Investigation on femtosecond laser micro machining spark plasma sintered TiB_2-10%SiC ceramic composites

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Abstract

TiB_2-based ceramic composites were applied in micro manufacturing fields including micro tools, micro reactors, micro exchangers and others micro components, owing to its superior mechanical and physical proprieties. In this work, micro channels were fabricated on TiB_2-10%SiC ceramic with hardness of 24.6±0.8 GPa and used as the workpiece sample by femtosecond laser with a wavelength of 1030 nm, a pulse duration 400 fs and repetition rate of 50 kHz. Multi-pulse ablation experiments on TiB_2-SiC ceramic composite with the corresponding laser fluence were conducted. In addition, comprehensive studies were implemented to analyze and evaluate the effect of laser energy and laser scanning speed on the width, depth, and wall angle of micro-channels, heat affected zone around the micro-channels and microstructures of laser irradiated zone. Scanning electronic microscopy equipped with energy dispersive spectroscopy and confocal laser microscopy were used to observe the microgroove morphologies and measure the depth, the width, wall angle as well as heat affected zone of the machined micro-channels. Results showed that ablation threshold of TiB_2-SiC ceramic composite under multi-pulse laser irradiation was 32 μJ at repetition rate of 50 kHz. In addition, laser energy was found to be positively proportional to channel width, channel depth, and heat affected zone width, however a little effect on wall-angle. The oxidation phenomenon and debris were obvious around both sides of the micro-channel. Moreover, higher scanning speed generated wider and shallower micro-channel resulting in larger wall-angle, while heat affected zone width remained unaffected. Furthermore, a predictive model between laser parameters and the response variable depth as well as width of the fabricated micro-channel was developed. This study provided the reference for precise micro manufacture of TiB_2-SiC ceramic composites.

Keywords: TiB_2-10%SiC ceramic composites; femtosecond laser; micro machining; ablation threshold; micro-channel.