SuSoS

Because Surface Matters.™

Hochauflösende Oberflächenanalytik an Polymer Substraten

SuSoS AG

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Topic

- SuSoS
- Thin film and thin film analysis
- Polymers and polymer films: strengths and weaknesses
- Examples:
  - Detection of contaminants on surfaces
  - Activation of polymer surfaces
  - Roughness of a thin film by XPS
  - Chemical imaging and Orientation of Thinfilms
- Summary

SuSoS

✓ SuSoS because surface matters. A lot.

- We focus on those 50 nanometers that make the difference, so our customers can take care of everything else.

✓ SuSoS because surface is tough.

- But solutions must be simple.

✓ SuSoS because truly understanding is most of the solution.

- Guiding customers through hard decisions is key to long-lasting relationships.

SuSoS Functional Polymer Thinfilms

- Applications
  - Medical Devices
  - Microfluidics
  - Diagnostics
  - And many more…
- Functionalities
  - Non-Fouling
  - High Lubricity in wet and dry state
  - Adhesion of anything to anything
  - Selective bonding
  - And even more…

SuSoS SURFACE TECHNOLOGY

Thin film and thin film analysis

- At SuSoS we focus on the **topmost atomic/molecular layers** of a product
- Surface Analysis Techniques at SuSoS:
  - X-ray Photoelectron Spectroscopy → **qualitative and quantitative** evaluation of chemical/atomic composition
  - Time of Flight Secondary Ion Mass Spectrometry → qualitative chemical/molecular composition
  - Variable Angle Spectro Ellipsometry → Thin Film Thickness
  - Micro Tribology and Indentation → Friction and Lubricity
  - Microscopy/AFM → Optical Appearance and Surface Roughness
  - Particle Counting → Amount of Particles in Solutions

Method	X-Ray Photoelectron Spectroscopy	Time of Flight Secondary Ion Mass Spectrometry	Energy Dispersive X-Ray Spectroscopy
	XPS	ToF-SIMS	EDX
Information depth	5-10 **nm**	1-2 **nm**	1-3 **µm** (= 1’000-3’000 nm)

Polymers and polymer films: strengths and weaknesses

Why Polymers?

- As Substrate
  - Often used in Medical Devices, Diagnostics or Microfluidics
  - Injection molded substrates are flexible, easy to produce with high accuracy and very small features and structures
  - High throughput with constant quality
- As Thin Film Coating
  - Functional groups can be easily exchanged and tuned to customer needs
  - With the right binding group polymer thin films can be bound to any substrate, even polymers
  - High flexibility, throughput and tunability

What obstacles in analysis can occur?

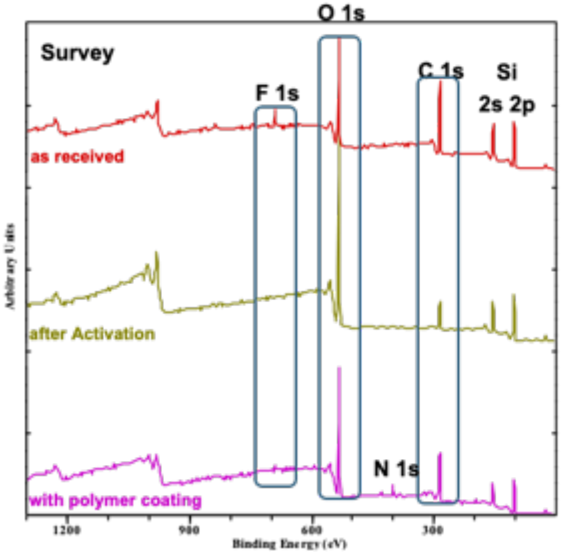
- Lack of Conductivity
- Carbon is Carbon
- Roughness
- De-gassing behavior

How can some of these be overcome for example with XPS?

- charge compensation
- different binding partners = different binding energy
- Nano morphology can be analyzed

XPS Standard measurements

- Detection of contaminants on surfaces → Silicone Substrate with superficial C-F_2 Contamination
- Activation of polymer surfaces → O2 plasma treatment reduces contamination levels and activates surface for further treatment/coating
- Evaluation of Polymer Coatings on Polymer Substrates → Non-fouling coating on silicone substrate can be detected due to additional coating related elements and binding groups



At.-%	C	O	N	F	Si
As received	45.7	26.8	0.0	2.8	24.7
after O2 plasma	18.5	53.9	0.0	0.0	27.6
Non fouling coating	40.3	34.0	4.3	0.7	20.6

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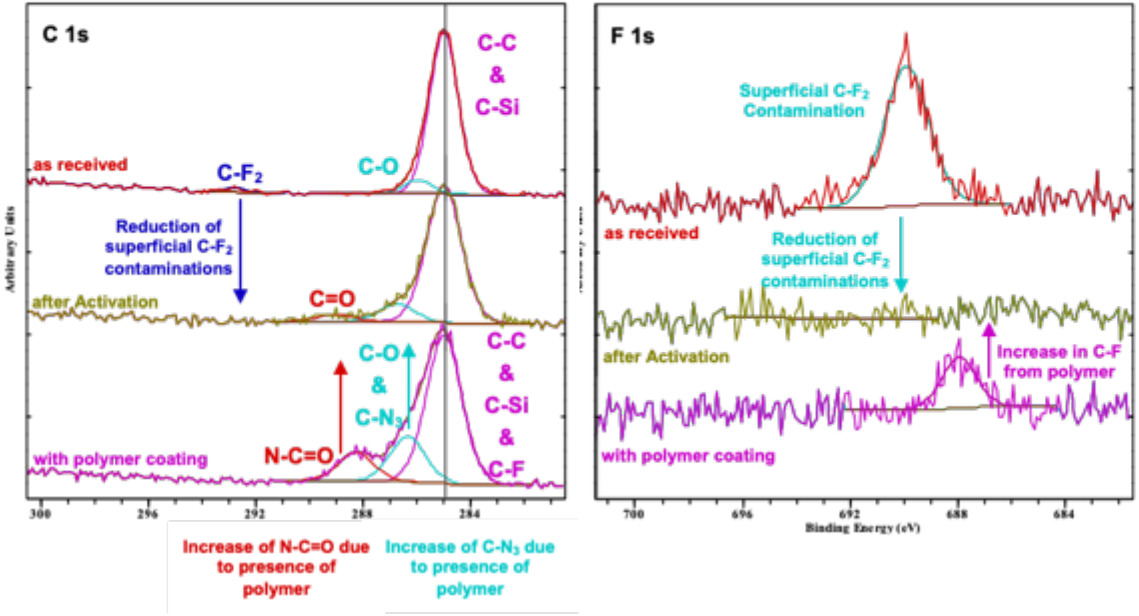
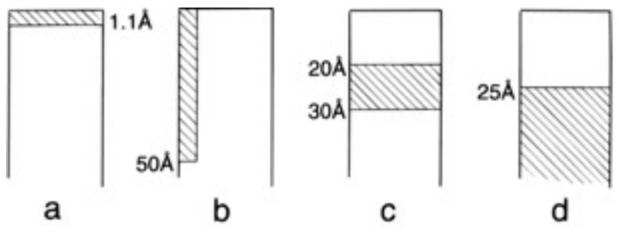
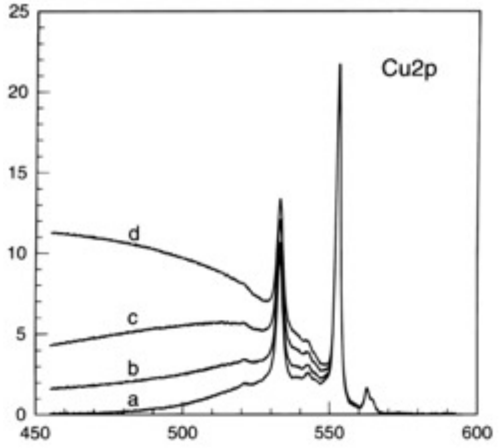


How does Morphology influence XPS





spectrum of emitted electrons:

$$J(E,\Omega) = \underbrace{\int dE_0 F(E_0,\Omega) \int ds\, e^{-i2\pi s(E-E_0)}}_{\text{Intrinsic spectrum at all positions}} \underbrace{\int dx\, f(x) e^{-x\Sigma(s)/\cos(\theta)}}_{\text{Background}}$$

Intrinsic spectrum at all positions

Background

$$\Sigma(s) = \frac{1}{\lambda} - \int_0^\infty K(T) e^{-isT}\, dT$$

$f(x)$ → sources: concentration of atoms at depth x

$K(T)$ → scatterer: probability that electron will lose energy T

S. Tougaard, Surf. Interface Anal. 25 (1997) 137-154

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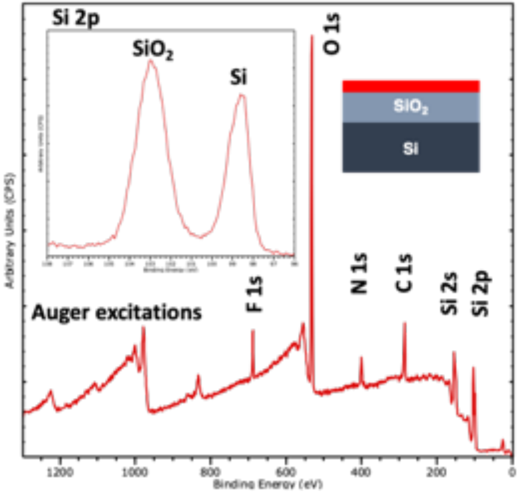
Roughness of a thin film by XPS

- AziGrip4™ Amine on SiO_2/Si
  - Substrate: Si and O
  - Polymer: C, N, O and F

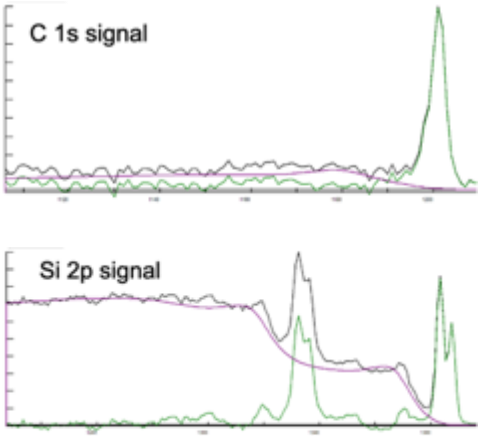


- Film Thickness by VASE

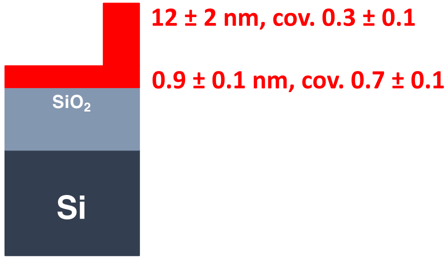
  SiO_2 = 3.45 ± 0.04 nm

  Polymer = 0.95 ± 0.08 nm → FLAT FILM

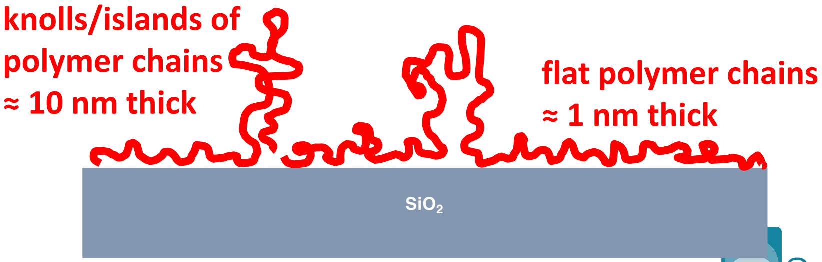
- Results from Background Analysis



Model



Surface Morphology of Polymer Chains



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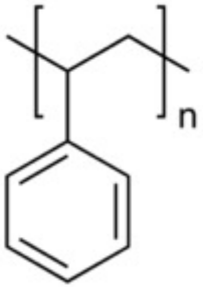
Polymer Hypergradients

– Hypergradient of two different Polymers

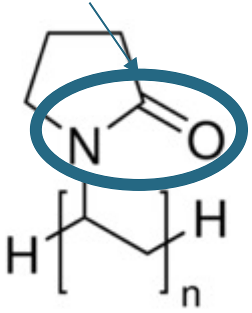
Polystyrene (PS)

- only aliphatic C



Polyvinylpyrrolidone (PVP)

- aliphatic C
- N-C=O

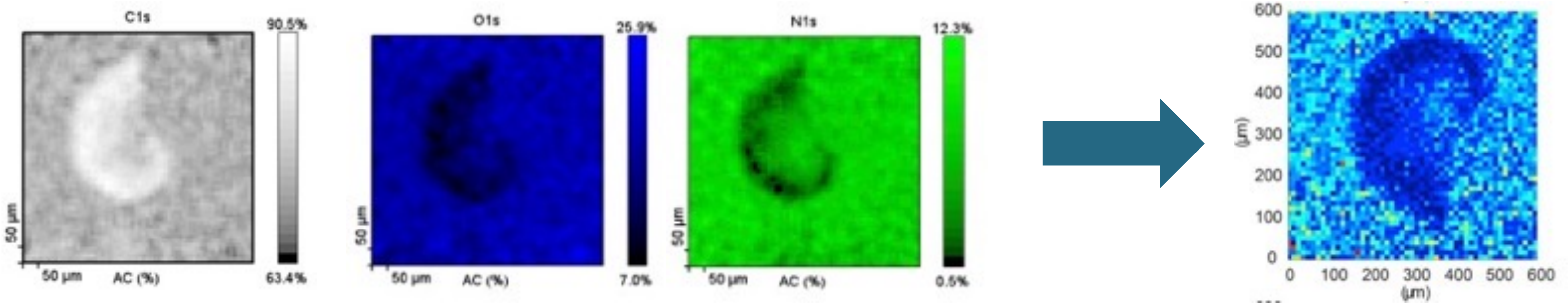


Gradient Patterns

Triangular ***Radial***

The difference in chemical composition of both polymers can be used to make hypergradients "visible" via ***Chemical Imaging***

Image collection with XPS

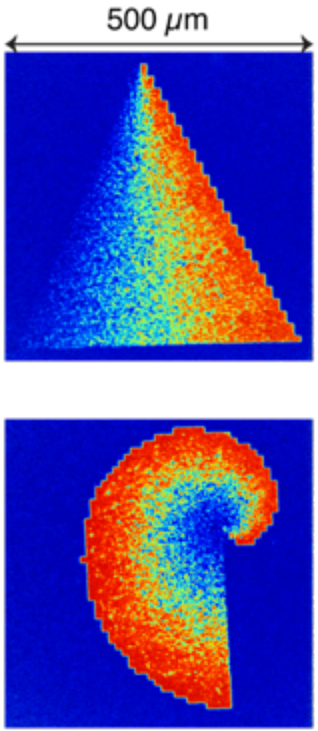


- N/C ration calculated for each pixel
- The percentage of PS was then estimated by assigning the ratio found on pure PVP to 100 % PVP, and N/C=0 to 100 % PS according to:

$$PS_{frac} = 1 - \frac{\left(\frac{N}{C}_{frac} - \frac{N}{C}_{PVP}\right)}{\left(\frac{N}{C}_{PS} - \frac{N}{C}_{PVP}\right)}$$

Comparison of Imaging Techniques

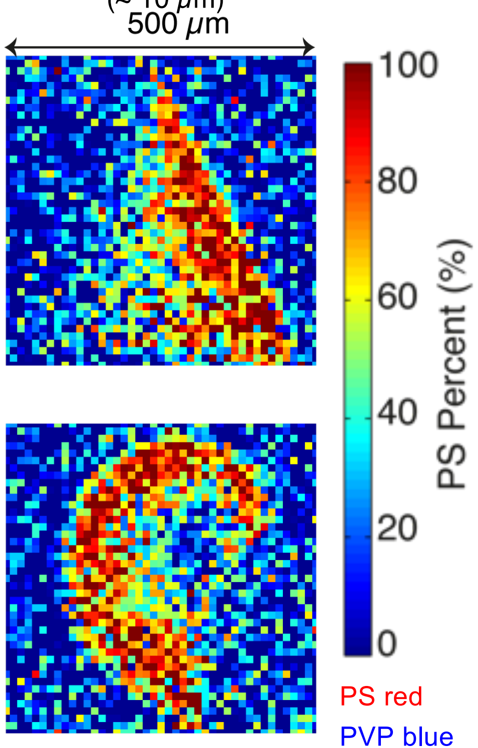
ToF-SIMS
(~400 nm)



- Lateral resolution is limited to size of X-ray beam.
- A semi-quantitative answer is possible at each acquired pixel.

- ToF-SIMS alternative for higher resolution images BUT
  - limited in terms of samples
  - quantification hardly possible

Imaging XPS
(~ 10 μm)



PS red
PVP blue

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Summary

- Polymers are flexible, versatile applicable materials used in Medical Devices, Diagnostics, Microfluidics and many other applications
- Polymer Thinfilms can be tuned in many ways with versatile functionalities, such as Non-fouling, high lubricity, selective binding, adhesion promotion and many more.
- By chosing the right bonding groups many materials can be treated, such as metals, ceramics, glass and plastics.
- The analysis of polymers can be hindered by various factors such as non-conductivity, carbon=carbon, surface roughness or degasing behavior.
- In XPS these obstacles can be mostly overcome and information on the qualitative and quantitave chemical composition can be obtained.
- With Inelastic Background Analysis the Nanomorphology of substrates and thinfilms can be assessed.
- With Imaging XPS even hypergradients of different polymers can be mapped and quantified.

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