Low-friction coatings on elastomers

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Outline

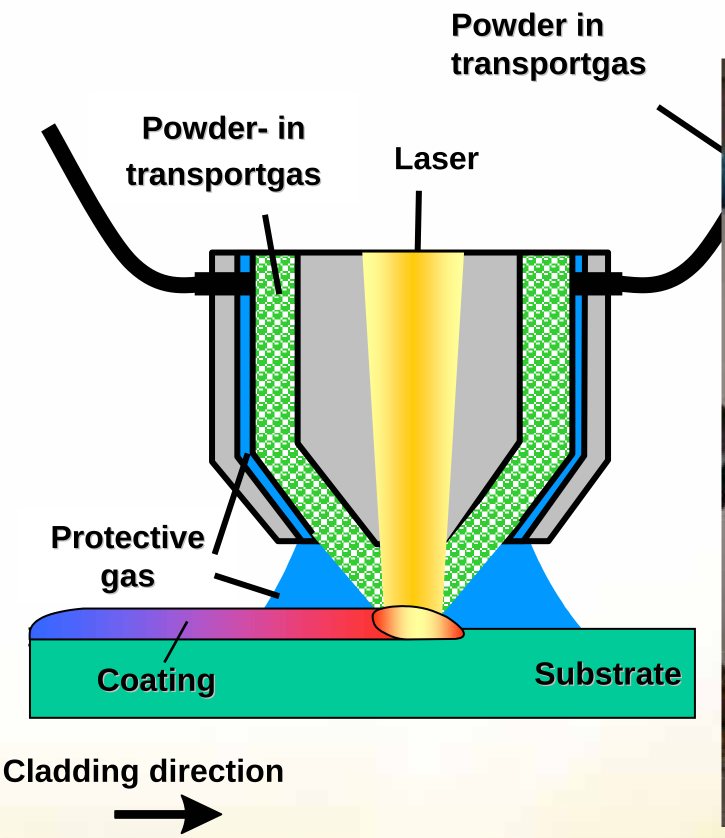
- ✓ Introduction
- ✓ Results
  - ✓ Thick coatings by laser cladding
  - ✓ Thin coatings by atmospheric plasma treatment
- ✓ Conclusions and future work

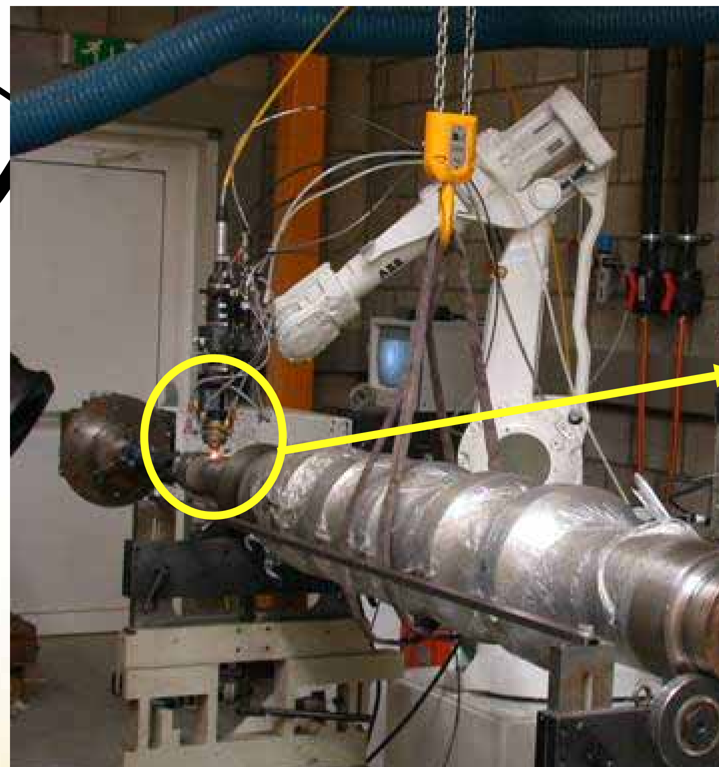
Surface treatment to improve tribological behaviour of elastomer components

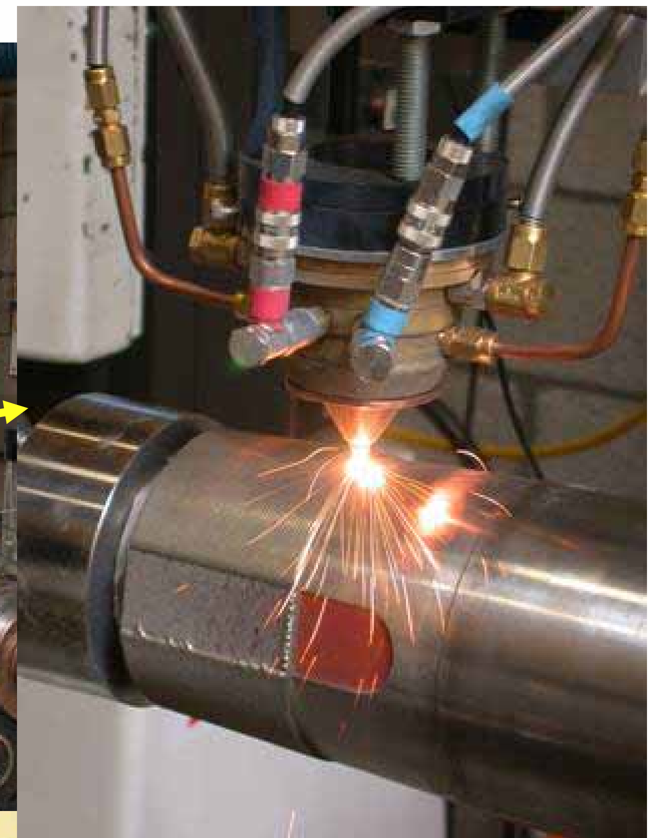
- Elastomer components in sealing and sliding applications
- Need to understand and improve the tribological behaviour of elastomers
  - High dry sliding friction → use of lubricants
  - Improved performance (reduce noise, vibrations, etc)
  - Environmental considerations (reduce of eliminate use of grease and lubricants)
- Development of surface treatments and coatings with solid lubricant properties compatible with elastomer materials
  - Laser cladding
  - Atmospheric plasma treatment

Laser cladding - general

- Melting of additive material, mostly powder, by means of a moving laser as heat source

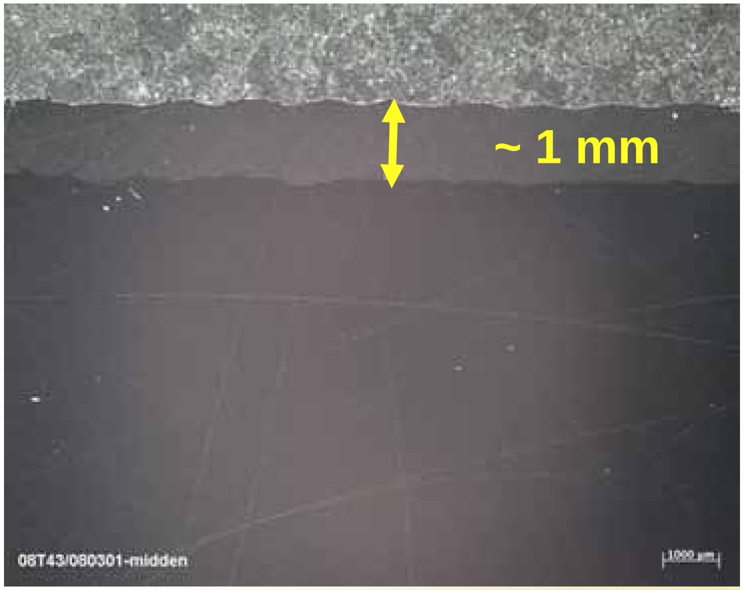






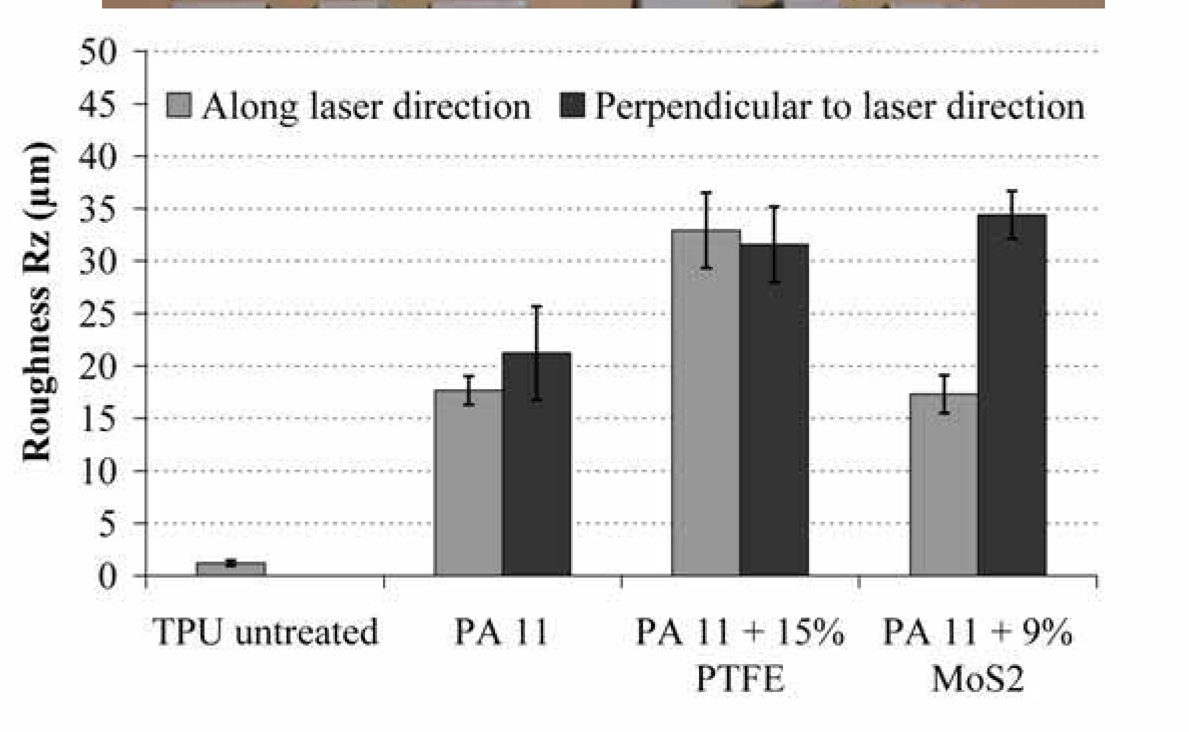
Laser cladding – type of coating in general

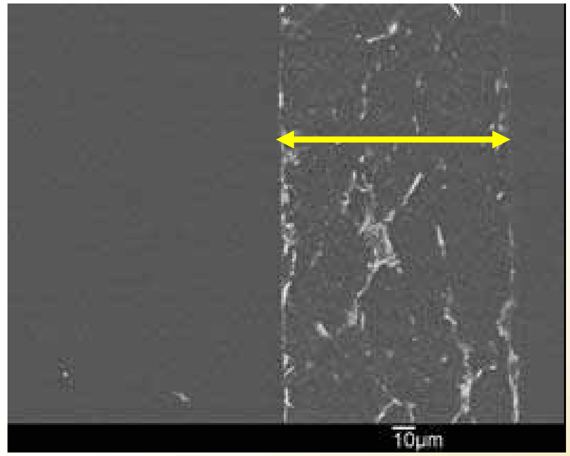
- Coating type: metal or metal-ceramic coatings
- Substrate materials: metals
- Thickness range: mm
- High-performance coatings
  - metallurgical bonding to substrate
  - no porosity
  - low heat input
- Applications: repair, improved corrosion / wear resistance

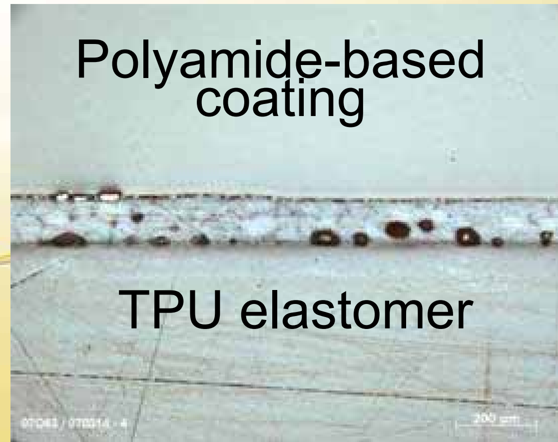


Laser cladding of polymer coatings

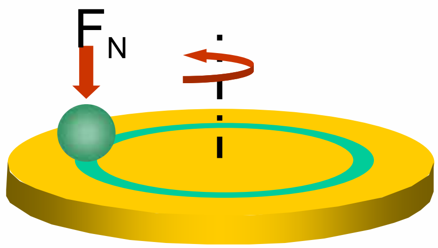
- Thermoplastic (composite) coating: polyamide-based
- Polymer, metal substrates: thermoplastic polyurethane
- Thickness in order of 100 µm
- Average roughness is relatively high







Ball-on-Disc tribotesting @ VITO

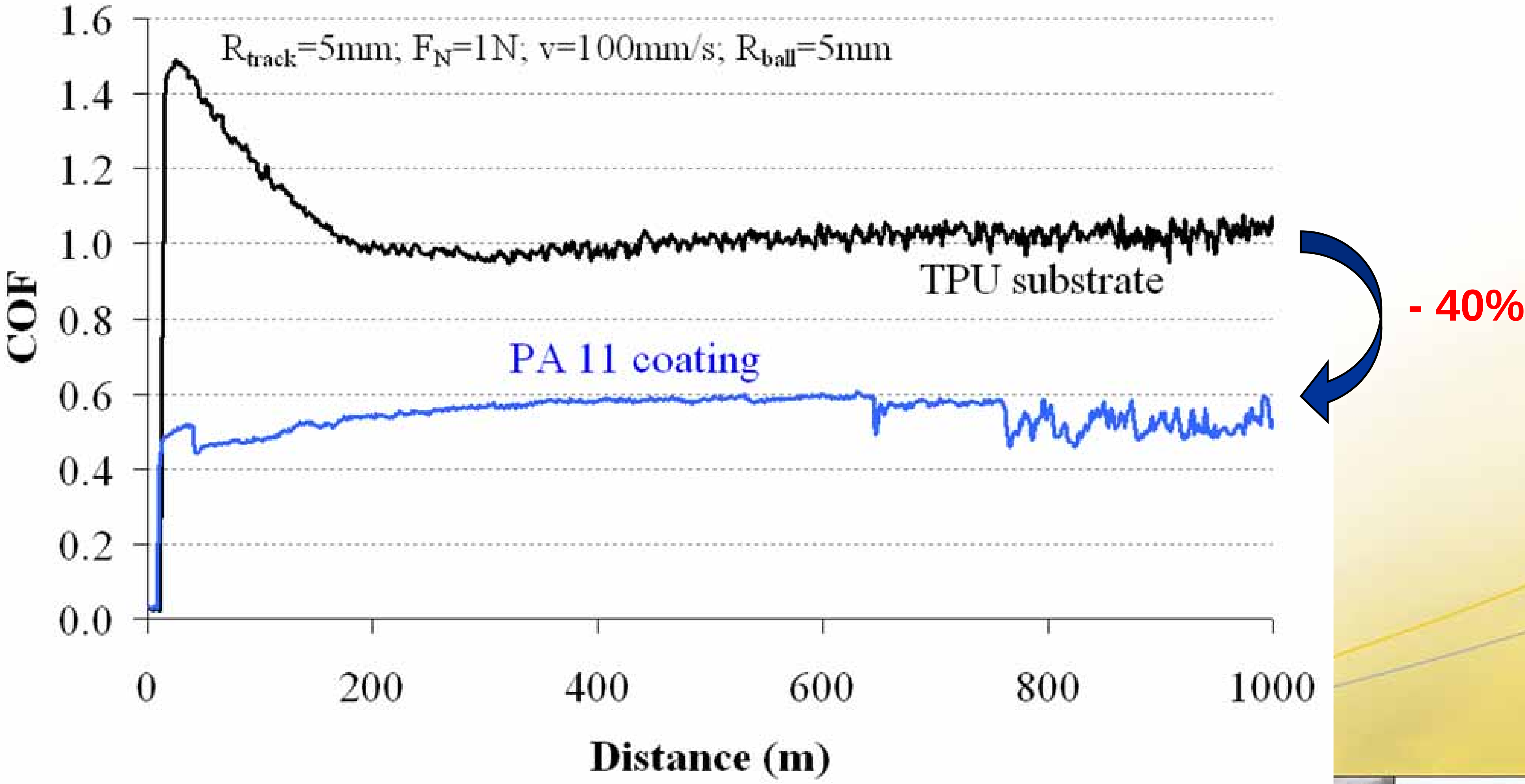


Test parameters:

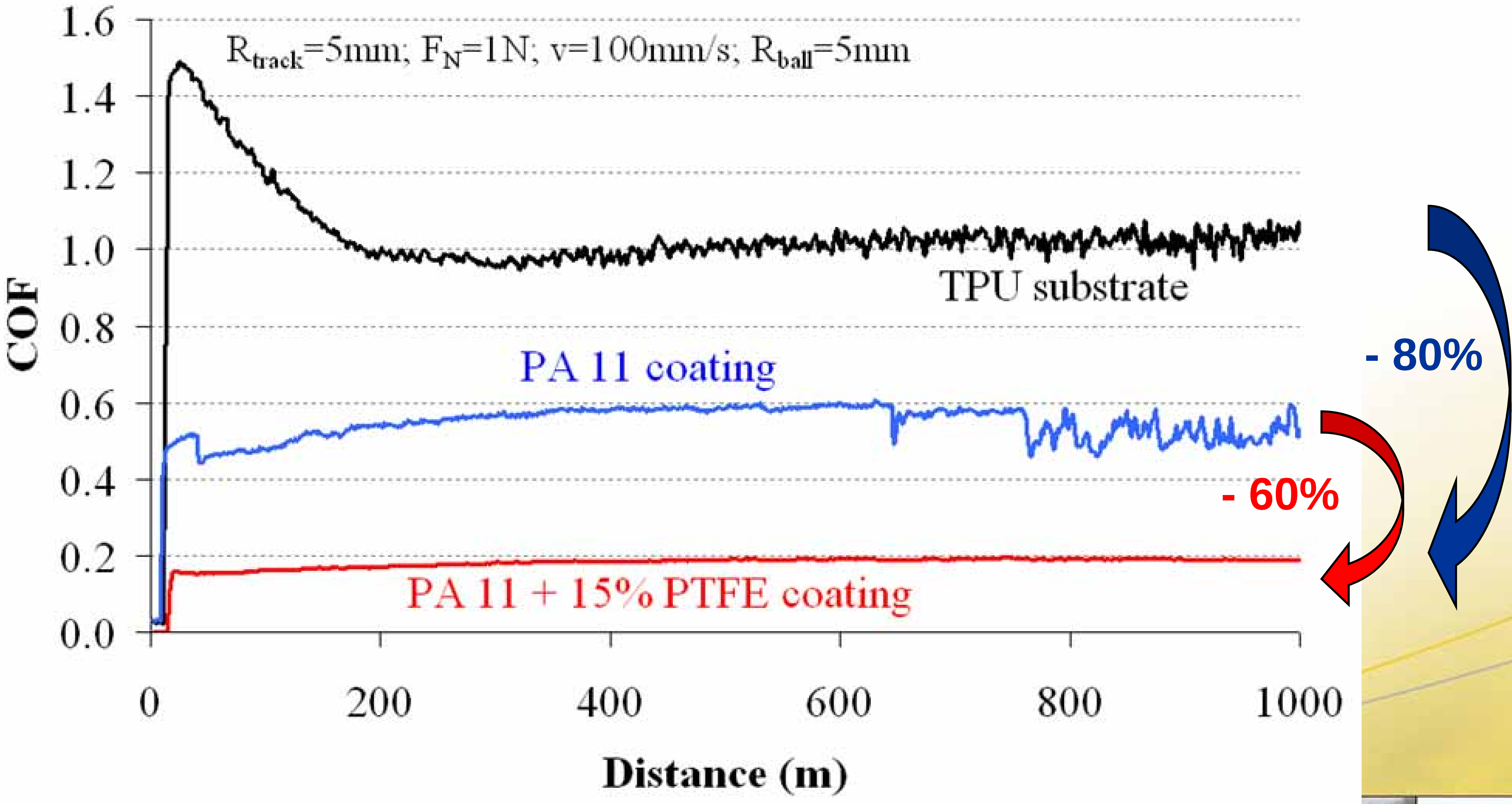
- F_N = 1 N
- ball radius = 5 mm
- wear track radius = 5 mm
- rotation speed = 100 mm/s
- unlubricated
- 100Cr6 steel counterface

CSEM BOD tribometer

Frictional behaviour of laser cladded coating

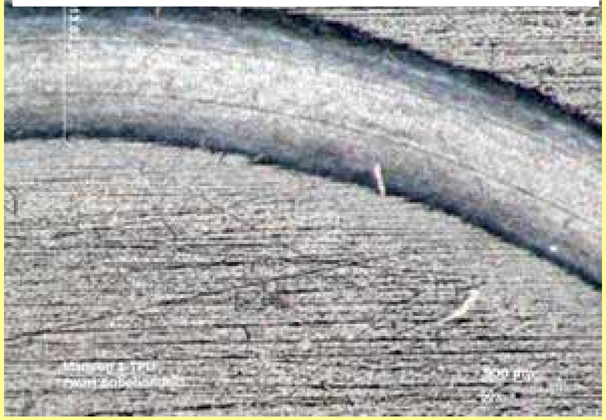


Frictional behaviour of laser cladded coating



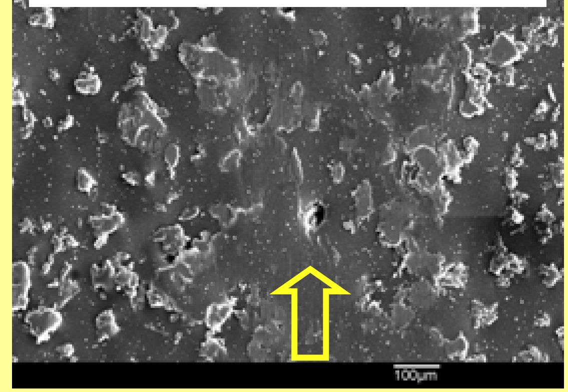
Analysis of wear after tribotesting

TPU

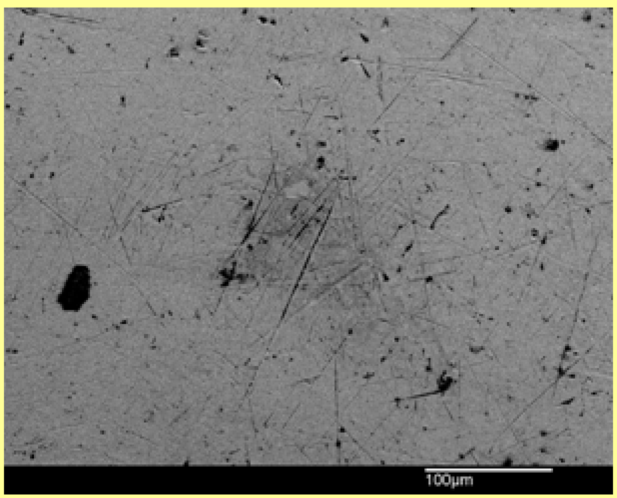


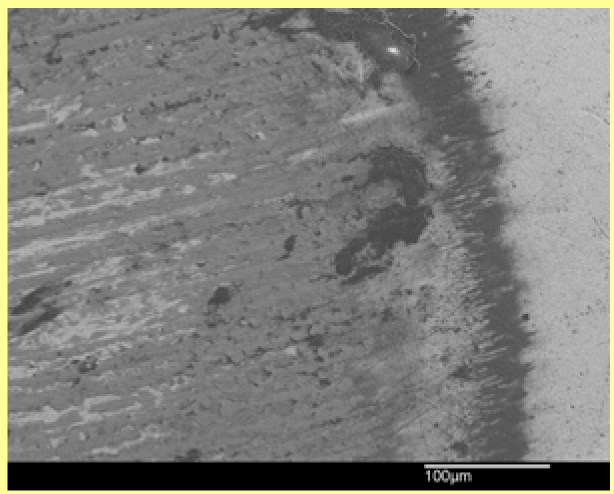
PA11

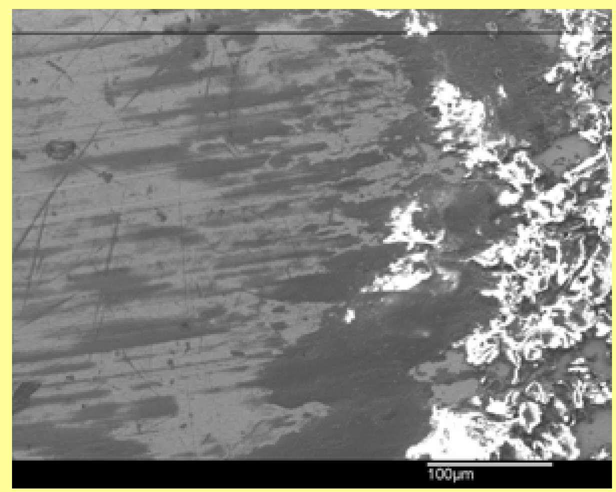
PA11 + 15% PTFE



Counterface material







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  - ✓ **Thin coatings by atmospheric plasma treatment**
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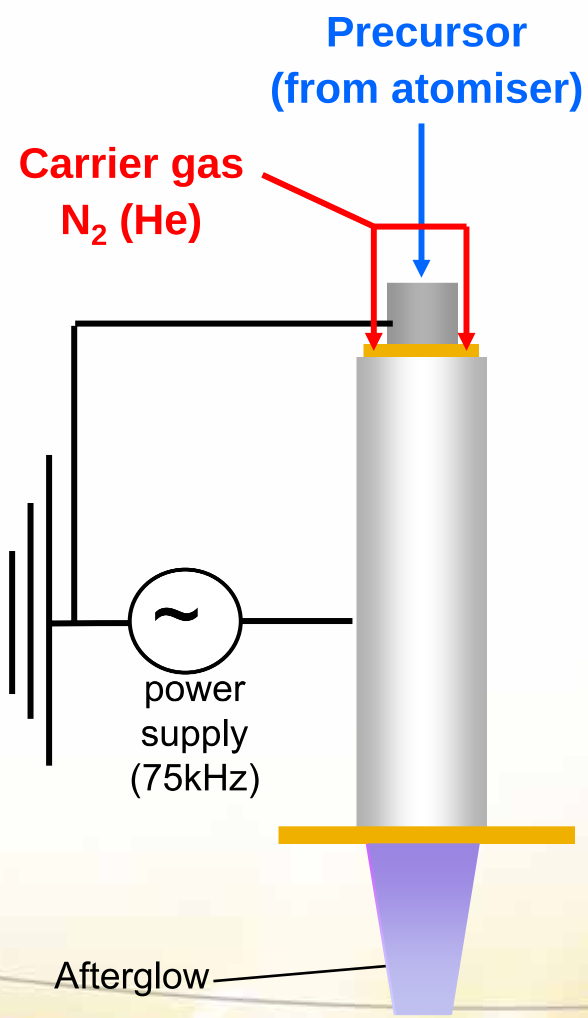
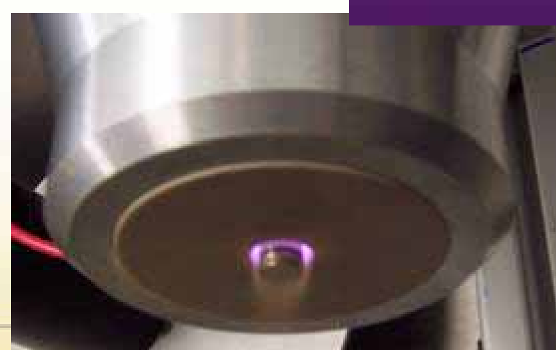
Atmospheric plasma technology

- Dielectric barrier discharge (DBD)
- Cold plasma surface engineering technique (surface cleaning, activation, coating)
- Low investment cost
- Continuous, in-line processing
- Easy upscaling
- Injection of all types of precursors (gases, liquid chemicals, dispersions etc)
- Different configurations (PlasmaSpot®, PlasmaLine®, PlasmaZone®)
  - Parallel plate: direct treatment of 2D (web) materials
  - Torch systeem: indirect treatment of complex, 3D components

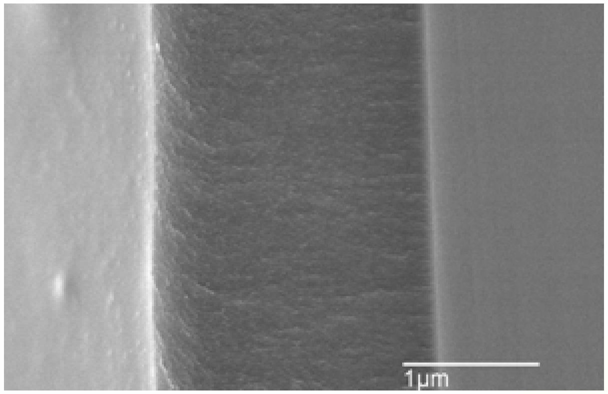
Setup of atmospheric Plasmaspot®

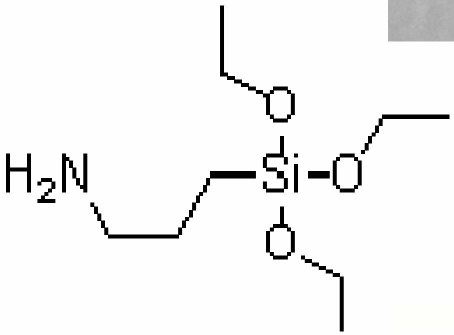


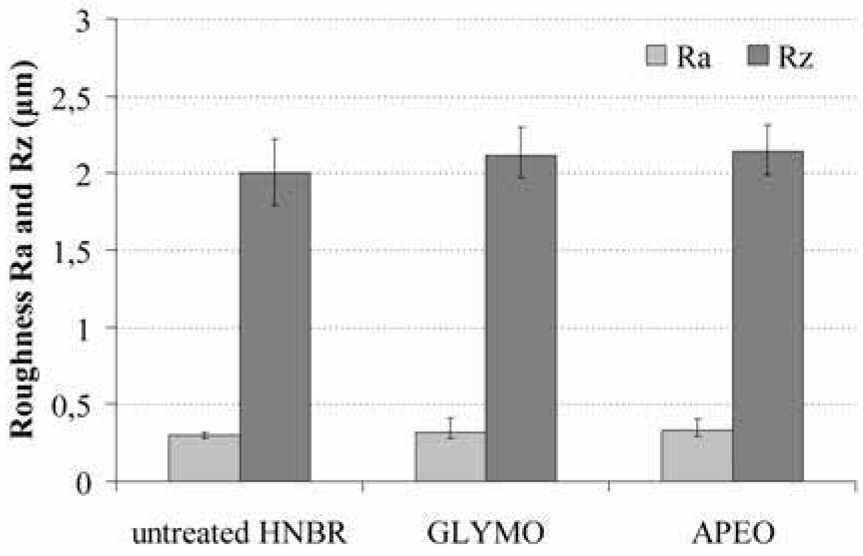


Coating type

- Thickness range: nm - µm
- All types of substrate materials: plastics, metals, glass, paper etc
- Coating type: siloxane-based hybrid (organic–inorganic) coatings
- Precursor: (Si-O-R) type e.g. APEO
- Roughness of substrate is followed
- Soft coatings compared to conventional tribological coatings
  - ➢ Less severe triboconditions







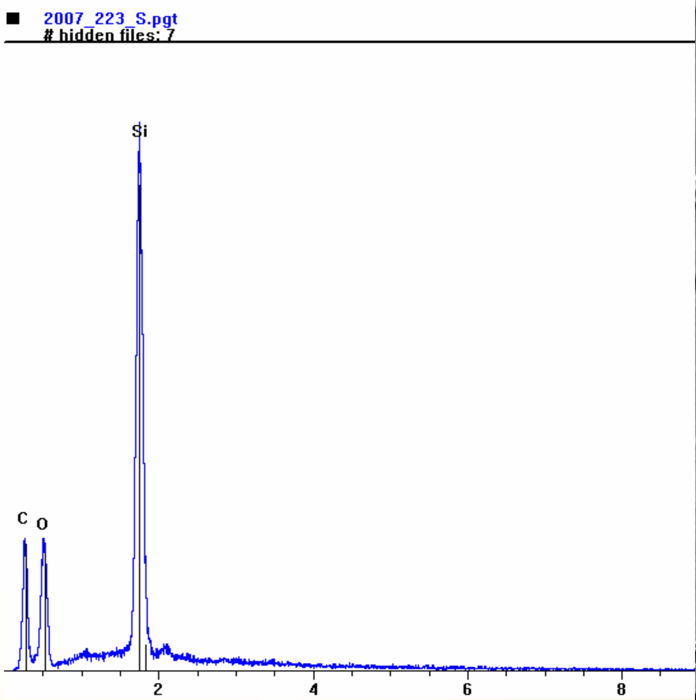
Typical hardness and E-modulus values

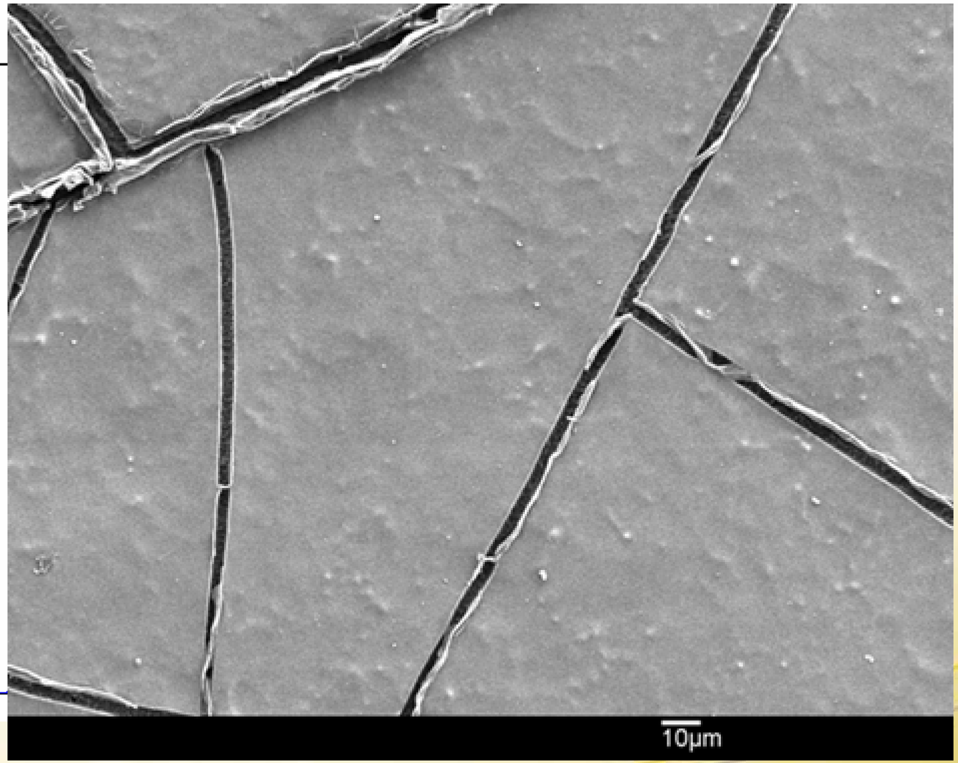
Instrumented indentation test

CSM (continuous stiffness measurement)

Material	H (GPa)	E (Pa)
APEO coating	**0.8**	**10^{10}**
Bulk PC	0.2	10^{9}
Bulk LDPE	0.02	10^{8}
Steel	10	10^{11}
Rubber		10^{6}

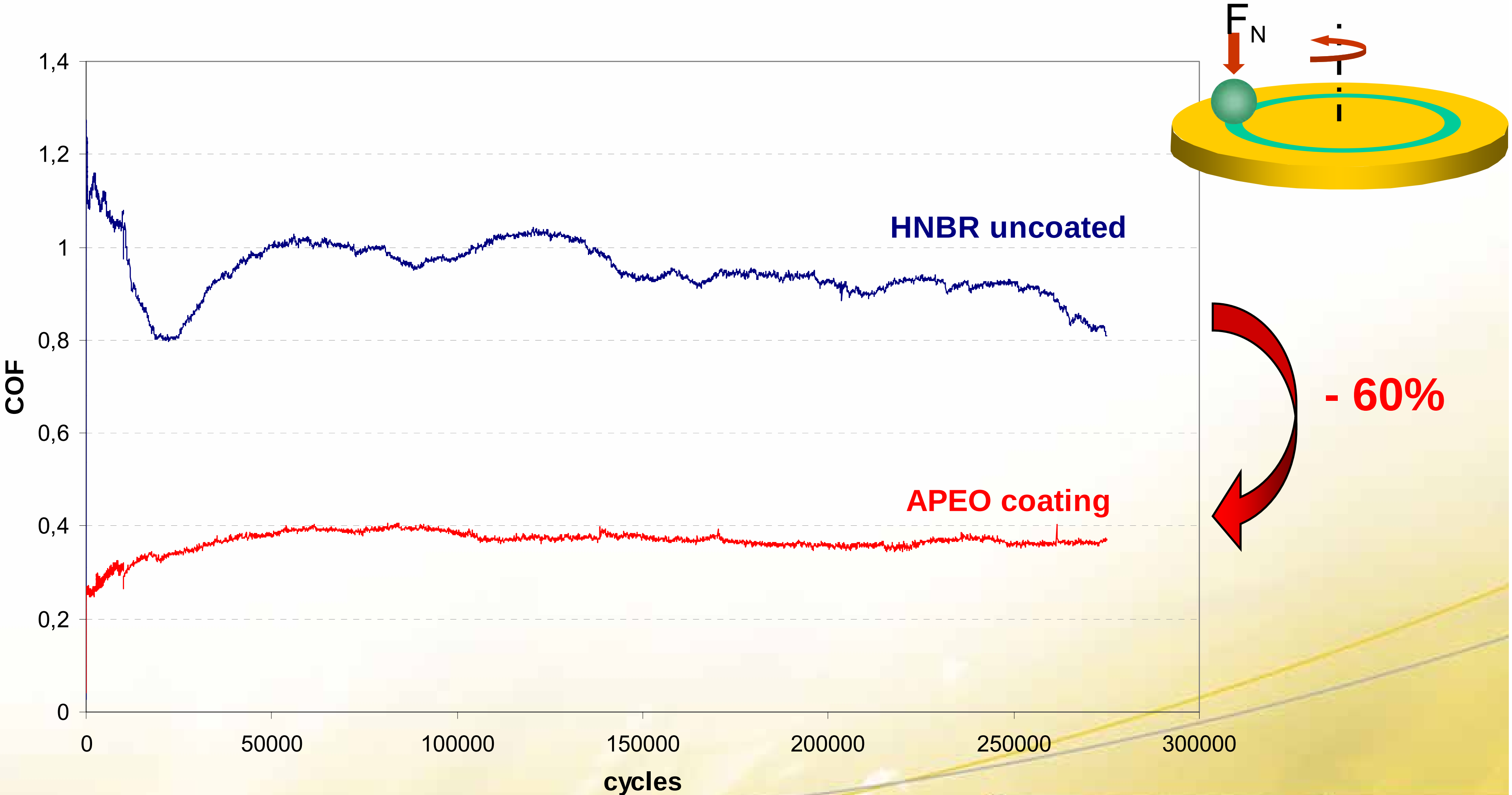
SEM/EDX-analysis of APEO coating on HNBR



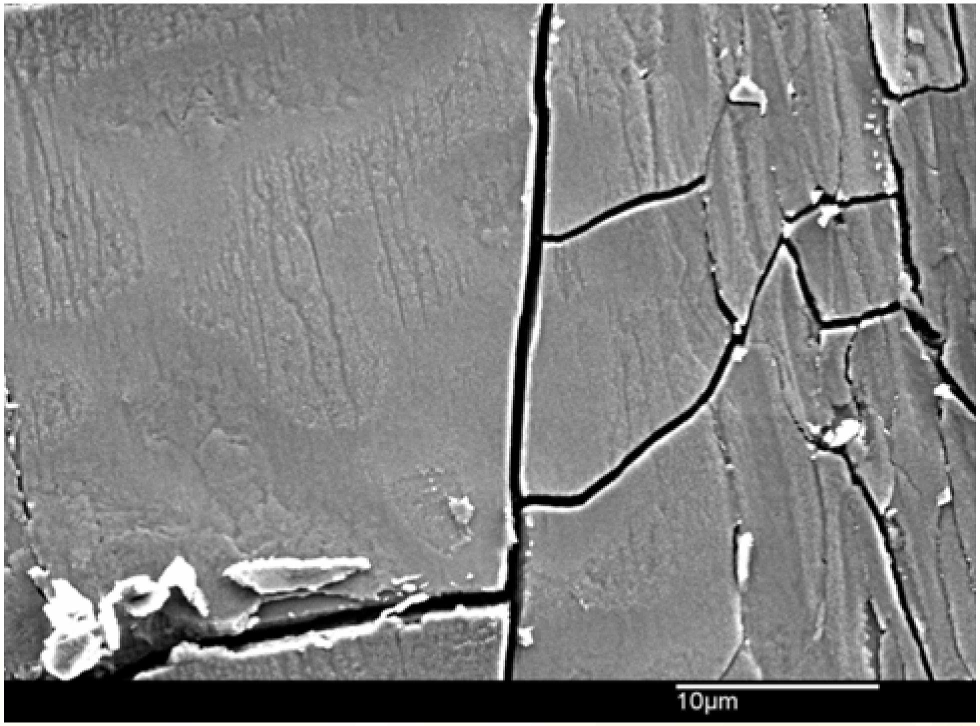


Plane view SEM

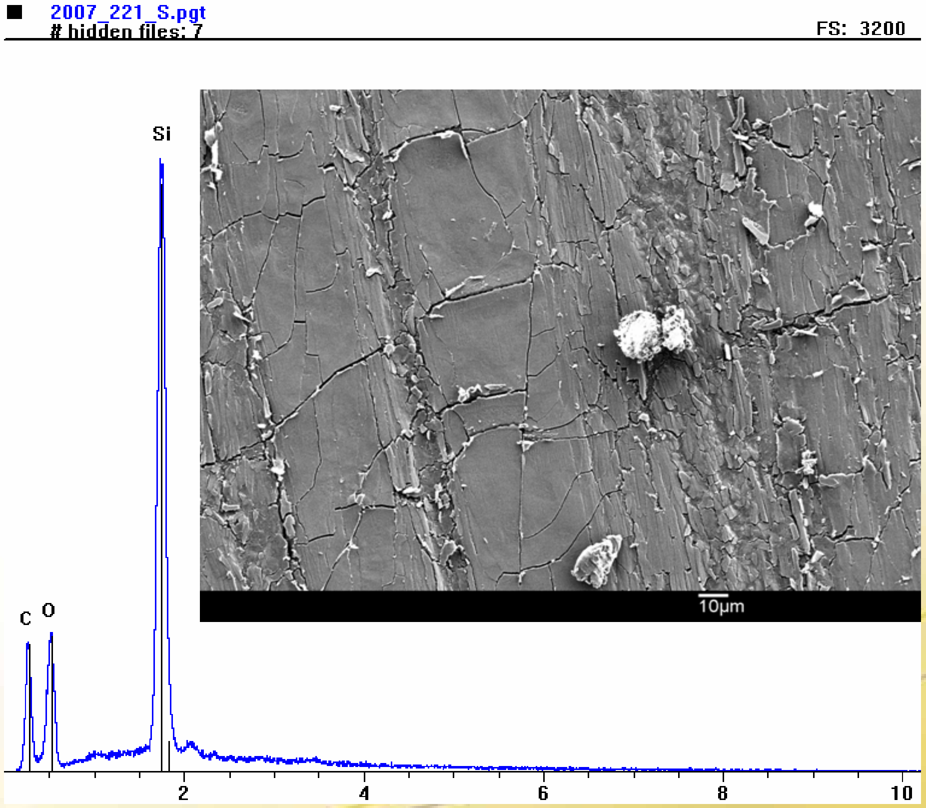
Frictional behaviour of plasma coating



Analysis of wear track after tribotesting



SEM



EDX

Lessons learned & challenges

- Atmospheric plasma and laser cladded coatings show potential as low-friction coating
- Need for tribomapping to identify application areas (e.g. running-in coatings, microtribology)
- Complex (tribological) behaviour of elastomers → selection and interpretation of tests

Thank you for your attention!

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