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ISF | RWTH AACHEN UNIVERSITY | APPLICATION-CENTER POF

Surface pre-treatment of an optical fluoropolymer cladding by low-pressure plasma technique for adhesive bonding

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INTRODUCTION

- Fluoropolymers are widely used in a variety of industries due to their high resistance and unique properties.
- In particular the high chemical resistance and thermal stability.
- Through the process step of fluorination, some of these positive properties can be transferred to polymers.
- In fluorination, fluorine is introduced into organic compounds with the aid of fluorinating agents.
- Primarily, chlorine or hydrogen atoms are replaced by fluorine atoms.
- When looking at the chemical structural formula of the polymethyl methacrylate PMMA material, it can be assumed that the outer hydrogen atoms are at least partially replaced by fluorine atoms (Figure 1).
- In the case of the cladding of polymer optical fibers (POF), the fluorination step serves to change the optical properties of the cladding material PMMA. The aim is to reduce the reflection index while maintaining at least a good transparency of the amorphous thermoplastic.

- Challenges bonding properties of Fluoropolymers:
  - High electronegativity
  - Stable C-F bond
  - Structure of the fluorine atom
  - Fluorinated molecules difficult to polarize/ ionize
  - Very low surface energy
  - Small adhesion work

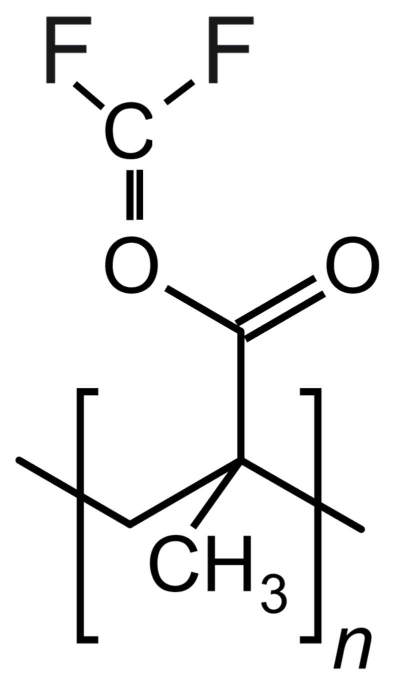


Figure 1: Example of chemical structure formal partially fluorinated PMMA

MATERIALS

- The POF is a commercially available multimode step-index fibers that consist of a polymethyl methacrylate (PMMA) core and cladding out of fluorinated polymer. POF with total diameter 500 µm (Asahi Kasei DB-500) is used. The size of the cladding is typically about 10 µm.
- The surface energy of the cladding is untreaded 24.5 mN/m (24.0 mN/m ^{D} + 0.5 mN/m ^{P}).
- The fluorine mass percentage in cladding is around 40% (measured with EDX).

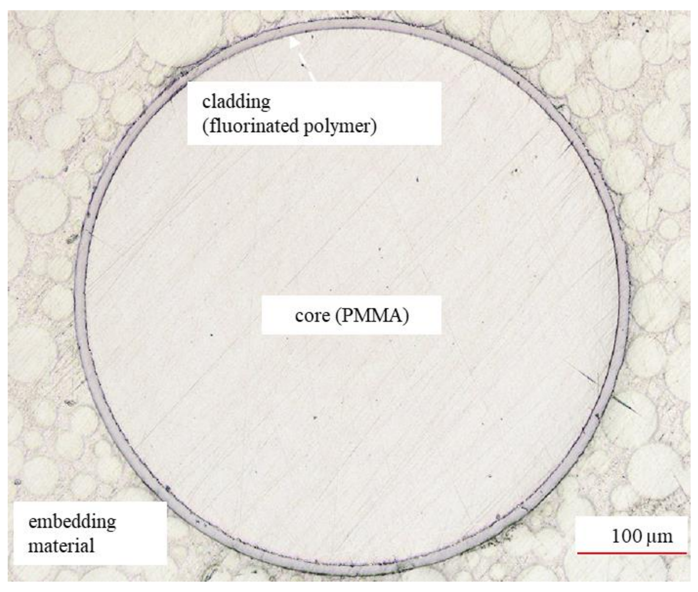


Figure 2: Microscopy image cross-sectional area

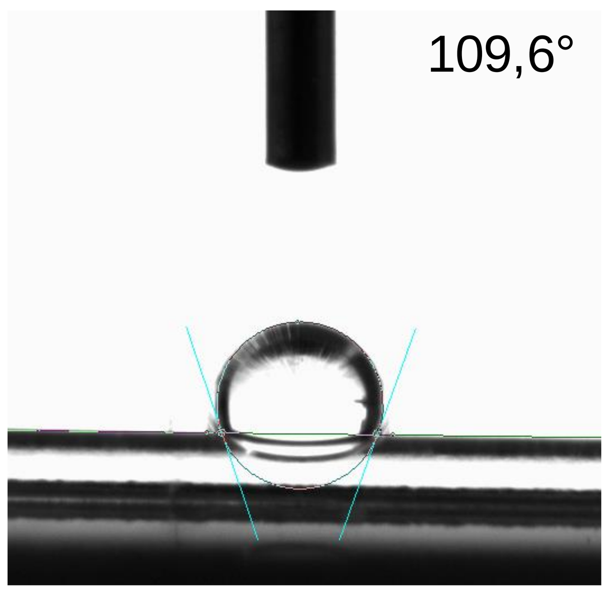


Figure 3: Wetting test with water

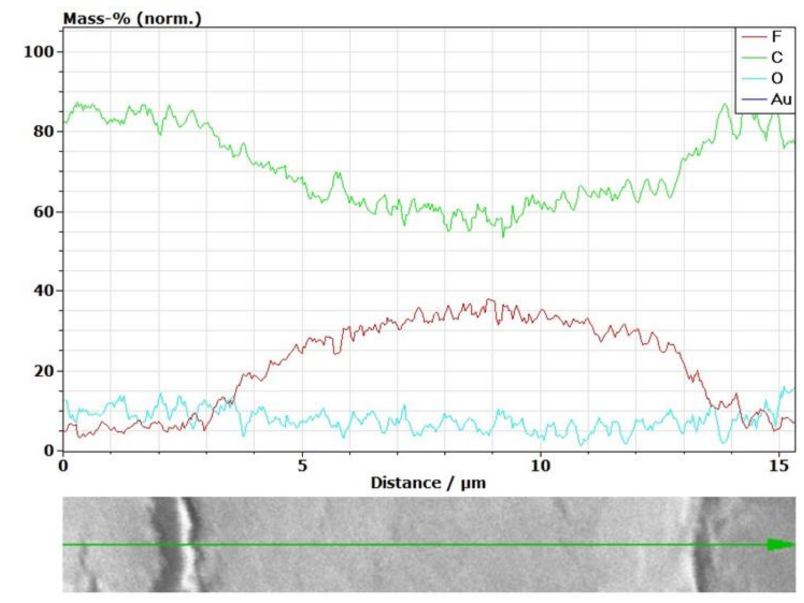


Figure 4: EDX examination of the cladding material

METHODS

- In low-pressure plasma technology, the choice of the process gas can initiate various mechanisms:
- Chemical activation with oxygen or nitrogen
- Physical ion etching with argon
- Chemical plasma etching with hydrogen
- The new cladding surfaces were examined by scanning electron microscopy and contact angle measurement to determine the topography and free surface energy.

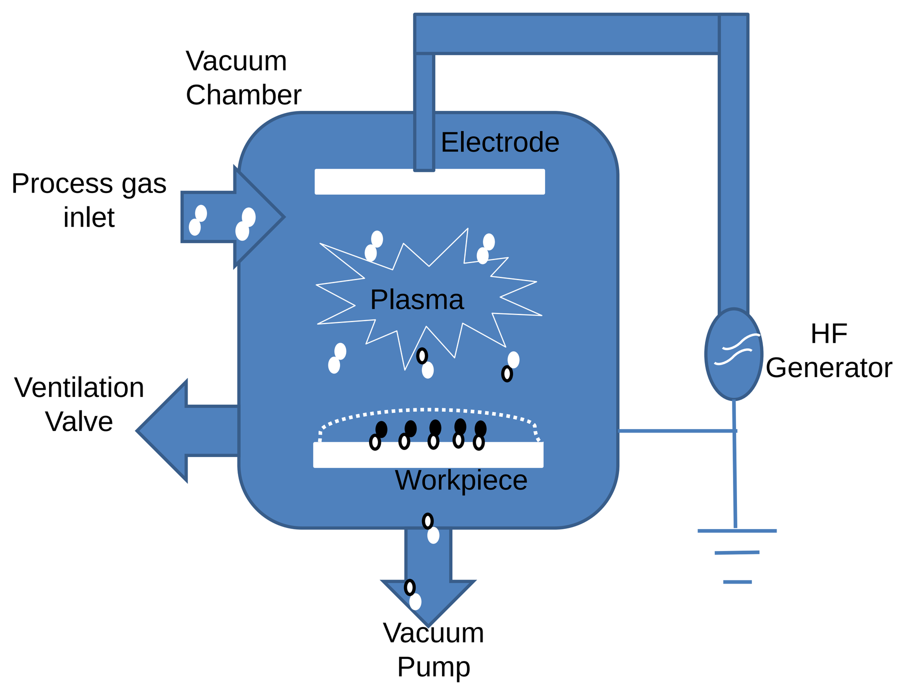


Figure 5: Schematic layout of the low pressure plasma system

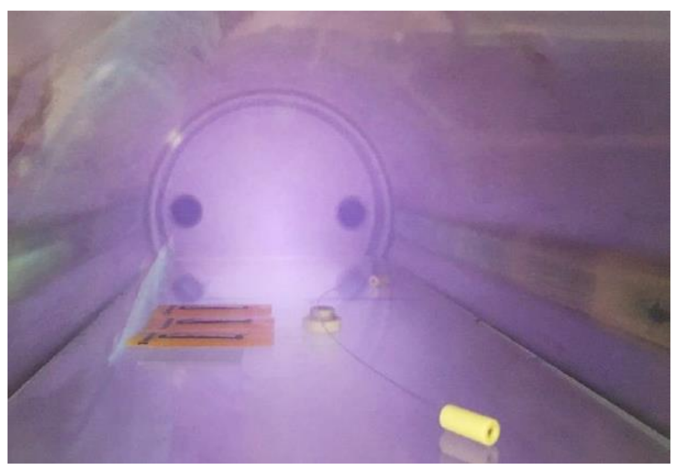


Figure 6: Insight into the running plasma process

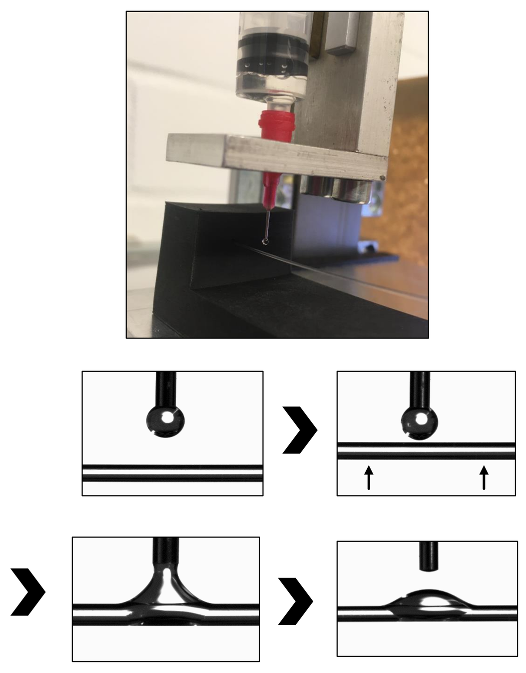
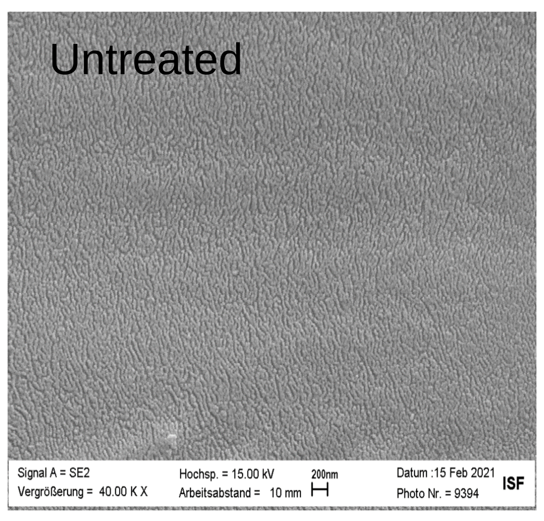
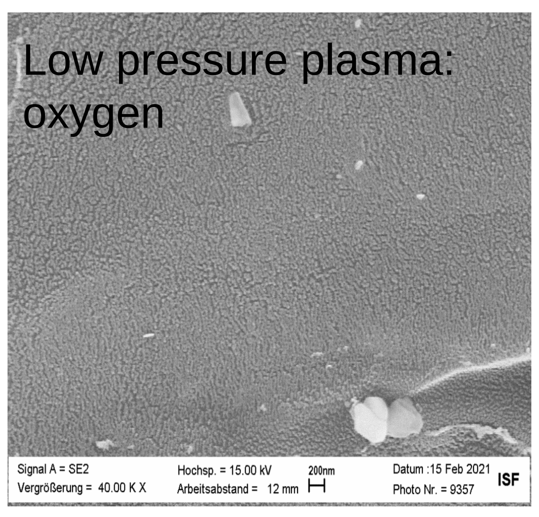


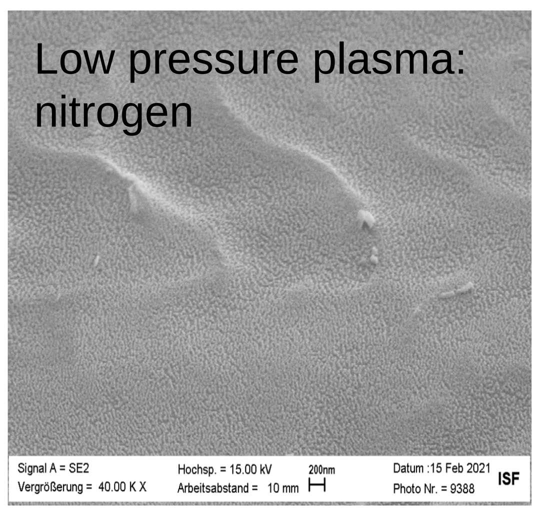
Figure 6: Performing the contact angle measurement

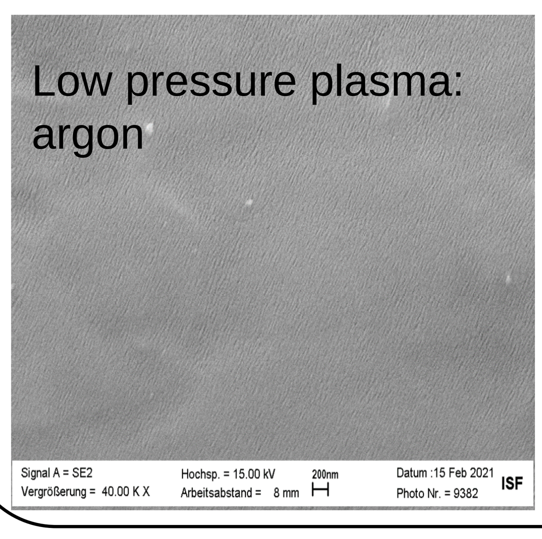
RESULTS

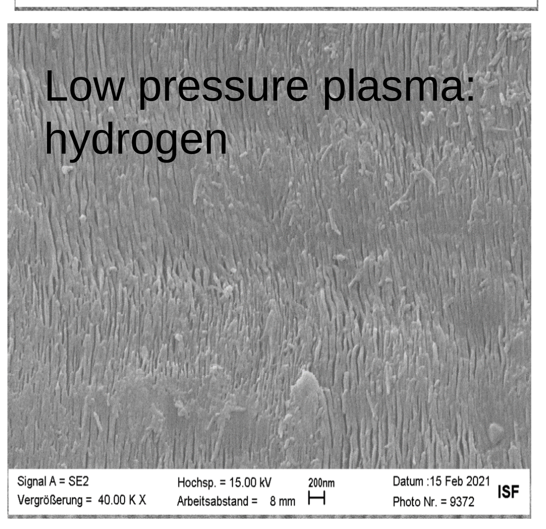
Surface topography





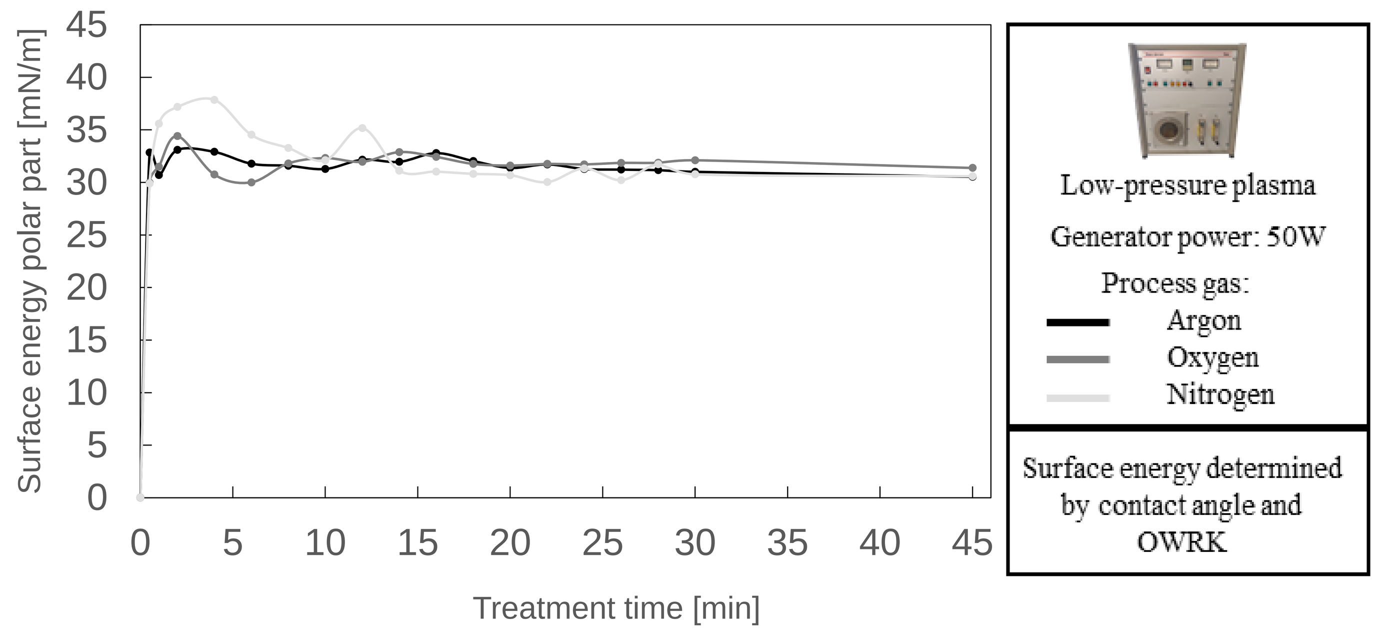






→ With the different mechanisms of plasma a change of the topography of the claddings is possible!

Surface free energy



→ In particular, the polar part of the surface free energy can be significantly increased with the low-pressure plasma!

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