Department 6
Electrical Engineering, Mechanical Engineering, Industrial Engineering

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Plasma electrolytic polishing for post-processing

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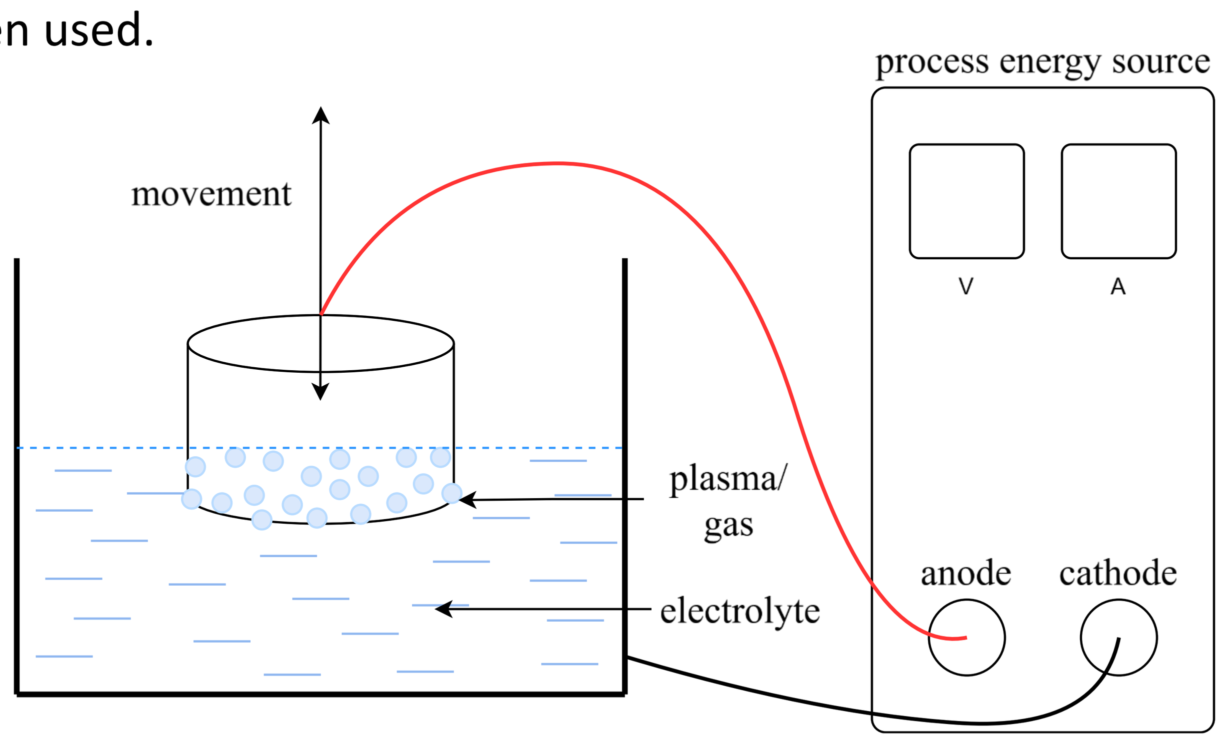
Introduction: Advances in additive manufacturing have enabled the production of complex geometries that are often unattainable through conventional post processing methods. However, these components typically require post-processing to achieve the necessary surface quality for functional applications. Plasma electrolytic polishing (PeP) emerges as a promising solution, offering environmentally friendly processing with low roughness values and high gloss finishes. This study investigates the optimization of PeP to enhance material removal rates and achieve uniform surface finishes. Key factors such as workpiece orientation, electrolyte flow, and cavity depth are analyzed to address challenges in polishing complex geometries. Experimental results demonstrate that targeted flushing of the electrolyte and vertical specimen alignment significantly improve removal rates, while minimizing gas bubble accumulation in cavities.

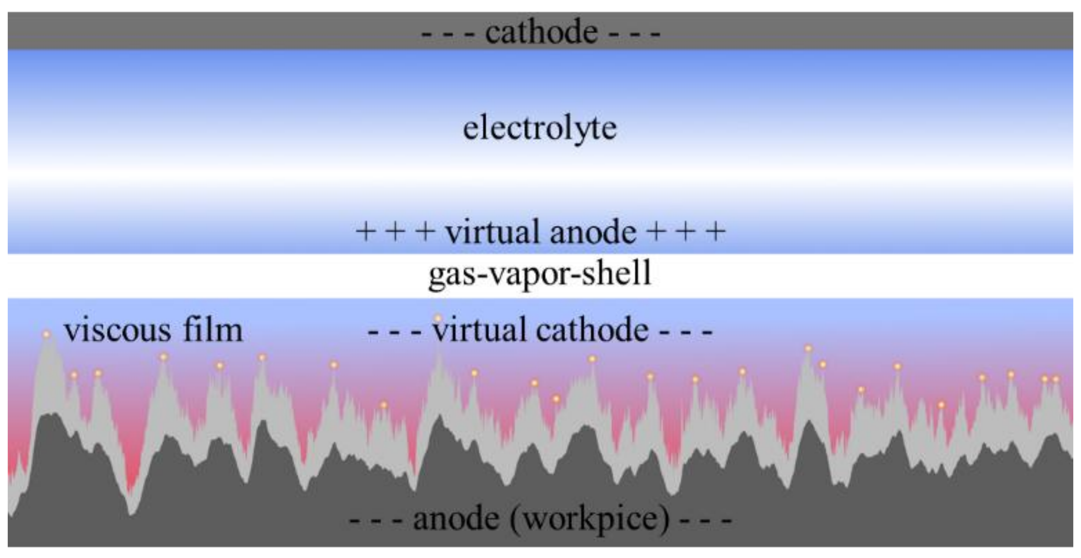
Plasma polishing

Plasma polishing systems typically consist of a cathodically connected polishing tank into which the workpiece is immersed. Non-toxic, weakly concentrated salt solutions can be used as electrolytes, which is an advantage over classical electropolishing, where highly concentrated acids are often used.

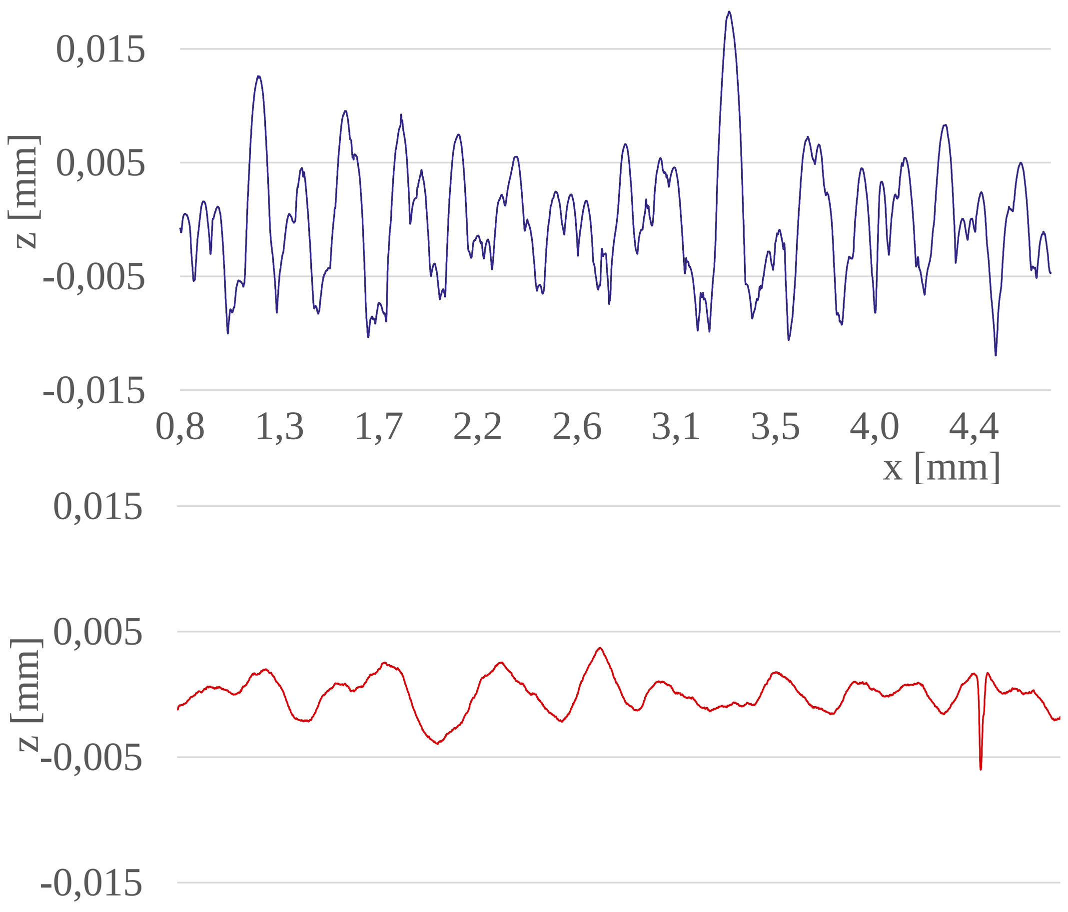


Setup of plasma polishing

According to Adamitzki's model [NES06], the gas-vapor envelope is bounded by a virtual anode and a virtual cathode. Within this envelope, a mixture of hot vapor and a boiling, viscous coating of the anode forms. This viscous film significantly contributes to the homogeneity and stability of the plasma and influences the interactions between the charged particles and the anode. Jacquet assumes that the anode coating acts as an insulator [JAC36]. In areas with cavities, the layer thickness is greater, resulting in a higher electrical resistance. The roughness profiles shows an additively manufactured sample (PBF-LB/M process) made of 1.4542 (X5CrNiCuNb16-4) before and after plasma polishing. The sample was treated for 10 minutes at a process voltage of 340 V and an electrolyte temperature of 70 °C. As a result, the surface roughness is reduced from Ra 4.2 µm to Ra 1.1 µm.



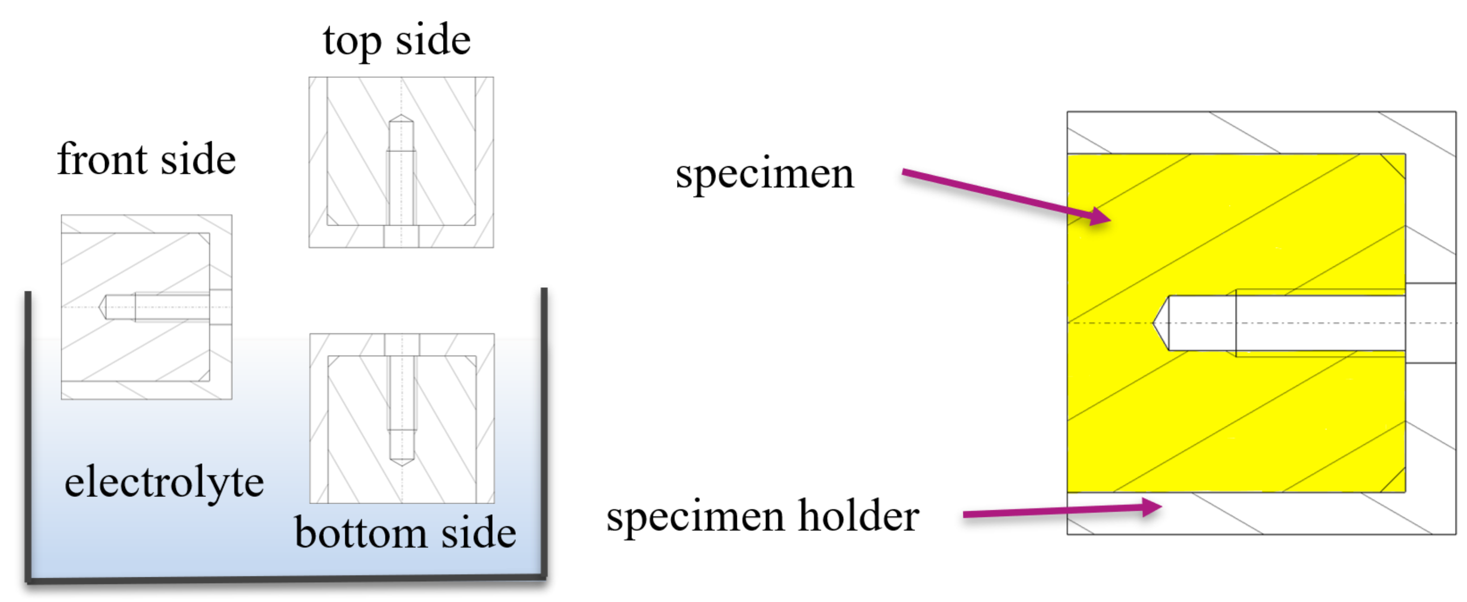
Model of the electrolytic cell during plasma polishing



Roughness profiles, top: unprocessed – bottom: polished

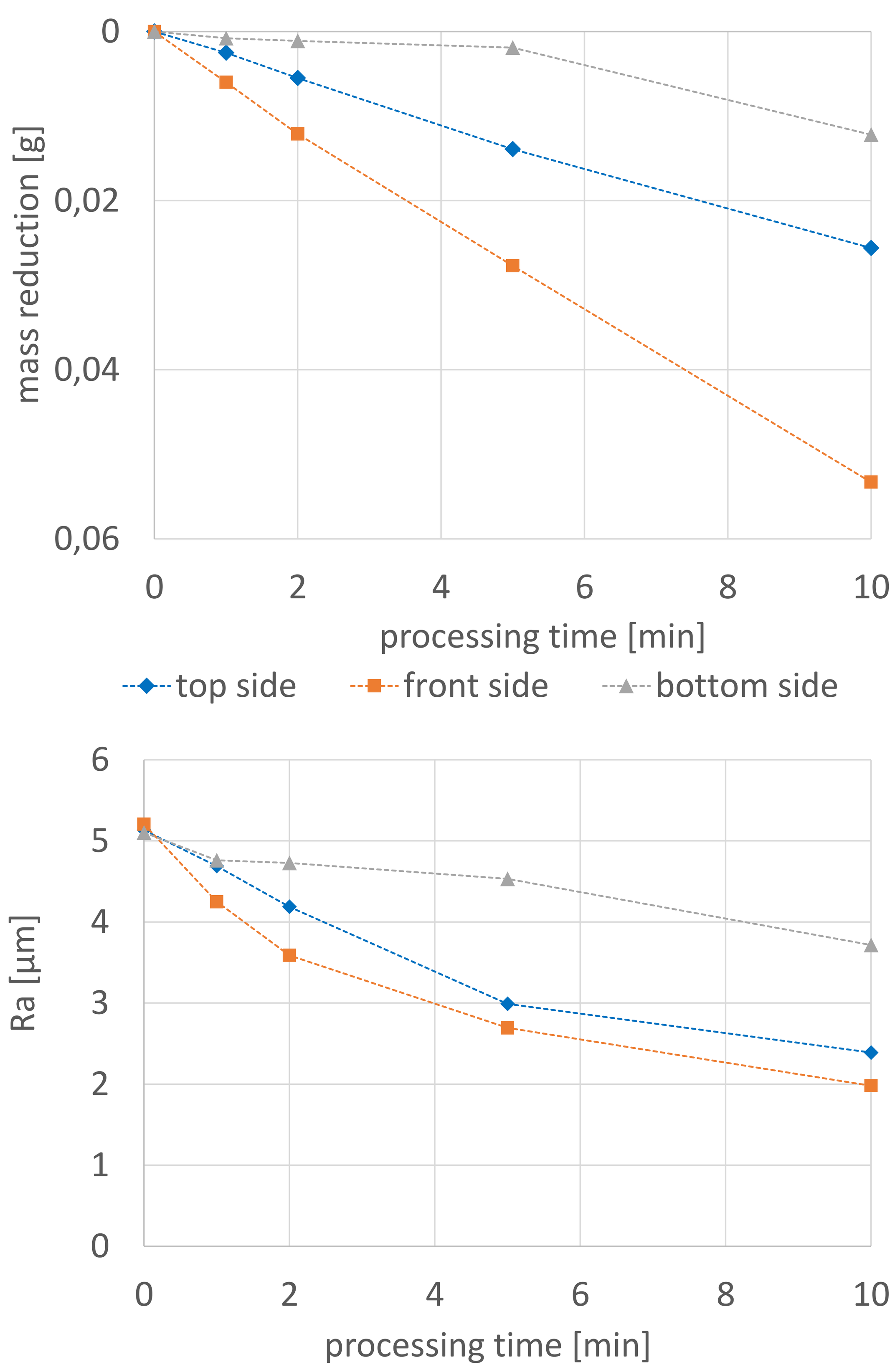
Experimental Setup

The objective was to evaluate the roughness and mass loss for a single surface. For this purpose, a workpiece holder with a flat blind hole (20 mm diameter) was fabricated. This setup enables the disassembly of the workpiece during intermediate steps, allowing the capture of mass and roughness values after different processing times.



Orientation of the specimen

The mass loss is nearly linear for all three orientations, thus validating the measurement results. In contrast, the roughness reduction is not constant and tends towards a minimum value, resulting in regressive curve progressions. It is shown that the roughness reduction depends on the orientation of the specimen in the electrolyte.



Mass reduction and roughness with different orientations of the specimen

[JAC36] Jacquet, P.A.: On the anodic behavior of copper in aqueous solutions of orthophoshoric acid, article, New York, 1936
[NES06] Nestler, K., Adamitzki, W., Unger, M., Faust, W., a.o.: Plasma Polishing of metallic surfaces – effects and models, international symposium on electrochemical machining technology, INSECT, Dresden, 2006