Improvements to the deposition process of plasma polymerized acrylic acid films using an atmospheric pressure dielectric barrier discharge

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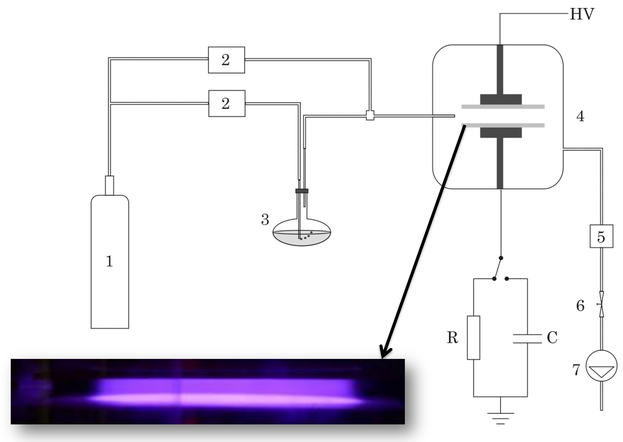
Introduction

- **Problem:**
  - Plasma polymerization of thin films via a traditional inlet inevitably results in a **gradient** thickness and an **inhomogeneous** chemical composition
- **Goal:**
  - Development of several **new inlet systems**
  - Deposition of **homogeneous** polyacrylic acid coating by controlling the **inlet flux**
- **Analysis:**
  - **Thickness measurements** using a white light interferometer
  - Modeling of the flow dynamics using **COMSOL**

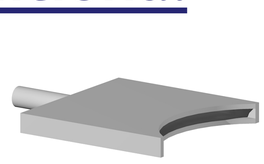
Experimental set-up DBD

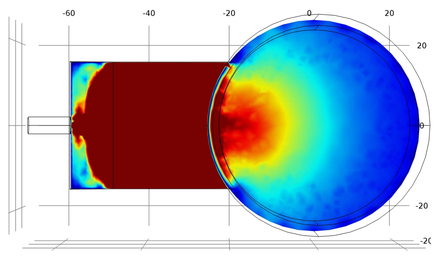
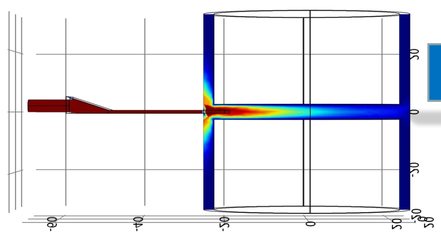
1: gas bottle
2: MFC
3: monomer bubbling flask
4: plasma reactor
5: pressure monitor
6: pressure valve
7: pump unit

P = 5 -100 kPa



Traditional

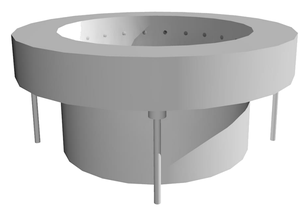


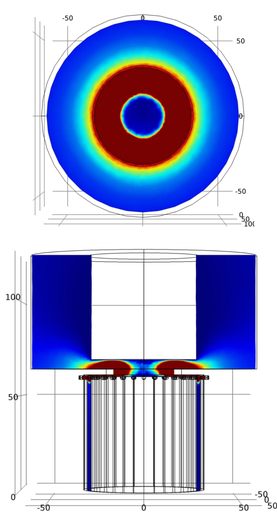



Mean thickness (nm)	SD (nm)	He (l/min)	AcAc (g/h)	P (kPa)
98,52	162,11	3	1	100
217,88	287,56	7	3	100

- Traditional sideway inlet
- Differences in thickness over 100%
- Gradient deposition through the reactor
- Different residence time of monomer resulting in functional group inconsistency

Ring inlet

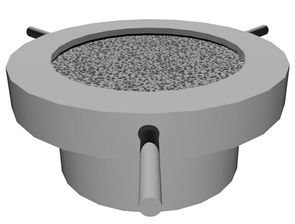
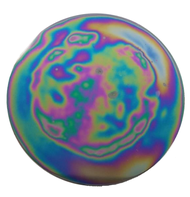
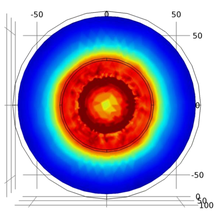
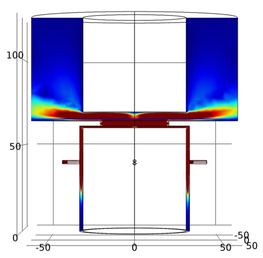




Mean thickness (nm)	SD (nm)	He (l/min)	AcAc (g/h)	P (kPa)
593,87	118,92	2	1	10,0
1217,76	174,78	7	3,5	15,3

- Ring inlet with 5 tubes and 24 inlet holes
- Differences in thickness between 20-25%
- Gradient deposition towards the center
- Different in residence time of monomer resulting in functional group inconsistency.

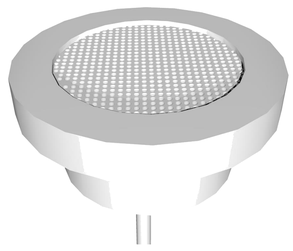
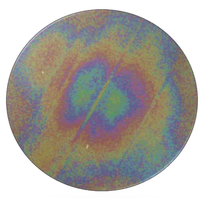
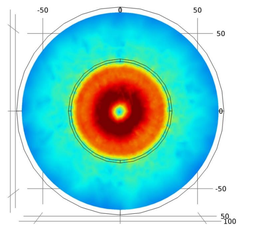
Porous glass

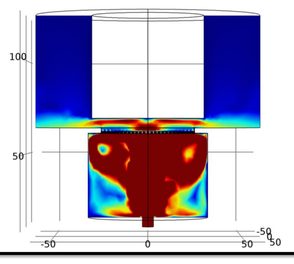
Mean thickness (nm)	SD (nm)	He (l/min)	AcAc (g/h)	P (kPa)
706,52	113,41	2	1	10,0
1201,26	207,18	7	3,5	14,0

- Porous glass inlet with 3 tubes and P0 glass disk of 3 mm thick
- Differences in thickness between 15-20%
- Radiant variations in flux result in rings of alternating thickness
- Dead zone in the centre due to sideway feed.

Micro-electrode

Mean thickness (nm)	SD (nm)	He (l/min)	AcAc (g/h)	P (kPa)
107,33	14,31	1	0,5	5
956,04	111,84	3	1,5	5,95



- Micro-electrode inlet with single tube
- Differences in thickness between 10-15%
- Smaller radiant variations in flux resulting in a single ring of higher thickness
- Small dead zone in the centre surrounded by ring of higher flux

Conclusion

- The **homogeneity** of the deposited coating is mainly influenced by the **flux** of the feed gas carrying the acrylic acid monomer.
- By introducing a showerhead-like inlet system such as the **micro-electrode**, a **uniform** residence time of the monomer across the plasma area is guaranteed.
- **Medium pressure** gave **better** overall results compared to treatment at atmospheric pressure.
- The COMSOL flux **models** are a **close match** to the **real-life** experiments and expose the flaws in the current designs.
- In the near future, the micro-electrode model will be **further adapted** to strive for a completely homogeneous deposition of plasma coatings.