Experimental investigation of accuracy, repeatability and reproducibility of multi-axis laser processing systems

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The requirements that complex miniaturised components for various application areas, e.g. in aerospace and automotive industrial sectors, have to satisfy are constantly growing and therefore the demand for precision multi-axis micro-machining system (MMS) is increasing. Laser-based MMSs that can fulfil such requirements have attracted a significant interest due to their capabilities to execute different laser processing operations, e.g. structuring, texturing, drilling, cutting and patterning, on free form surfaces in a fully integrated platform on a wide range of materials. However, component technologies of such laser-based MMSs have intrinsic shortcomings, i.e. associated with their mechanical stages and beam deflector systems, which constrain their accuracy, repeatability and reproducibility (ARR) and therefore their wide deployment. Although information about accuracy and repeatability of these component technologies are provided in their technical specifications, it is not possible to judge the overall processing uncertainty in executing multi-axis machining operations based on this information. Therefore, to investigate the capabilities of these component technologies, a series of experiments were conducted using a state-of-the-art multi-axis laser-based MMS. In particular, the effects of mechanical and optical axes on its ARR was investigated while processing free form surfaces. This research provides an insight into the manufacturing challenges and limitations of laser micro-machining platforms associated with the fabrication of 3D miniaturised components for various potential application areas.