Comparison of stainless steel and PEEK for the manufacturing of micro-fluidics chips through micro-milling

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Abstract

Micro-fluidic and lab-on-chip structures are an integral part of modern medicine and biotechnology. An important application of these chips is the production of lipid-based nanoparticles that can be used for the encapsulation and transport of active pharmaceutical ingredients. They consist of a series of micro-channels with a characteristic basic structure and geometric shape that enable specific flow behavior. The fabrication of micro-fluidics, which is mostly made of polymers, includes soft lithography, chemical etching, and micro-injection molding. These manufacturing processes involve high processing times and costs, and therefore limit the overall efficiency of micro-fluidic chip applications. Direct machining of these chips by micro-milling is a relatively low-cost alternative that has not been extensively investigated. Therefore, the present study focuses on micro-milling of micro-fluidic chips in experiments with different milling parameters. Stainless steel and PEEK are specifically compared as base materials for milled chips. Since burr formation is a key factor for nanoscale structures during chip fabrication, burr height is analyzed as the main process characteristic. From this and from the measurement of the surface parameters, the specific most suitable parameters for both materials are derived. These are then used to machine a test sample of a micro-fluidic structure and the machining time for this process is evaluated. It was found that the machining time was significantly shorter when machining PEEK, while the stainless steel had the advantage of a lower burr height. Overall, micro-milling has proven to be a viable machining process for the fabrication of micro-fluidic structures.