Atmospheric Pressure Plasma Deposition of low friction coatings on engineering thermoplastics:

The plasma-process-structure in the versatile spray coating technique as basis of commercial applications

Dietmar F. Kopp[1], Jürgen M. Lackner[1], Reinhard Kaindl[1], Wolfgang Waldhauser[1], Maximilian Stummer[2], Anna M. Coclite[3]

Contact

1

JOANNEUM RESEARCH Forschungsgesellschaft mbH

MATERIALS

Institute for Surface Technologies and Photonics

Dietmar Kopp

Leobner Straße 94a
8712 Niklasdorf, Austria
Phone +43 316 876-33 04
Fax +43 316 8769-33 04
dietmar.kopp@joanneum.at

materials@joanneum.at
www.joanneum.at/materials

2

INOCON Technologie GmbH
Wiener Straße 3
4800 Attnang Puchheim, Austria

3

Institute of Solid State Physics
Graz University of Technology
Petersgasse 16
8010 Graz, Austria

Introduction

The focus of this research is to apply several types of low friction coatings (*e.g.* MoS_2, graphite) on different thermoplastic substrates with a hot gas plasma jet. Dry lubricant coatings are of interest from a fundamental point of view for nano and micro scale mechanical systems. MoS_2 belongs to the family of layered two-dimensional transitional metal dichalcogenides (TMDs). Such as graphite and hexagonal boron nitride, its crystal structure consists of covalently bonded sheets, which form stacks that are held together only by weak Van der Waals interactions [1].

Methods

- Low friction coatings were deposited by an atmospheric pressure plasma jet (APPJ) of laboratory size, equiped with an Inocoat plasma head of 3rd generation (IC3).
- Tribological characterizations by an Anton Paar Micro Combi Tester (MCT 01-06315)
  - Evaluating the coefficent of friction (COF) and relative penetration depth
- Scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM/EDS) analysis by TESCAN-SEM Vega 3
  - Distribution of elements of the coating inside/outside the wear track
  - Cross-section investigations *i.e.* coating thickness, distribution of elements

Lab coating plant

The coating principle as well as a robot controlled system that is developed and industrialized by INOCON Technology GmbH is illustrated in Fig. 1.

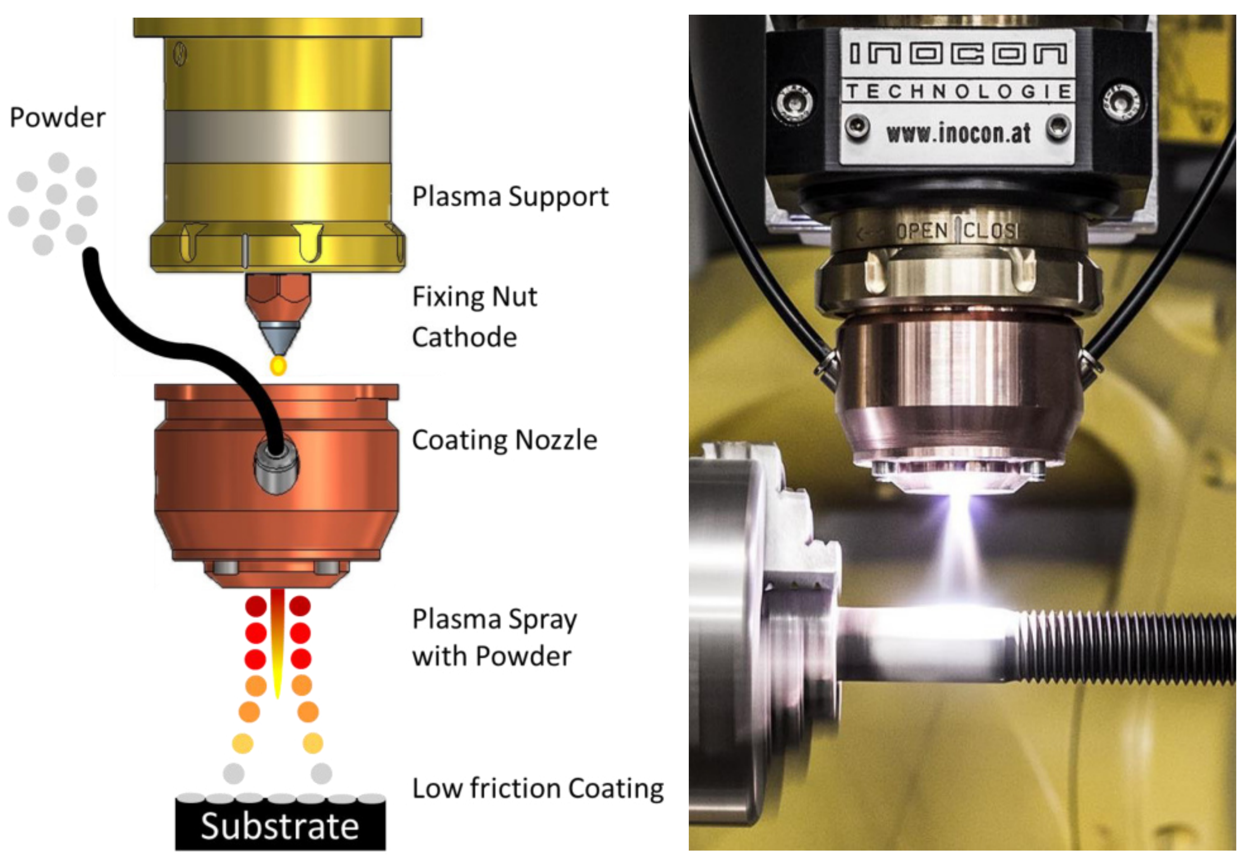

Fig. 1 Coating process within the APPD; Image was kindly provided by INOCON Technologie GmbH.

Results

In Fig. 2 the cross-section of a MoS_2 coating on PA 12 substrate including EDS mapping of Mo and S is given. The porous structure of the ~130 µm thick coating after 40 passes of the plasma jet and the preferable deposition within roughness "valleys" are visible.

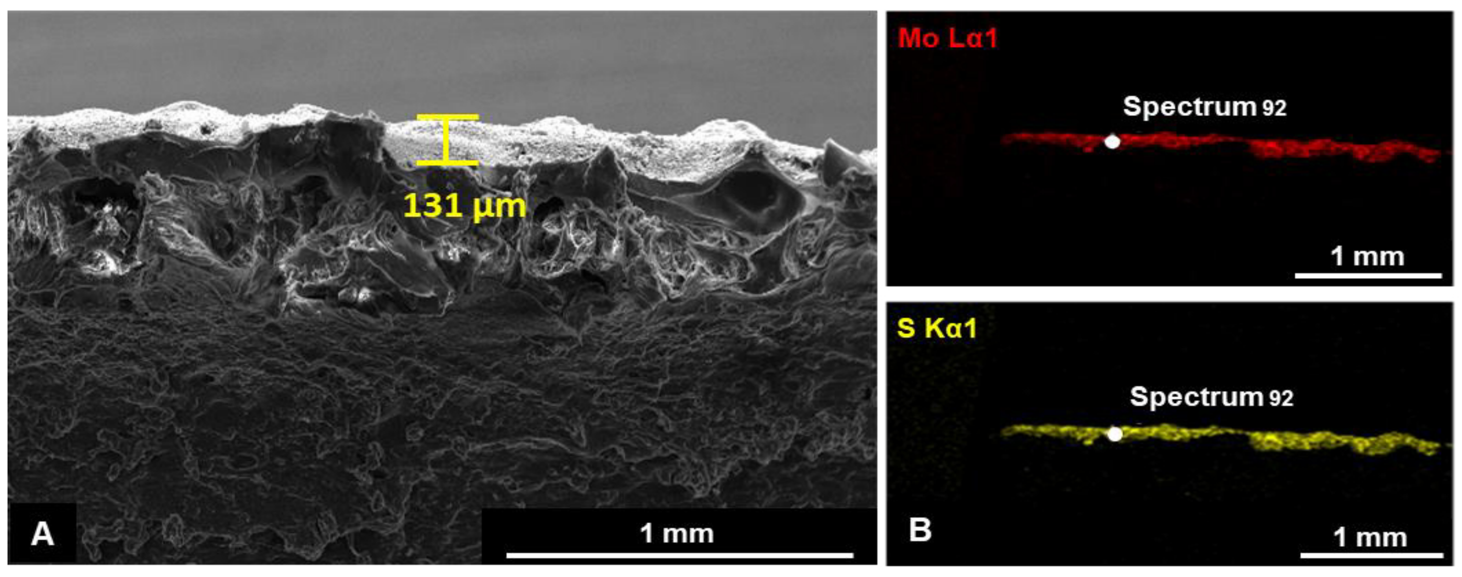

Fig. 2 Cross-section SEM image of a MoS_2 coating on smooth PA12 substrate deposited by 40 coating passes (A) and EDS element distribution images (B) of Mo and S. The chemical composition (atom%) of "spectrum 92" is 7.0% Mo, 4.2% S, 14.5% O, 67.3% C and 7.0% N. .

The tribological performance of the MoS_2 coating vs. the MoS_2-C composite on the PA 12 substrate is given in Fig. 3.

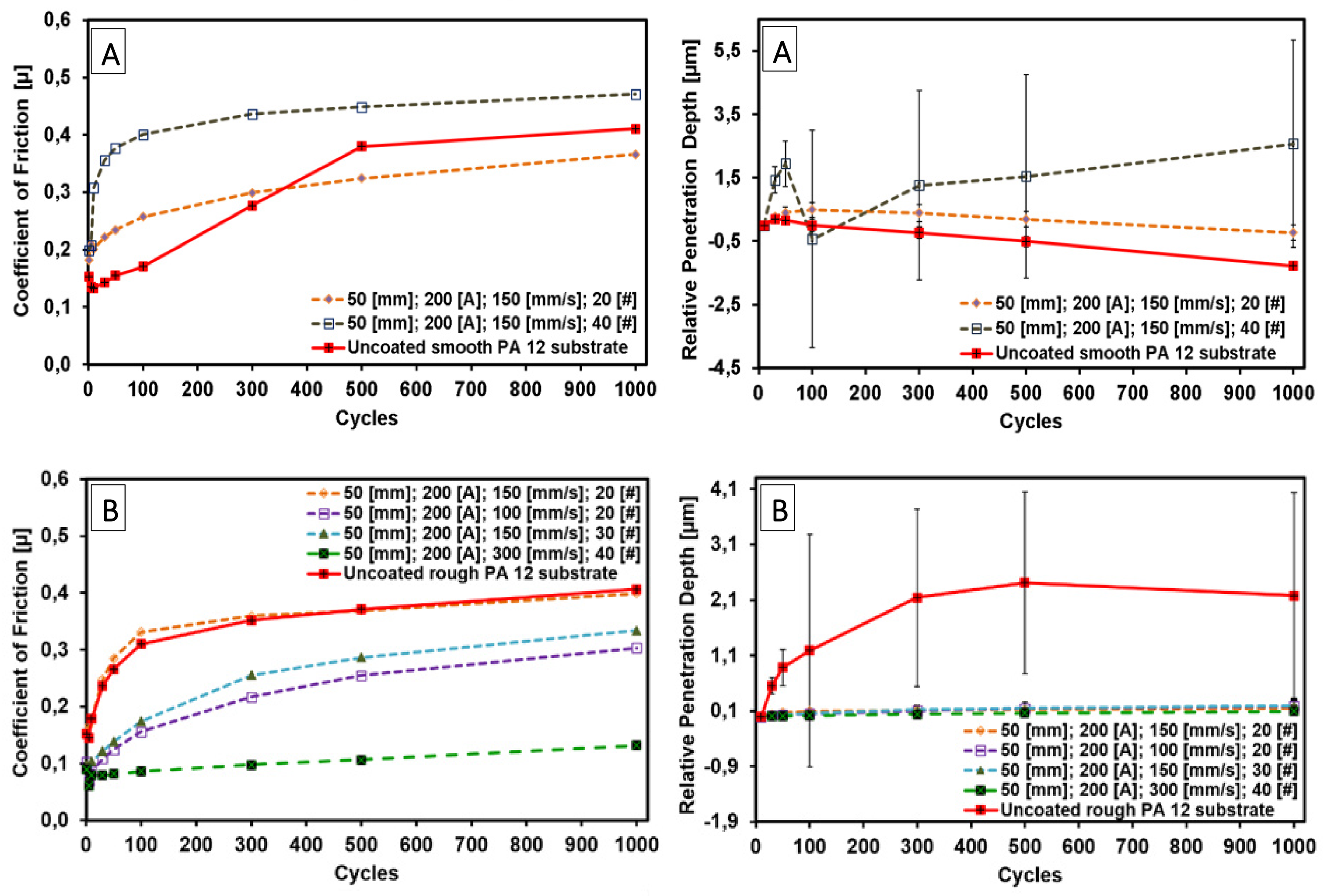

***Fig. 3** __A__: COF (left) and relative penetration depth (right) of MoS_2 APPJ coatings in dependency of the coating thickness (doubled coating pass number [#] 20 vs. 40) at similar power of APPJ (measured by the discharge current, 200 [A]), coating pass speed 150 [mm/s] and a distance plasma jet nozzle – PA 12 upper surface of 50 [mm]. Coatings on smooth PA12 substrates; __B__: COF (left) and relative penetration depth (right) of MoS_2-graphite APPJ composite coatings. Coatings on rough PA 12 substrates*

Conclusions

- Surface topographical dependency with respect to adhesion properties
  - Mechanical anchoring phenomenon of the APPJ
- SEM/EDS analysis by TESCAN-SEM Vega 3
  - Elemental composition of the coating (inside/outside the wear track) changes

References

[1] K.S. Novoselov, A. Mishchenko, A. Carvalho, A.H.C. Neto. 2D materials and van der Waals heterostructures, Science, 353:461, **2016**.

THE INNOVATION COMPANY