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INVESTIGATING THE INFLUENCE OF ELECTROLYTE COMPOSITION AND VOLTAGE SIGNAL SHAPE ON SURFACE TEXTURE IN SPARK-ASSISTED CHEMICAL ENGRAVING (SACE)

Carmel Ganza[1], Seyed Mahmoud Seyedi Sahebari[1], Jana Abou Ziki[1*]
[1]Department of Mechanical and Manufacturing Engineering, Ontario Tech University, Oshawa, Canada.
carmel.ganza@ontariotechu.net, seyedmahmoud.seyedisahebari@ontariotechu.net, jana.abouziki@ontariotechu.ca[*]

ABSTRACT

Spark Assisted Chemical Engraving (SACE) has emerged as a promising technique for machining non-conductive materials such as glass and ceramics. The machining quality in SACE, as demonstrated by literature, is highly dependent on key parameters, particularly the electrolyte type and concentration, as well as the machining voltage. While the literature has also highlighted the effectiveness of a pulsed voltage during machining, utilizing other signal waveform types in tandem with the electrolyte concentration remains an avenue for exploration of the resulting outcomes on the surface texture of microchannels produced.

This study experimentally examines the effects of electrolyte composition and machining voltage on surface texture replication and overall machining quality. Sodium hydroxide (NaOH) concentrations, ranging from 10 wt.% to 40 wt.%, and potassium hydroxide (KOH) concentrations, varied between 40 and 50 wt.%, are used to evaluate their influence on microchannel geometry. Additionally, machining voltage is varied between 35V and 45V, and the effects of different waveform types—pulsed, sinusoidal, and triangular—are analyzed. Given that electrolyte composition is a challenging parameter to modify during machining, achieving comparable surface textures by adjusting the voltage signal type offers a practical approach to process refinement.

The surface texture is assessed qualitatively by examining machining patterns on the glass surface, while quantitative analysis includes measurements of microchannel depth, width, and surface roughness using a 3D profilometer. This study extends previous research by demonstrating that machining voltage waveform selection can replicate surface textures typically obtained with specific electrolytes, potentially reducing the need for electrolyte changes. Furthermore, the findings reinforce the feasibility of achieving consistent machining outcomes across varying conditions, thereby enhancing the repeatability and process control necessary for scalable applications.

By enabling surface texture replication through parameter adjustments rather than electrolyte modifications, this study contributes to advancing the commercial viability of SACE. The results support the adaptability of SACE machining for industrial microfabrication, providing insights into how voltage signal control can improve process reliability and repeatability on non-conductive surfaces.