ADVANCES IN PRECISION GLASS MOLDING OF FUSED SILICA

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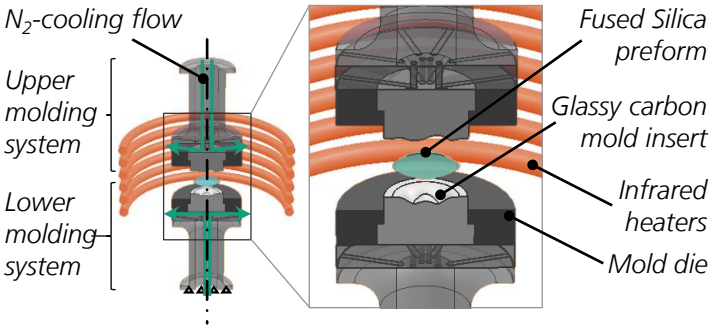
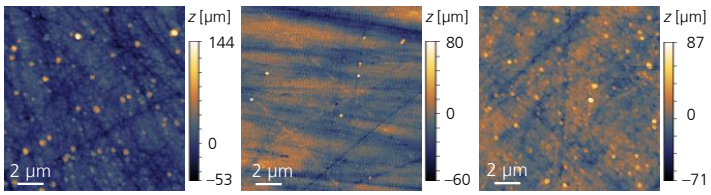
Shortened Abstract: Fused silica as a highly durable material for laser beam shaping or optical communication plays an irreplaceable role in photonic and optical systems. The conventional, direct manufacturing processes for the production of fused silica optics (e.g. grinding and polishing) are increasingly reaching the limits of efficiency and complexity. The Precision Glass Molding of fused silica can overcome these limits but faces challenges that prevent it from becoming a significant industrial application. These include primarily the wear of the molding tools, which is caused by the challenging process conditions (temperatures of up to 1,400 °C, high forming stresses, etc.). Although the mold wear mechanisms are well understood in a qualitative sense, quantitative service lifetime prediction for the forming process cannot be provided. This study presents a mathematical model comprising a combined Monte-Carlo and Multi objective genetic algorithm approach in order to overcome this issue. The simulation is able to reproduce the dynamic surface alteration during the wear occurrence.

#1 – Molding system and initial situation

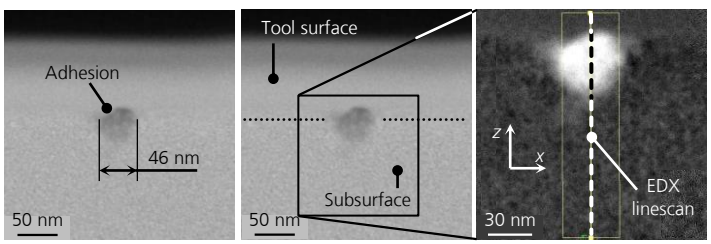


#2 – Wear on molding tools



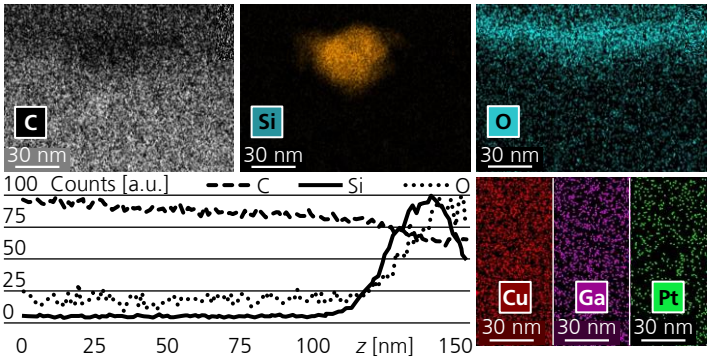
After several molding cycles, circular adhesion appear on the Glassy Carbon molding tools, marking the main wear mechanisms and degredating the quality of the molded lenses

#3 – Analysis of adhesions



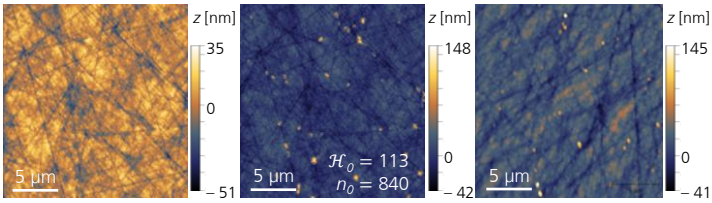
The adhesions are target of in-depth analysis, such as EDX, in order to understand their origin, formation and to define remedy strategies.

#4 – Analysis results



EDX analysis shows that the adhesions contain a high content of silicon. Furthermore, small traces of Si_3N_4 and carbon delamination were found by other measurement approaches.

#5 – Statistical modeling of mold wear evolution



Optimized Monte-Carlo simulation of altered surface (middle) in comparison to initial state (left) and measured wear (right). A high accuracy of the model was demonstrated.

#6 – Conclusion

During fused silica molding, the molds will degredate due to chemical reactions. Avoiding them is practically not possible. For this reason, a statistical simulation can predict the wear evolution and helps deciding, when to refurbish the molding tools.