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Enhancing the gas film stability during Spark Assisted Chemical Engraving (SACE) process

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ABSTRACT

Spark Assisted Chemical Engraving (SACE) is a non-conventional process for micro-machining non-conductive materials. This process has the potential to machine various micro-structures of relatively high aspect ratio (around 10) and at an acceptable machining rate compared to other chemical processes. Machining occurs when a voltage higher than a critical value is applied across a tool and a counter electrode dipped in an electrolytic bath. This causes bubbles to form around the tool and then they coalesce into a gas film that isolates the tool from the surrounding electrolyte. As a result, high energy discharges are generated through the tool and heat the substrate beneath it causing local material removal by thermal-assisted etching. The gas film breaks and reforms on average every few milliseconds. In fact, its lifetime varies depending on various machining conditions including: the properties of the electrolyte, wettability of electrode-electrolyte interface, tool material, geometry, and tool immersion depth. It has been shown that the gas film stability affects the machining quality and repeatability. A stable gas film helps in maintaining a uniform local temperature and enhance material removal rate thus resulting in enhanced machining repeatability and quality. The attempts made to date to stabilize this film by tuning some of the machining parameters are not integrated. Hence, there is a critical need for a comprehensive study of the effect of all major influencing parameters on the gas film stability. This work presents an experimental parametric study of various factors that influence the gas film as an attempt to enhance its stability. Among the investigated factors are the applied voltage magnitude and frequency, the electrolytic solution, and the tool dipping depth. The gas film stability is evaluated based on the film formation time and lifetime as well as the discharge frequency. These entities are calculated from the recorded machining current signals using a signal processing algorithm for the various applied machining conditions. In a next step, the present results will be applied while machining in order to study the influence of the film stability on machining repeatability and quality.