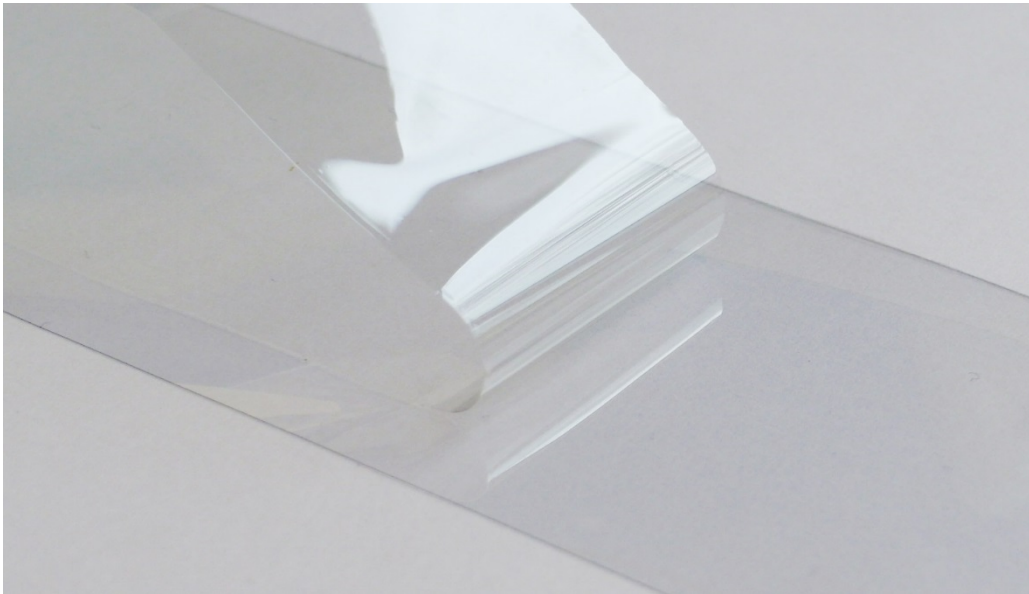

Surface modification of polyethylene terephthalate (PET) and oxide coated PET for adhesion improvement

AIMCAL 2016 Dresden



Juliane Fichtner

Tobias Beck

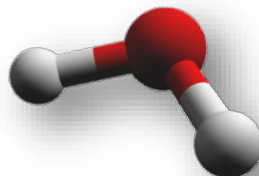
Frank Simon (IPF, Dresden)

Motivation

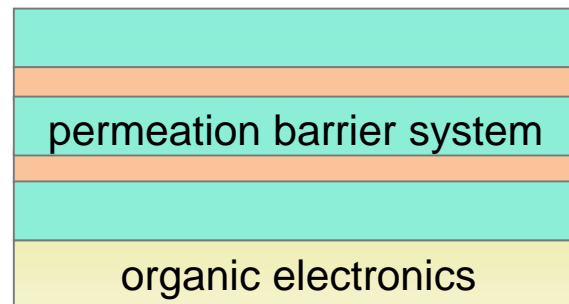
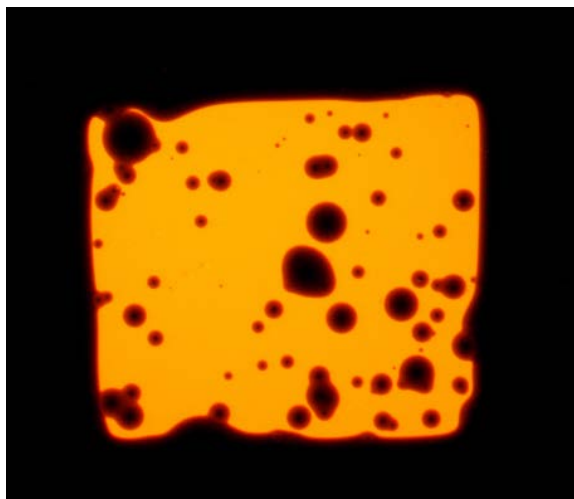
oxygen



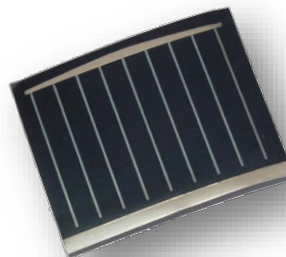
water vapor



organic electronics



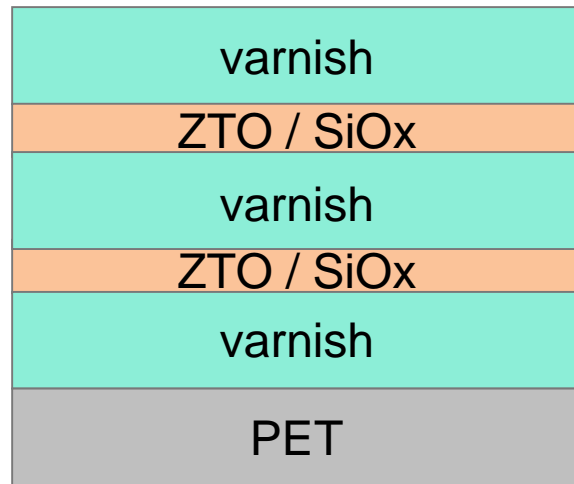
flexible solar cell



flexible OLED



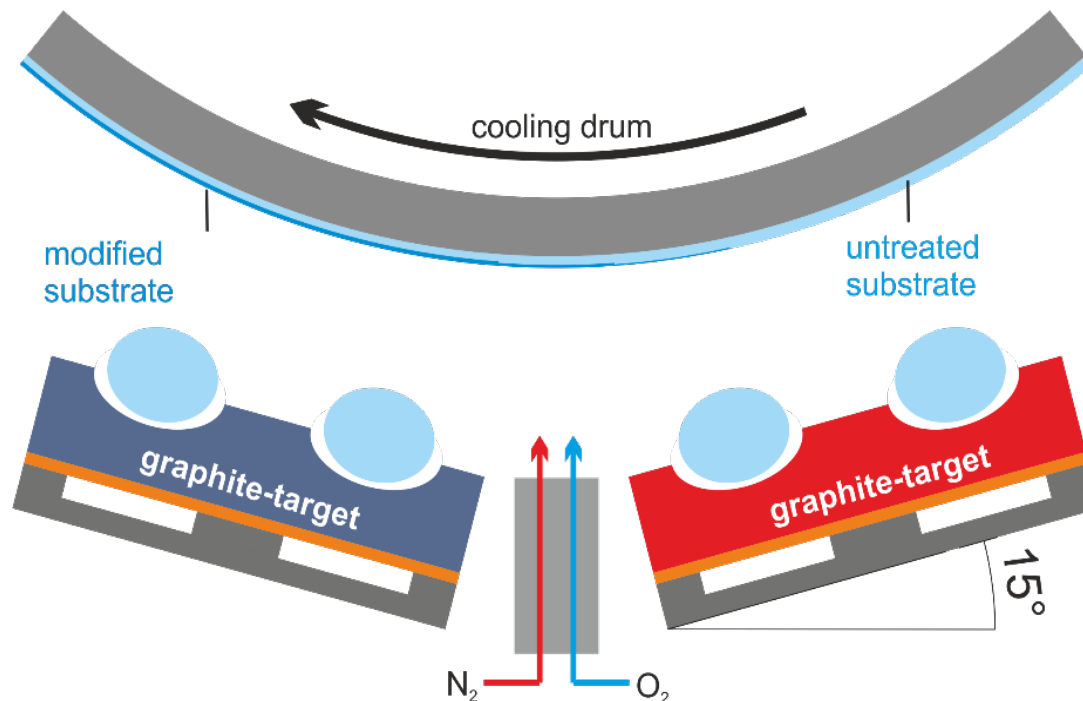
Motivation



➔ sufficient wetting behaviour and adhesion for good performance necessary

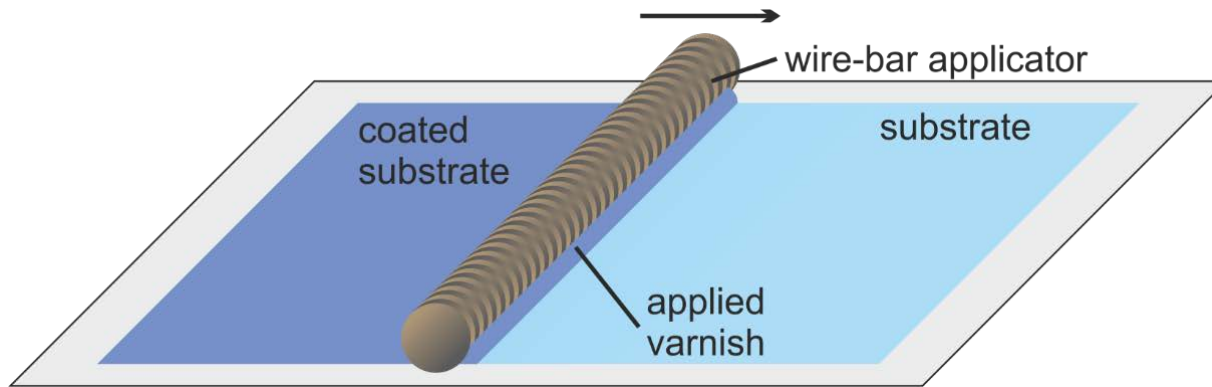
BUT low surface energy ➔ **surface modification**

Process parameter – low-pressure plasma treatment

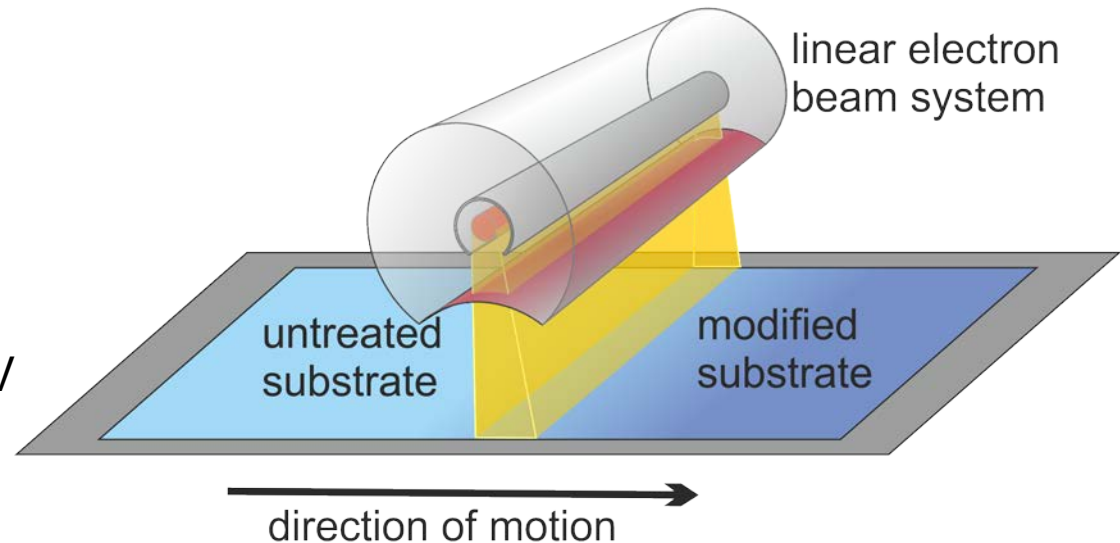


- electrical power: 1 – 5 kW
- web speed: 1 – 5 m/min
- process pressure: 0,5 – 2,5 Pa
- dual magnetron, bipolar mode

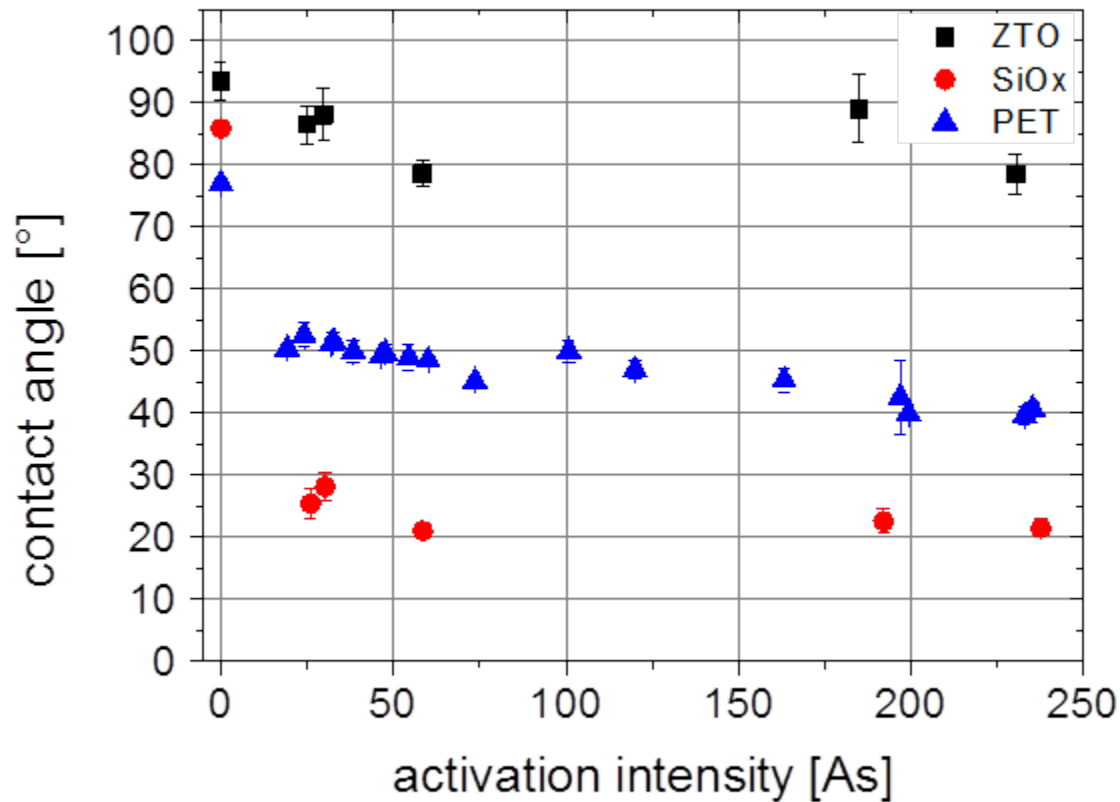
Varnish layer manufacturing



- acrylic based varnish
- Layer thickness: 10 μm
- curing dose: 25 kGy
- Acceleration voltage: 150 kV
- Electron current: 2 mA
- Motion speed: 150 mm/s

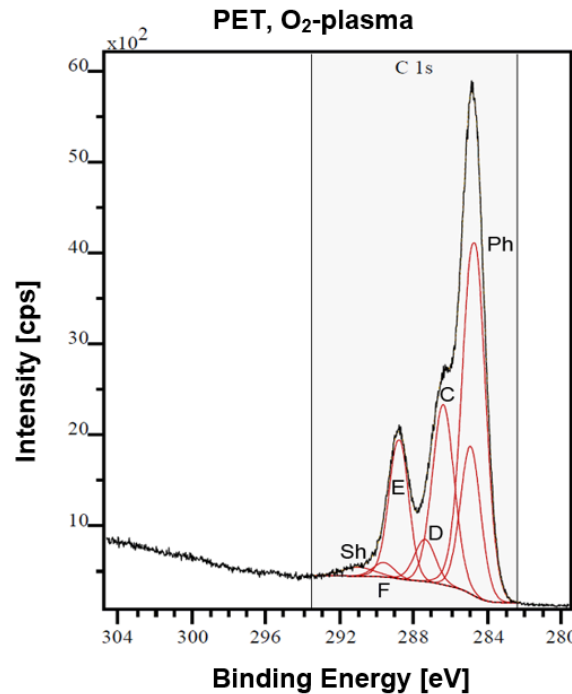
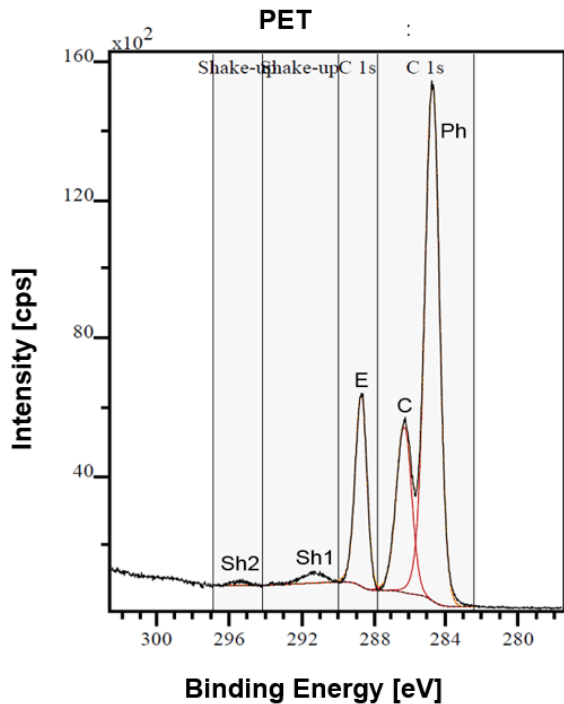


Contact angle – O₂-plasma

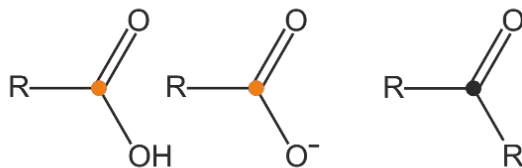
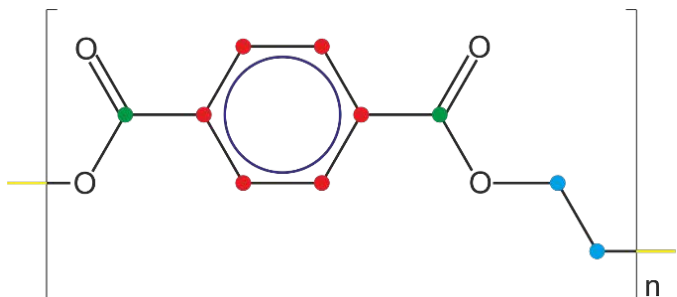


- Contact angle ↓
- ZTO → surface cleaning
- PET + SiO_x → surface modification

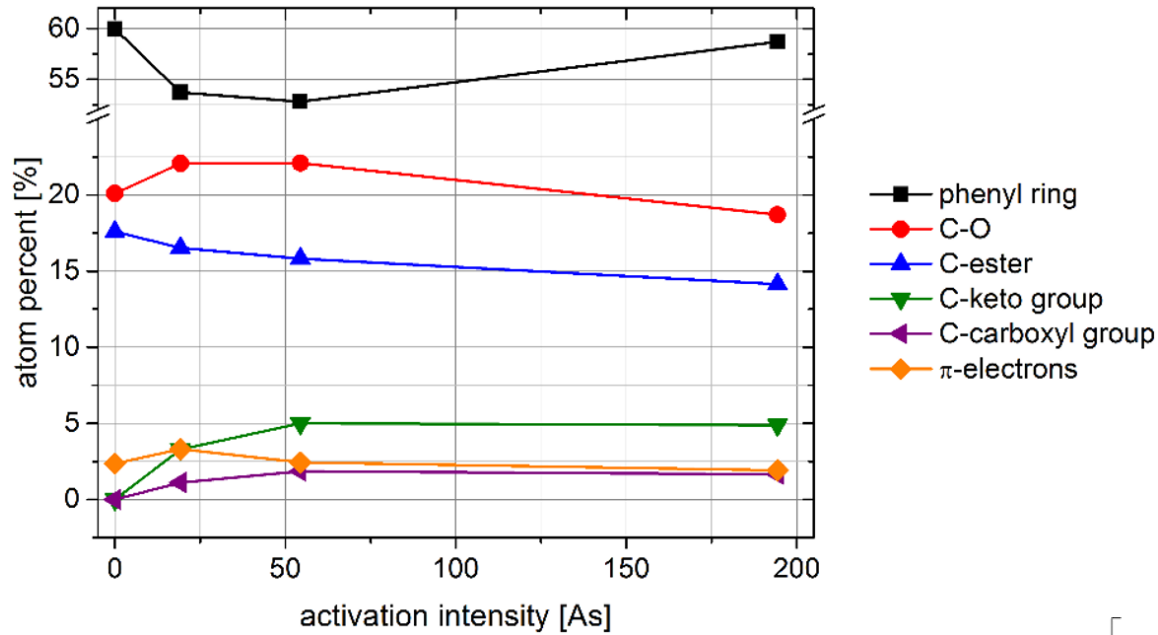
XPS - PET - O₂-plasma



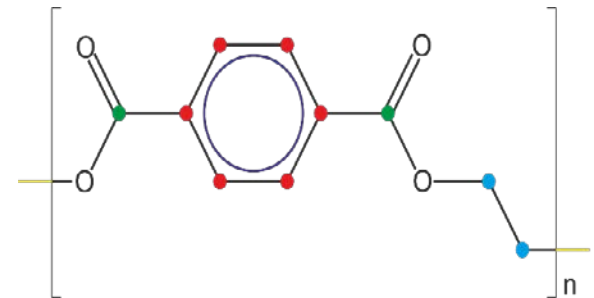
- Ph** C-atoms of phenyl ring
- C** C-atoms with one O-atom
- E** C-atoms carboxylic acid ester
- Sh** Peaks of π-electrons
- D** C-atoms of keto group
- F** C-atoms of carboxyl group



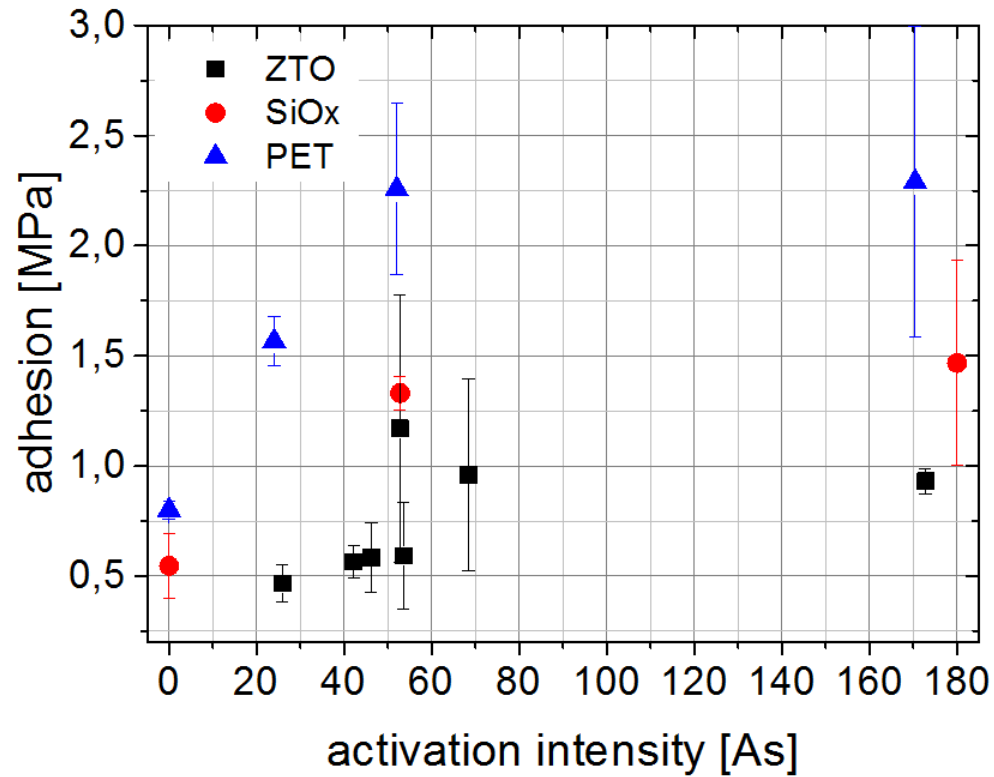
XPS - PET - O₂-plasma



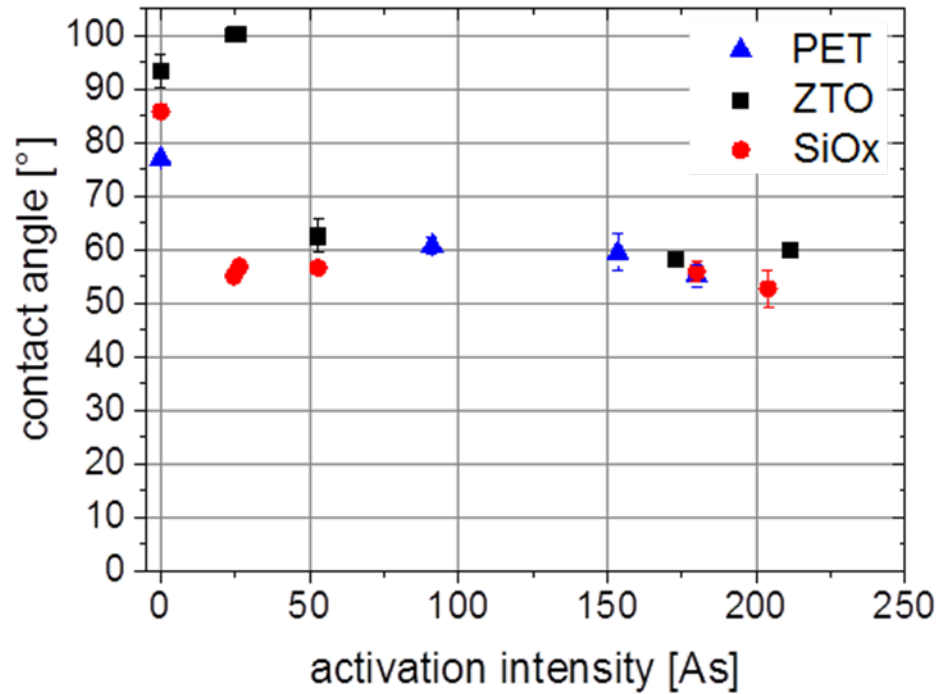
- Carboxylic acid ester ↓ + carboxyl group ↑ →



Varnish adhesion - O₂-plasma

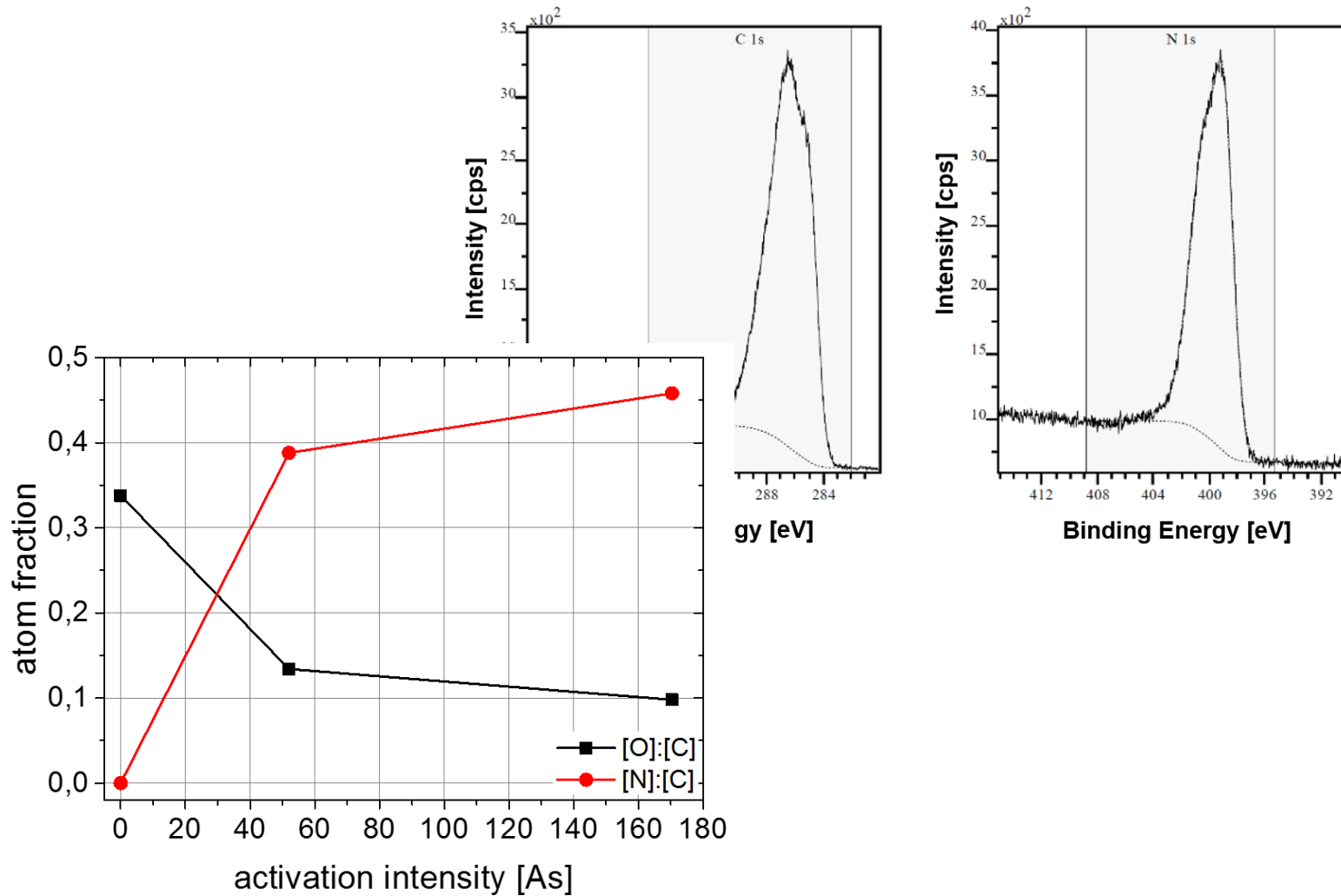


Contact angle – N₂-plasma

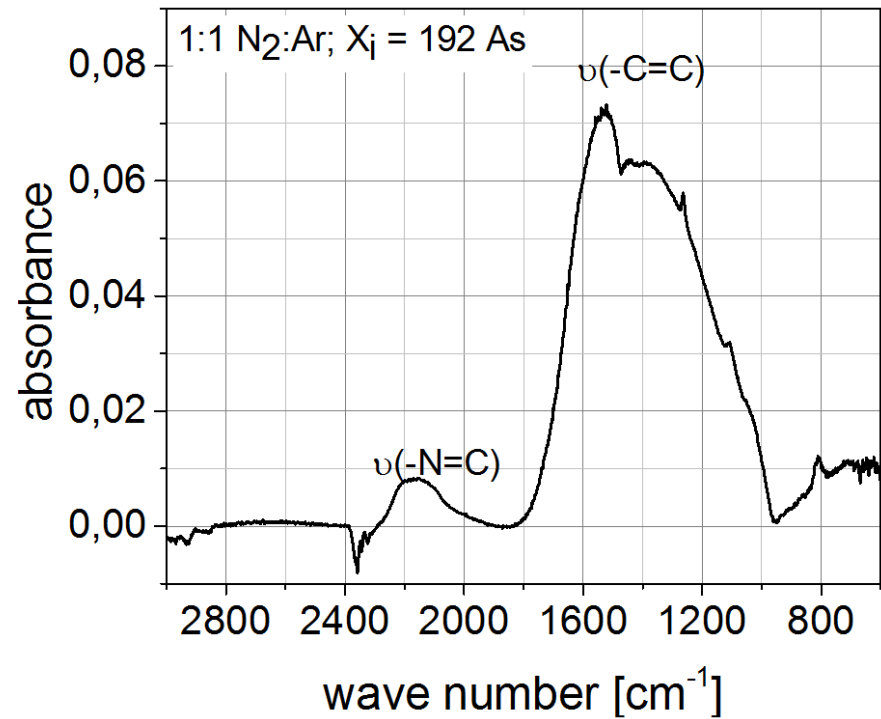
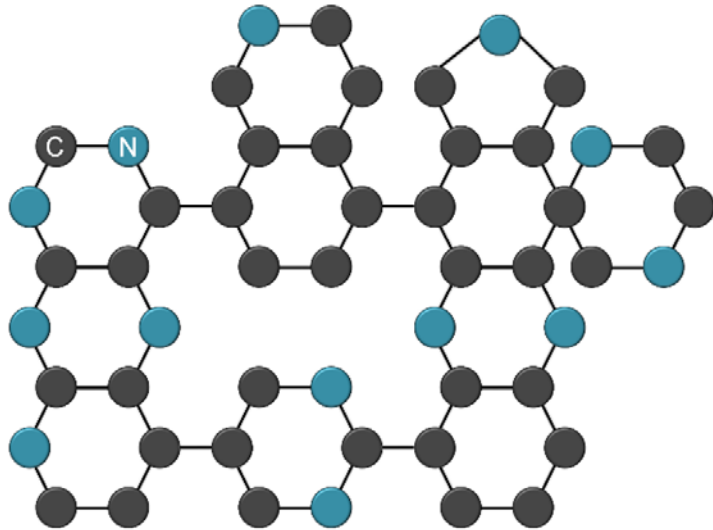


- Contact angle decreases to a similar level for all substrates

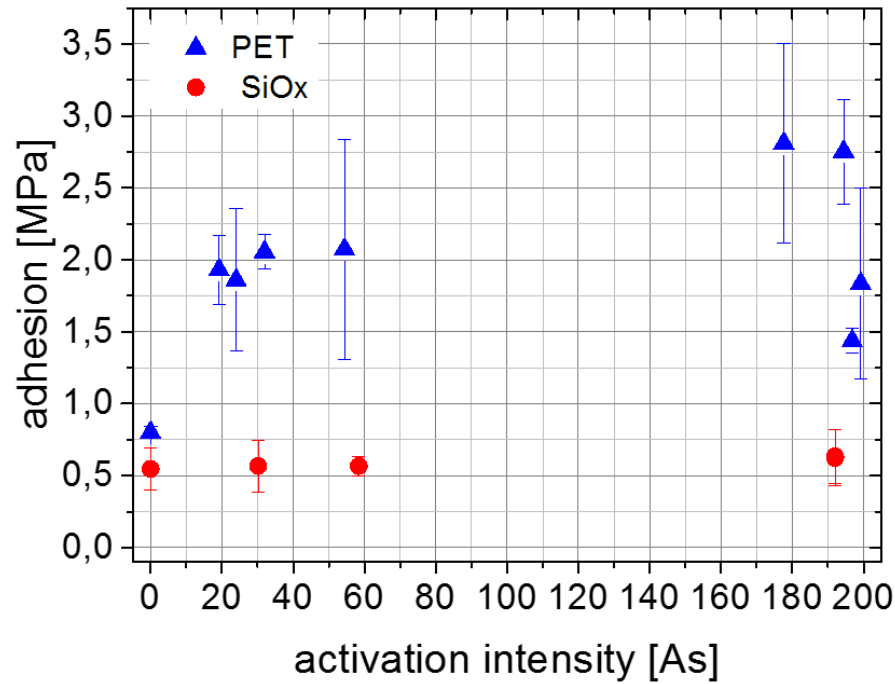
XPS - PET - N₂-plasma



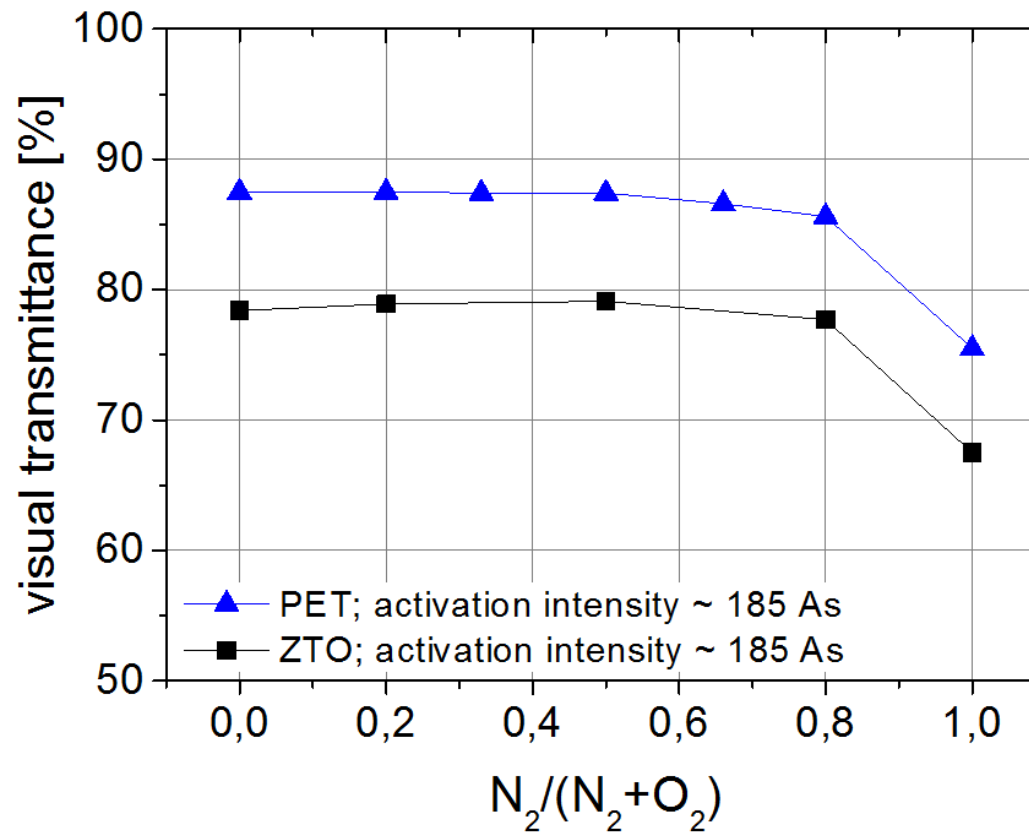
FTIR-ATR - N₂-plasma



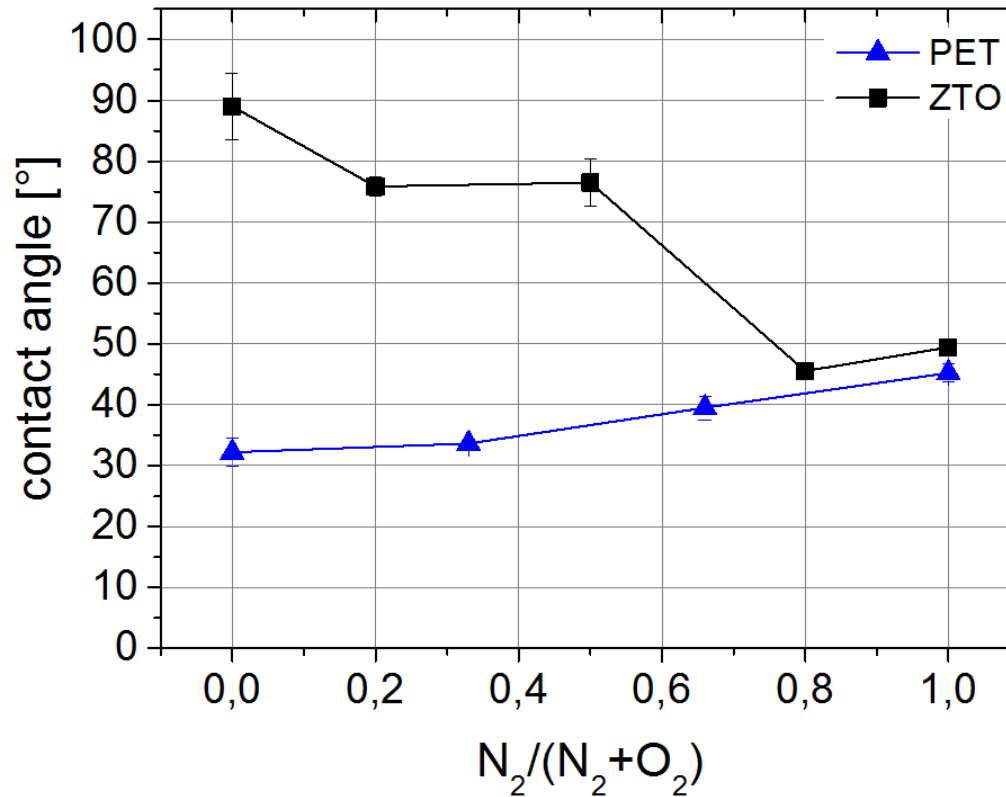
Varnish adhesion - N₂-plasma



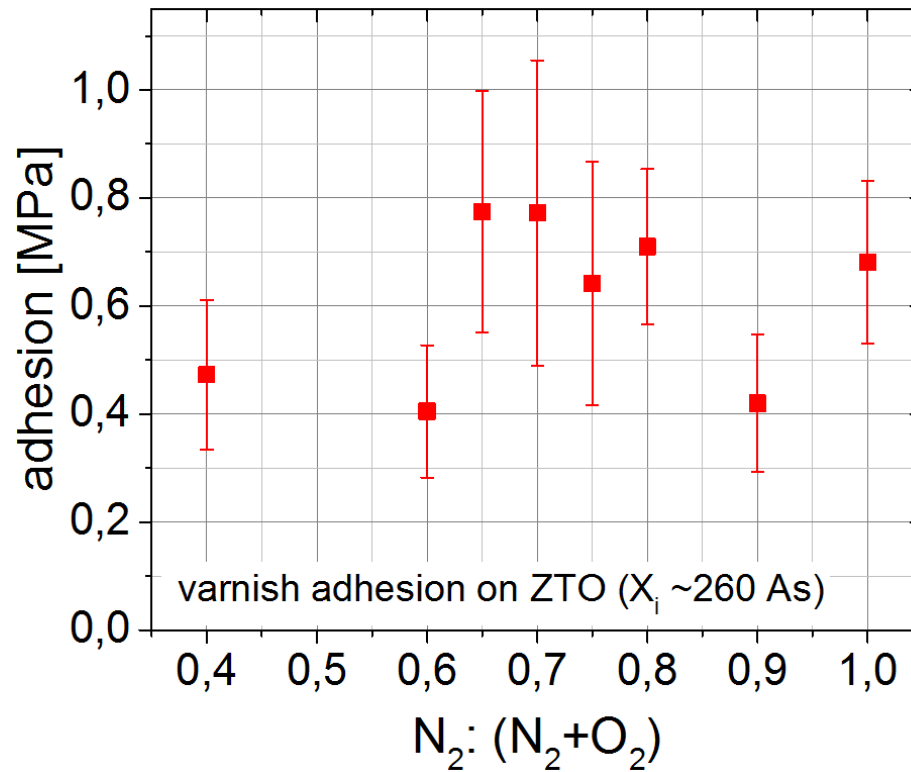
Process gas mixtures - Visual transmittance



Process gas mixtures – contact angle



Process gas mixtures – varnish adhesion



Permeation rate

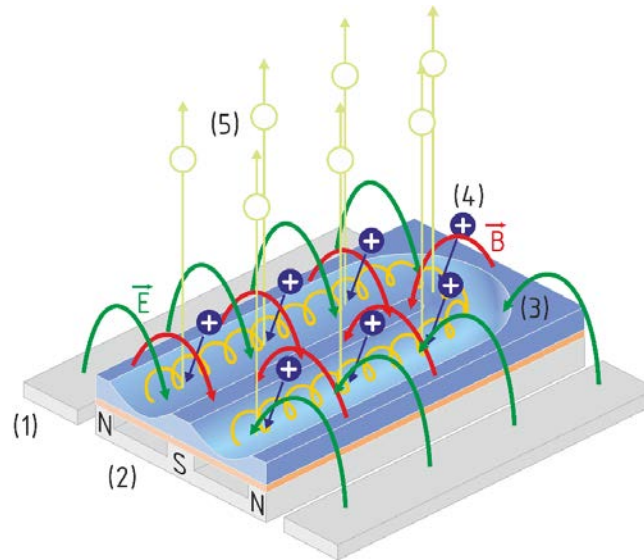
plasma gas	X_i [As]	WVTR [g/(m ² *d)]	OTR [cm ³ /(m ² *d*bar)]
x	x	0,067	0,25
N ₂	172,8	0,069	0,2
O ₂	184,8	0,076	0,3

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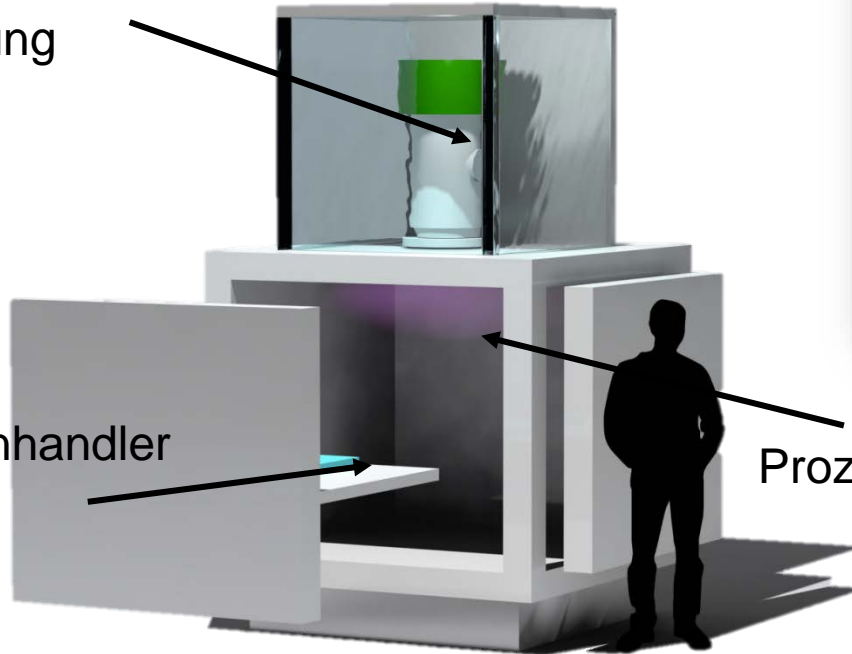
Double magnetron



1) Anode, 2) Permanentmagnet, 3) Target (Kathode), 4) auftreffende Ionen, 5) gesputterte Teilchen. Die grünen Pfeile zeigen die Richtung des elektrischen Feldes, rote Pfeile die Richtung des Magnetfeldes und orange sind die Elektronenbahnen dargestellt.

REAMODE

Elektronenstrahl-
erzeugung



Prozessraum

Probenhandler
linear

atmospheric pressure electron beam radiation

- acceleration voltage: 150 kV
- ion power: 2 mA
- motion speed: 15 – 140 mm/s
- atmosphere: air, N₂