# Micro-Milling of burr-free thin Structures for die-sinking EDM Applications

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**Abstract**

As a result of the continuous miniaturization of micro-electro-mechanical systems (MEMS), the demand for optimized manufacturing solutions for a precise and reliable production is constantly increasing. Certain components of MEMS are commonly produced using injection molding. This process guarantees an efficient and reliable production of large quantities at low costs. The employed molds in injection molding are made of hardened steel in order to reduce wear formation and to provide high accuracy of the shape. The structuring of the molds is conducted using die-sinking EDM, as this process removes material independent of the workpiece hardness. The shaping of either macro- or micro-features can be conducted during the same process step. Aside from this, the realization of sharp inner corner radii, low surface roughness and steep flanks are feasible. Therefore, the employed electrodes in micro-die-sinking EDM have to be carefully structured using micro-milling. For micro-applications, electrodes made of pure copper are often employed. This paper presents the micro-milling strategy and dimensional limitations when performing burr-free micro-structuring of pure copper. The quality of an eroded shape is defined to a high extent by the condition of the electrodes. In the case of using flawed electrodes or having structures afflicted with burrs, a significant decrease of shape quality after erosion can be caused. By deriving an impeccable micro-milling strategy, precise and flawless micro-structures in electrodes can be established. The micro-milling is carried out using tools with a diameter as low as 150 µm and an effective cutting length as low as 300 µm. This enables the machining of micro-structures with a high aspect ratio. Also, this leads to a capability of manufacturing ribs with a width and height as low as 40 x 190 µm and a length of 5 mm. It also allows pillar sizes as low as 50 x 50 µm and a height as low as 190 µm. Due to the small tool diameter, pitch distances below 200 µm are possible to machine. To prevent excessive deformation during micro-milling of the tool or structure, the process forces are monitored and evaluated. In comparison to a FEM analysis, the maximum expected displacements are calculated.