High-Power Picosecond Laser Machining of Advanced Materials

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Over the last few years, there has been an increased interest on the exploitation of new-advanced materials (from hard ceramics to coated composites) in high-value manufacturing; most of which are not compatible with conventional machining including continuous-wave and long pulse lasers. Over the last two decades, short (nanosecond (ns)) and ultra-short (picosecond (ps); femtosecond (fs)) pulse laser machining has been evaluated by various researchers and proposed as an alternative to the current state-of-the-art machining techniques for advanced materials. However, most of the established/existing research on this topic is based on low power lasers (<100 W), which are not suitable for industrial production environments due to their low material removal rate.

This paper presents the results of a fundamental study performed using a 300 W picosecond laser for the deep machining of various advanced materials, including tungsten carbide, metal-matrix composites and nickel superalloy. The influence of various laser parameters on the geometric precision and quality (surface and sub-surface) of the ablated area was analysed, and the ablation mechanism is discussed. At optimal conditions, no significant thermal defects such as a recast layer, micro crack or heat-affected zone were observed, even at a high average power of 300 W. The material removal rate (MRR) seems to be proportional to the average power of the laser. Edge wall taper appears to be the major issue that needs to be resolved to enable industrial exploitation of high power ultra-short pulse lasers.