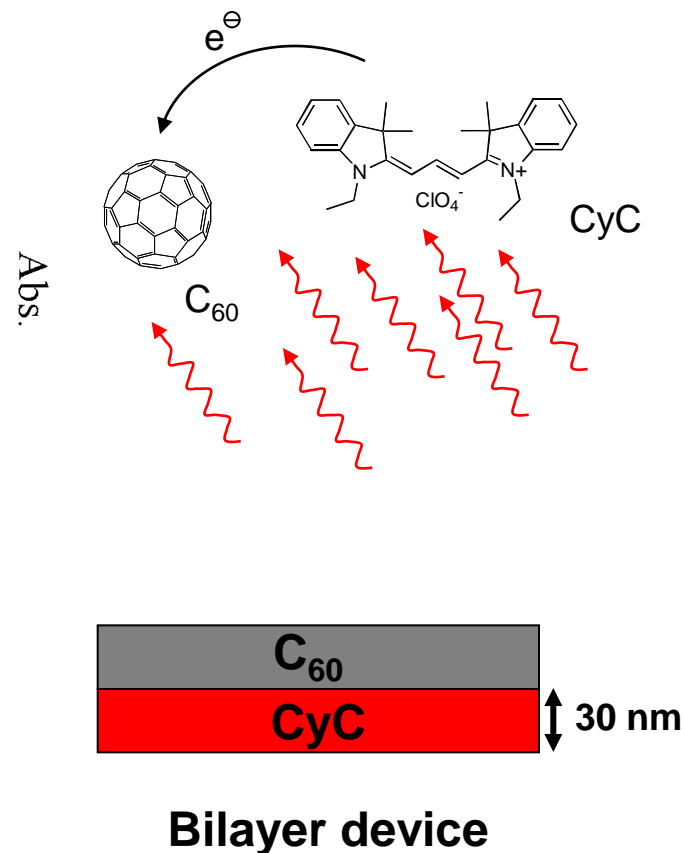
The exciton diffusion length constraint



Internal quantum efficiency close to unity

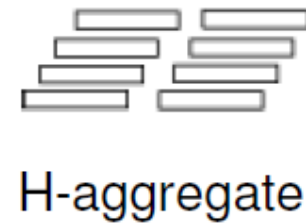
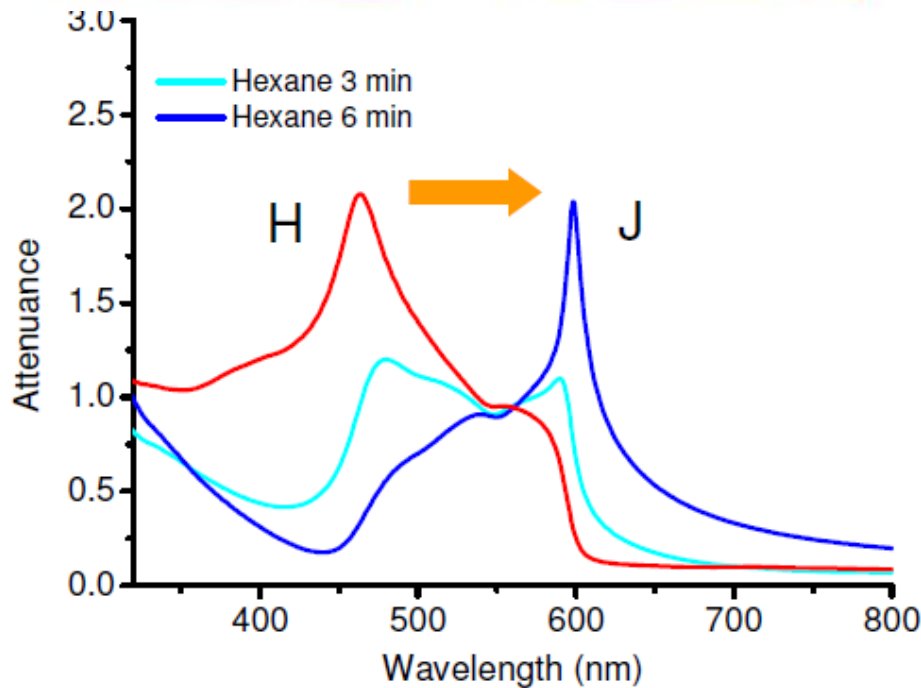
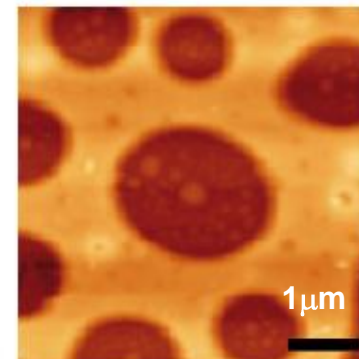
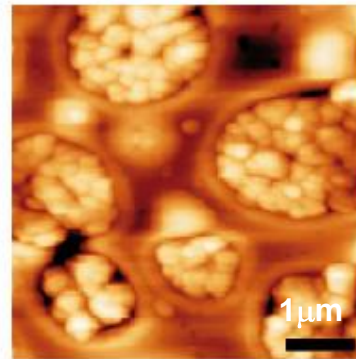
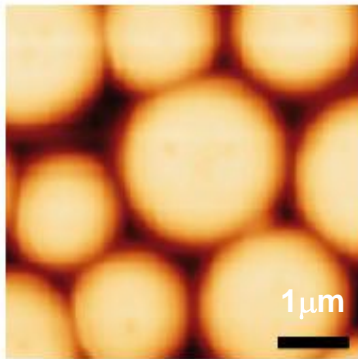


- pristine
- doped 0.02 mol/mol NOBF₄
- - - absorption



Fan B., Castro F. A., Heier J., Hany R., Nuesch F., *Org. Electron.*, 2010, 583-588

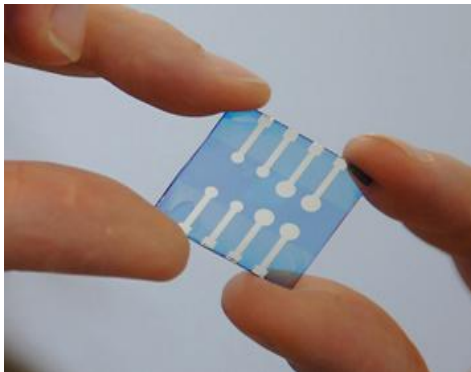
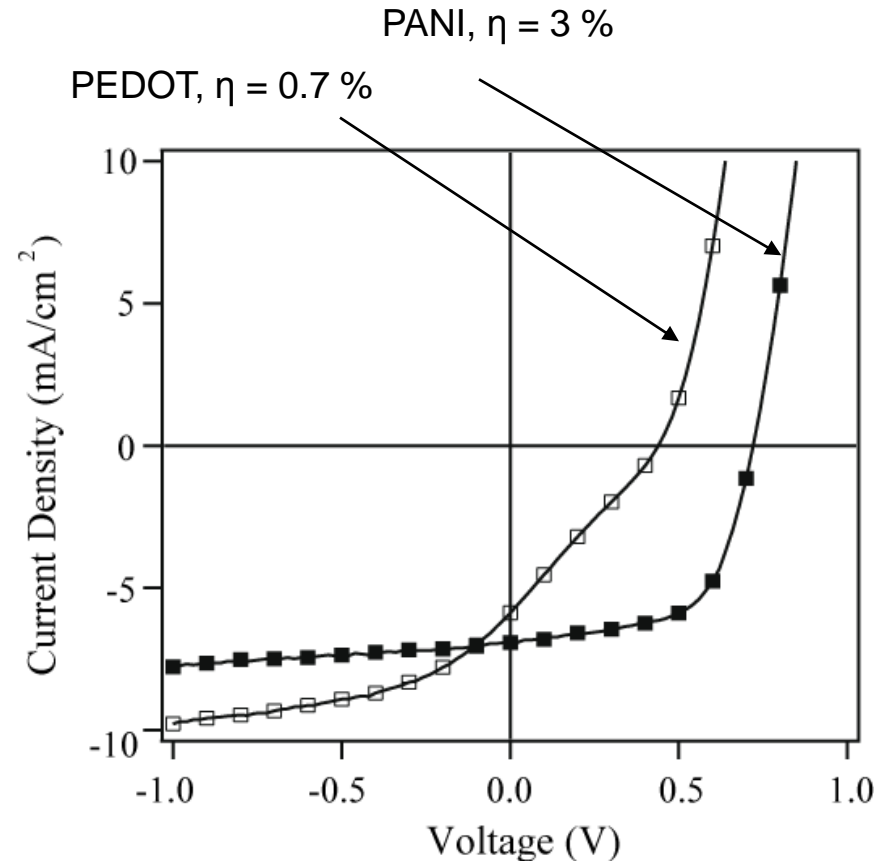
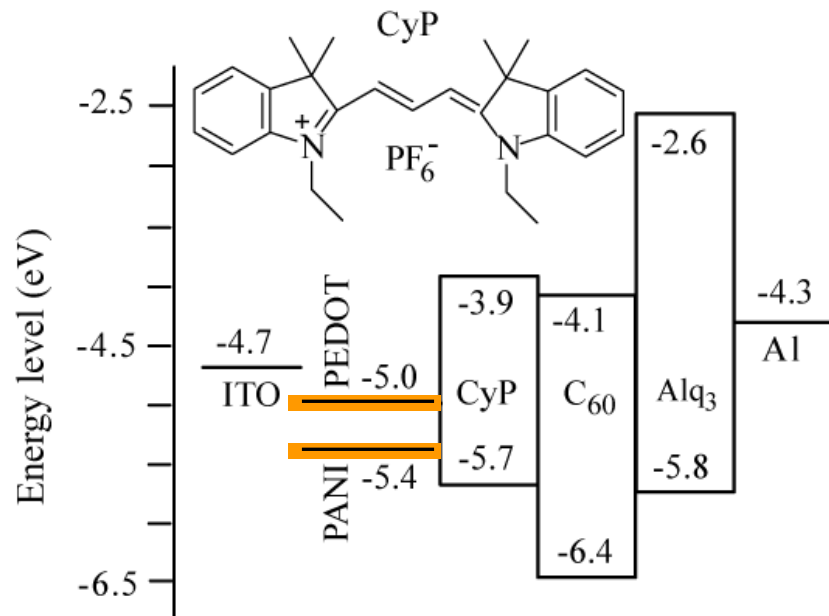
Aggregation promotes charge collection?



Hany R., Fan B., Castro F. A., Heier J., Kylberg W., Nuesch F., *Prog. Photovoltaics Res. Appl.*, Submitted.

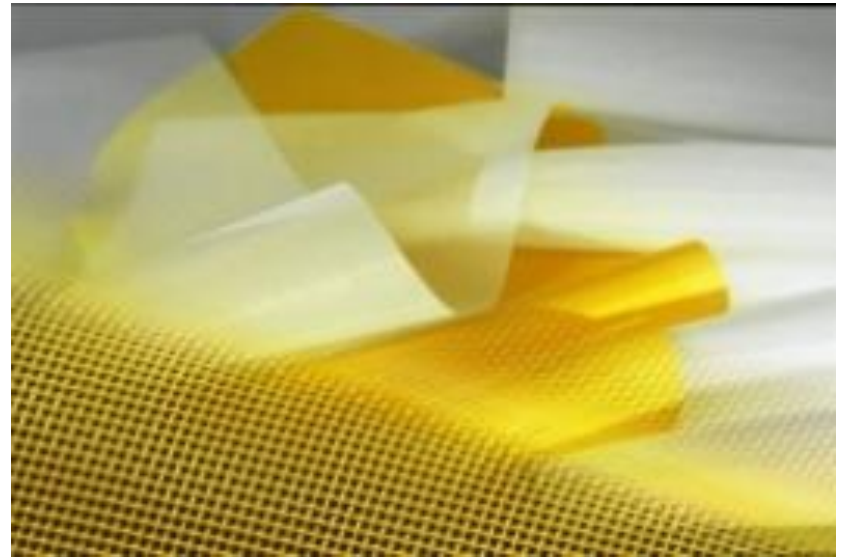
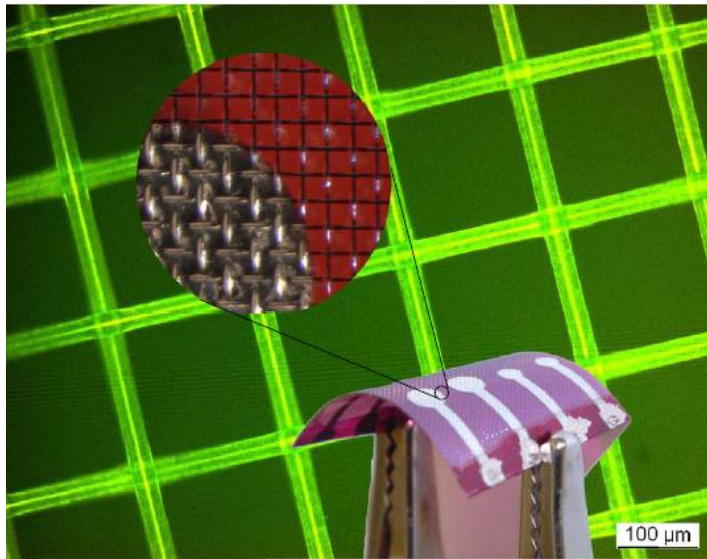
J. Heier, R. Steiger, F. Nüesch, R. Hany, *Langmuir* **2010**, doi: 10.1021/la903313k

Towards high performance *bilayer* cyanine solar cells – Energy level matching



Fan B., Castro F. A., Tsu-Te Chu B., Heier J., Opris D., Hany R., Nuesch F.,
J. Mater. Chem., 2010, 2952-2955

Transparent, flexible precision fabric electrodes for OPV



- **Transparent flexible electrode to replace ITO on glass/PET**
- **Polymer solar cells optimal for flexibility**

German Patent No. DE102008055969.5

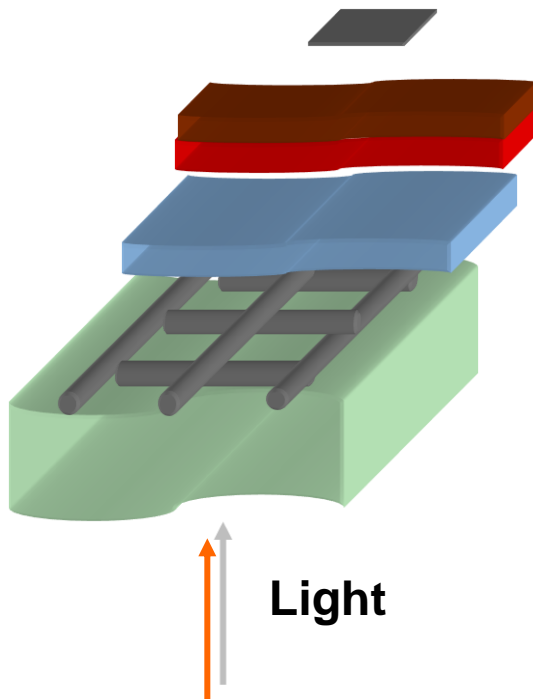
Castro F. A., Chabreck P., Hany R., Nuesch F., *Phys. Status Solidi RRI*, 2009, 3, 278

Properties of fabric electrodes

Sheet resistance

PET-ITO: 40-80 Ω/\square

Fabric: 1-10 Ω/\square



Al contact

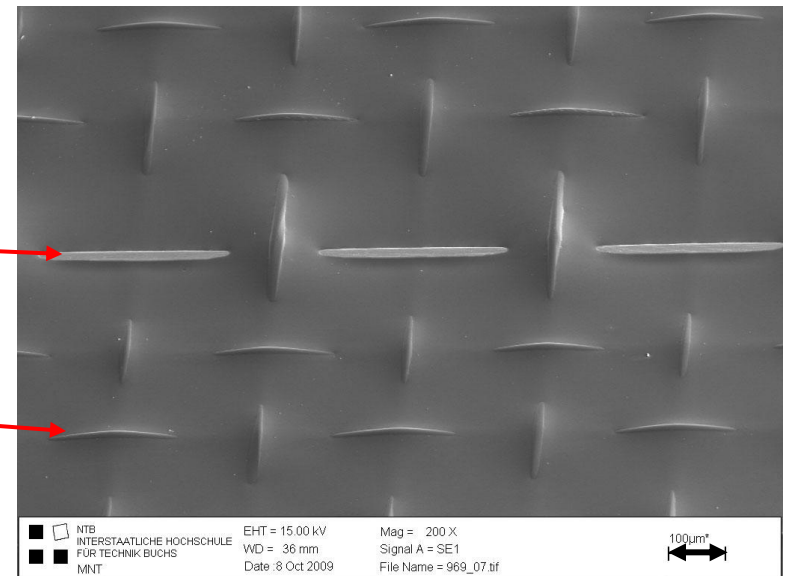
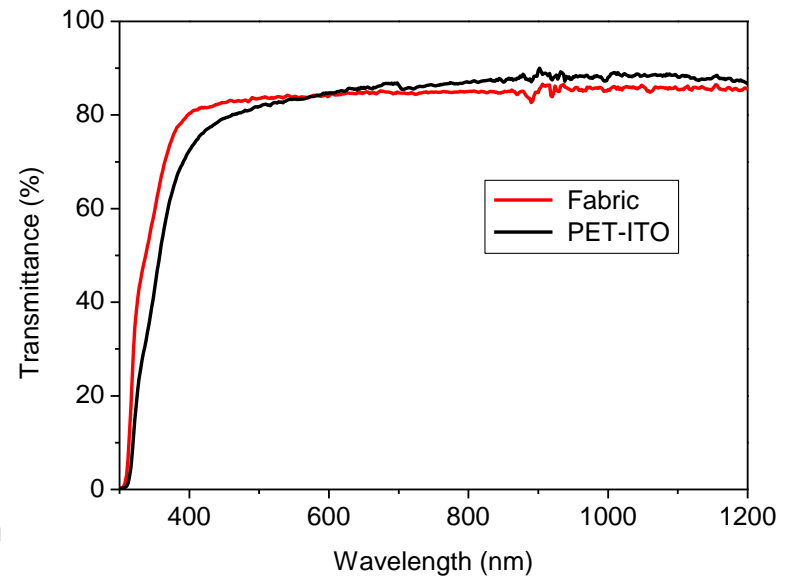
Active layer ~ 100-200 nm

PEDOT:PSS ~ 100-1000 nm

Fabric substrate

Metal fibre

Polymer fibres
with polymer filling



100 μm

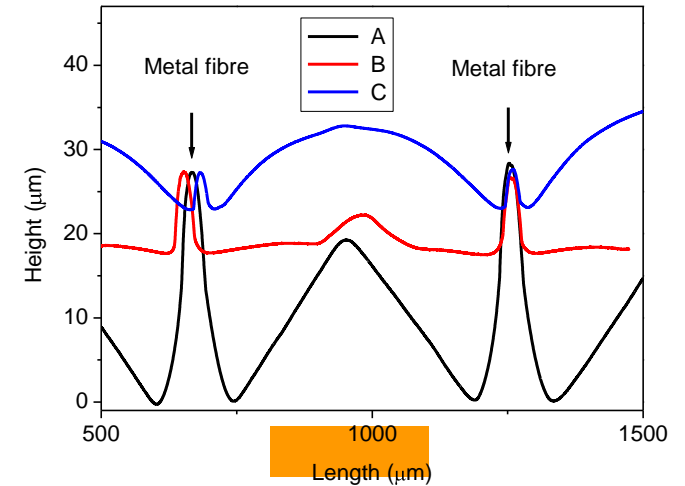
Substrate „smoothness“

Devices with Bulk heterojunction structure

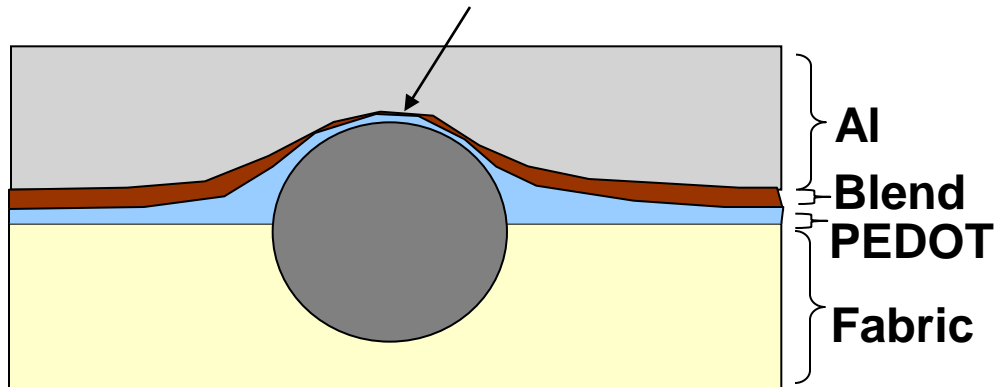
P3HT:PCBM blend (state-of-the-art)

The diagram illustrates the device structure and the chemical components. On the left, the chemical structures of P3HT (poly(3-hexylthiophene)) and PCBM (phenyl-C61-butyric acid methyl ester) are shown. The central part shows a cross-section of the device with a substrate, a layer of the P3HT:PCBM blend, and a metal fibre. A yellow arrow indicates the position of the metal fibre. A circuit diagram above shows a current source connected to the metal fibre and the substrate.

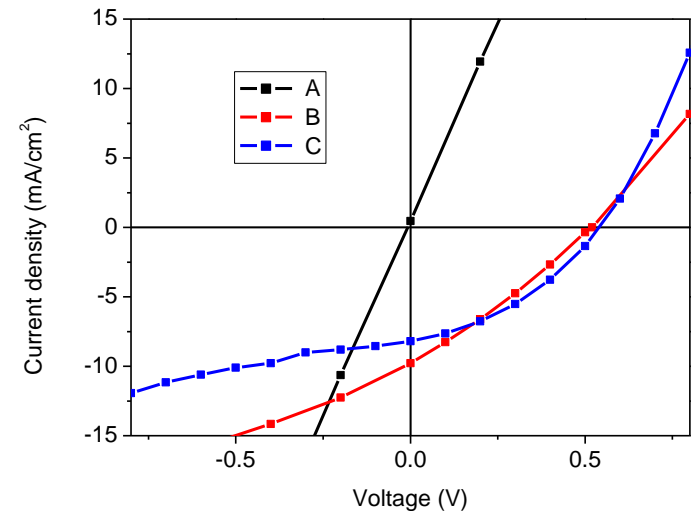
Profile



Critical area where short circuit could happen

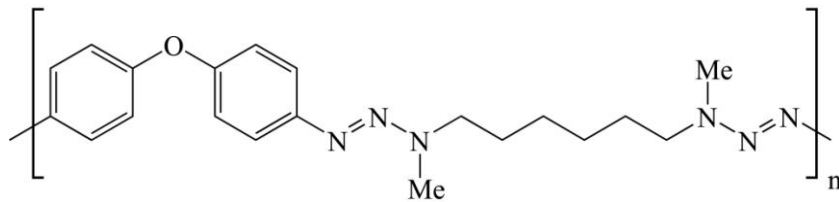


Device I-V curves



Laser-induced forward transfer using a photodynamic release layer

Use of a UV-sensitive dynamic release layer

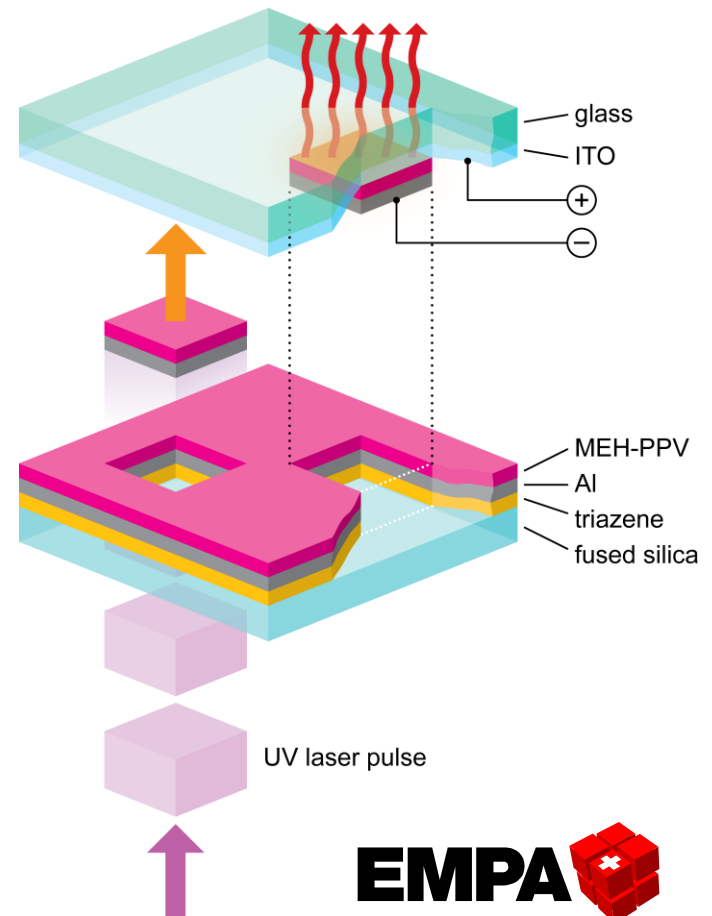


triazene polymer

Advantages :

- Dry transfer technique → not limited by the solvent
- Three-dimensional structuring allowed
- Low thermal impact, debris-free ablation

M. Nagel et al., *Macromol. Chem. Phys.*, 208 (2007), 277-286

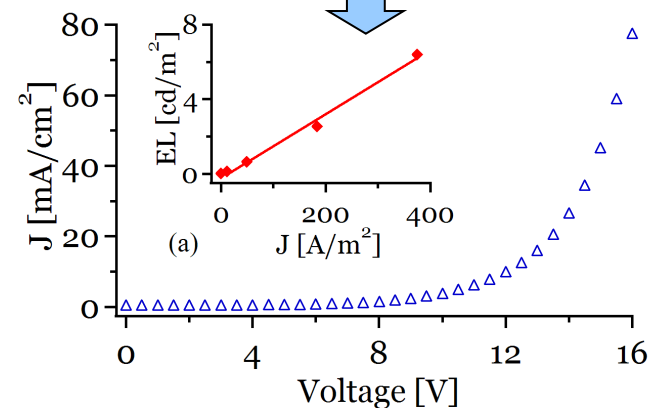
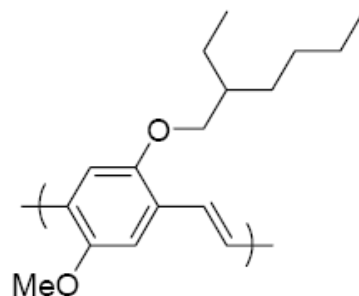
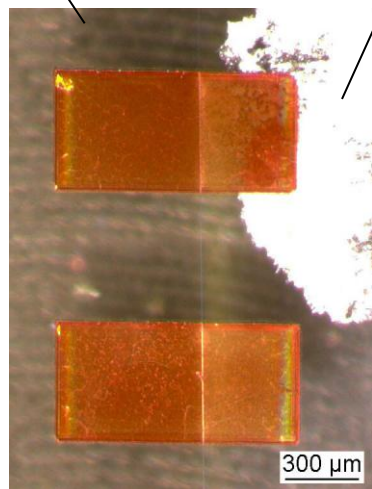
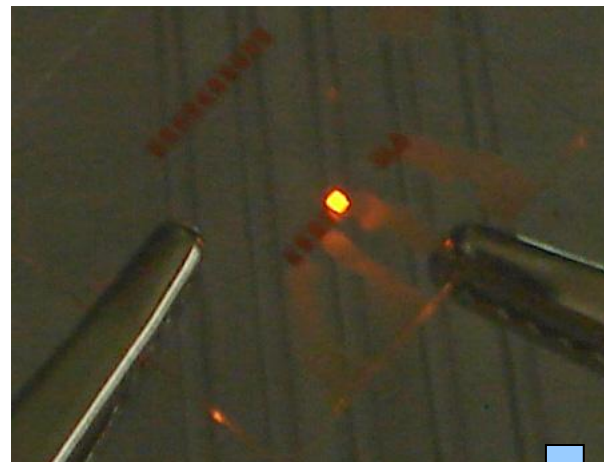
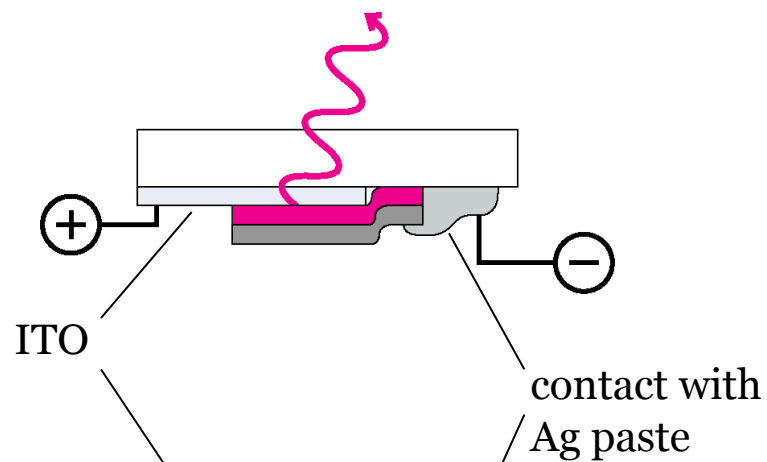


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OLED fabricated by the LIFT method



R. Fardel et al., *Appl. Phys. Lett.* **91**, 061103 (2007)

Swiss PV platform



ThinPV Workshop: “A look inside solar cells”, 16.11-18.11. 2008, Monte Verità, Ascona. For more details see conference announcement on our webpage: <http://thinpv.empa.ch>

Conference in preparation to the CCEM project: “Photovoltaics of the Future”, 12.4.2005, Empa Dübendorf

ThinPV Workshop: “Thin Film PV - Needs and Desires from Industry”, 5.10. 2007, Empa Dübendorf

ThinPV Conference: “Transparent Conducting Electrodes for Photovoltaics”, Stade de Swiss, Bern, January 25th in 2010.

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Marina Simeunovic

Simon Kuster

Dr. Thomas Geiger

EPFL

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Prof. M. Grätzel

PSI

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ETHZ

Prof. D. Schlüter

Sefar

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U. Sondenegger

Solaronix

T. Meyer

Physical & Colloid

Chemistry (University of Utrecht)

Dr. Jan Groenewold



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research



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Eidgenössisches Volkswirtschaftsdepartement EVD
Bundesamt für Berufsbildung und Technologie BBT
Förderagentur für Innovation KTI