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Chemical Solution Deposition of Poly (methyl methacrylate) thin films via dielectric barrier discharge

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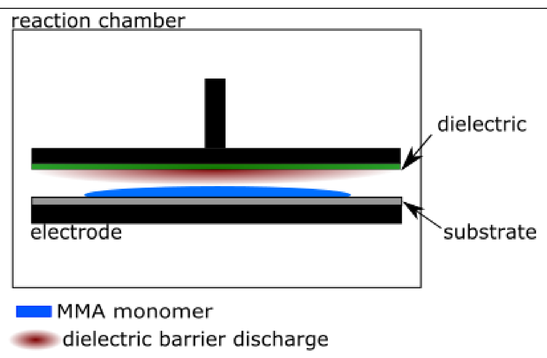
Introduction

Plasma-enhanced vapour deposition (**PECVD**) is a well known process for deposition of solid polymer coatings. The monomers has been transfered into gas phase and they start polymerizing under the influence of plasma. Plasma polymerized PMMA through PECVD process does not show the same characteristics as the thermic polymerized PMMA. Studies also prove, that polymerization of MMA through initiation of plasma in the liquid state is possible. In this work, the formation of coating has been proceeded directly in the liquid phase of monomer via dielectric barrier discharge (**DBD**). The advantage of this method is that there is no transfer into the gas phase needed. The thin film could also be directly applied onto substrate surface under the atmospheric conditions.

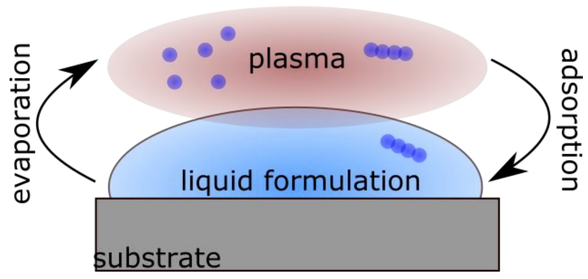
Experimental Setup



Conditions:

- Volume of the reactor chamber: 10,6 L
- Atmospheric air
- Peak voltage: 13,33 kV
- Distance between dielectric and substrate: 1,5 mm
- MMA monomer: 2 mL
- Plasma treatment: 5 min
- Repetition Voltage: 1,6 kHz

PECSD mechanism



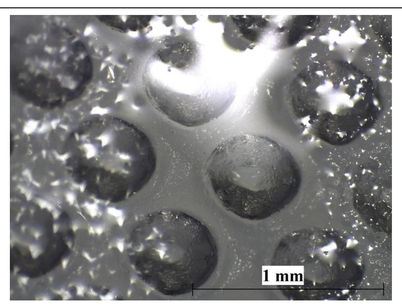
Possible processes:

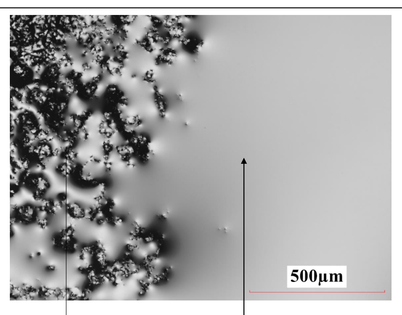
- Evaporation of MMA into gas phase
- Polymerization ignition in the gas phase under the influence of plasma
- Polymer condensation and increasing polymer chain length

Reaction:

- Radical polymerisation in the plasma phase
- After adsorption: reactions continue in the liquid phase
- Reactions in the interface: further initiation, chain scission and etching of polymerization

Surface analysis of the film on polypropylene





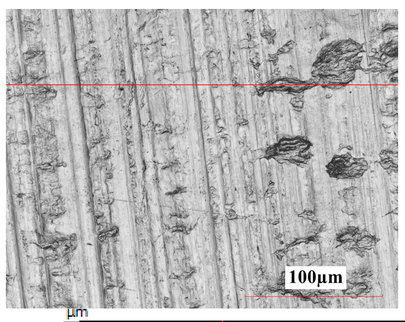
Surface of polymerized film after plasma treatment:

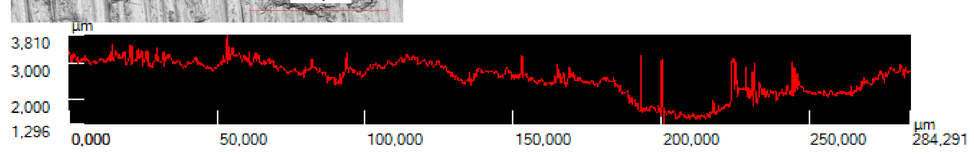
- Transparent film
- High viscousity
- No consistent thickness

Coherent coating

Border zone

Surface profile analysis of the film

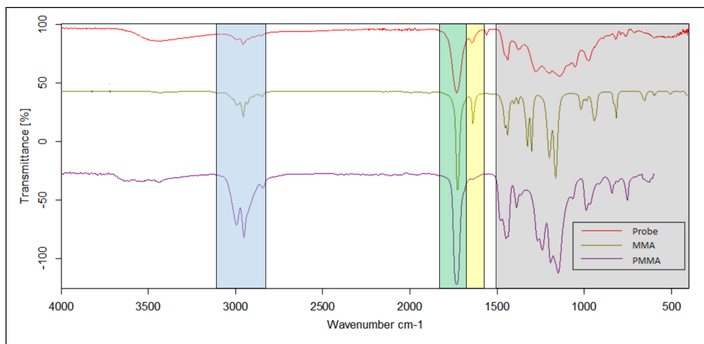




Surface of the film after plasma treatment:

- Also no consistent thickness
- Thickness: 3 µm

Analysis of chemical compounds

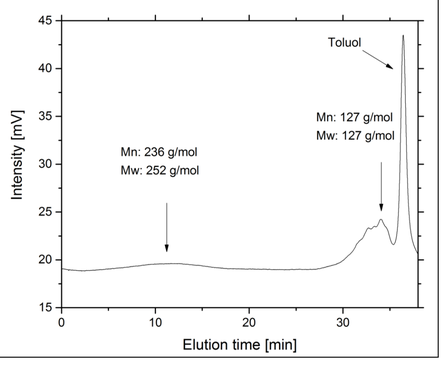


Weavenumber [cm^{-1}]	Assignment
2956 (s, br)	OH stretch (water)
3051 - 2879 (w, m)	sp2-sp3 stretch
1732 (s)	Carbonyl stretch
1645 (w)	C=C stretch
1530 - 450	Finger print area

- High similarity to thermic polymerized PMMA
- C=C strech vibration: existing of monomer

Analysis of chain length

- Two main fractions
- Oligomers contain three repeating units
- Average length of the molecules: between one and three repeat units.
  - → Produced coating contains monomers
  - → No polymer with high amount of repeating units



Summary

- Polymerization under the influence of plasma has been taken place.
- High evaporation rate
- Mixture of monomers and oligomers in the film
- Viscous film: monomer as plasticizer

Acknowledgement

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Atom- und Molekülphysik an Oberflächen

Plasma-Enhanced Reactions