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Micro surface texturing of alumina ceramic with nanosecond laser

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Abstract

In order to fabricate micro surface textures on alumina ceramic, the effects of single pulse intervals processing and ring cutting processing on the laser surface textures were discussed. The advantages and disadvantages between the two kinds of processing method were compared. The crater diameter and depth increase with the increase of laser pulse energy, and the increasing number of pulses significantly affects the crater depth for the single pulse intervals processing. As for the ring cutting processing method, micro-pit depth changes with the average power, whereas the micro-pit diameter mainly changes with scan radium. By optimizing laser processing parameters the micro-pit dimensions could be independently controlled. These two methods could process micro-pits with different diameters and depth on alumina ceramic.

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Keywords: laser surface texturing; Alumina ceramic; Single pulse intervals processing; Ring cutting processing

1. Introduction

Surface texturing has emerged in the last decade as a viable option of surface engineering resulting in significant improvement in load capacity and friction coefficient of mechanical components. Laser Surface Texturing (LST) is probably the most advanced so far for its efficient, low cost and universal [1]. Alumina ceramic is a kind of engineering ceramic with good wear resistance, corrosion resistance, and other characteristics. Due to high hardness, big brittleness alumina ceramic breaks easily under mechanical impact, so it is difficult to use conventional machining methods. It will produce a large number of micro cracks which can easily cause stress concentration.

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Many researches have been made on the mechanism, process, and engineering applications of laser surface texturing. Zhang[2] established the basis of laser ablation theory, and investigated the influence of laser parameters on the shape and depth of the ablation profile. Gilbert[3] simplified the model for the rapid prediction of the surface texture size. In the process, Vilhena[4] studied the effect of laser energy and mode on the surface texture and optimized the texturing process parameters. Fu[5] put forward single pulse intervals processing technology and used it for SiC mechanical seal samples.

Though some researches have been done on processing methods about laser surface textures, the comparison between the different methods still needs to be put forward. In the current study, micro-pit textures were fabricated by two different kinds of processing methods, single pulse intervals processing and ring cutting processing. The effect of laser processing parameters on the machining quality and the comparisons of technical characteristics between the two kinds of processing methods were systematically analyzed.

2. Experimental details

In this experiment, alumina ceramic with content of 99% was used. The properties of the alumina ceramic are listed in Table. 1. A nanosecond Nd：YLF laser was used in this experiment, and all kinds of laser surface texture, such as micro-pits and micro-grooves, could be fabricated by using the five axis machining system with independent design as shown in Fig. 1(a). Through the lens, laser beam could be focused on the workpiece surface. The parameters of the laser system are shown in Table. 2.

When the pulse laser beams on the surface of metal materials, there will be obvious splash phenomenon which affects the morphology observation and detection. Therefore, the sample processed needs to be put into the ultrasonic cleaning machine for 10min. The surface morphologies and topographies were measured by a laser confocal scanning microscopy(Keyence VK-X200) as shown in Fig. 1(b). Fig. 2(a) and Fig. 2(b) show the micrograph of surface textures. Recast layer can be seen in Fig. 2(b). Fig. 2(c)shows the 3D morphology of micro-pit. Micro-pit depth and width could be measured in sectional drawing as shown in Fig. 2(d).

Table 1. Properties of alumina ceramic.

Properties	Value
Density(g/cm3)	3.85
Compressive strength(MPa)	2400
Elastic modulus(GPa)	340
Vickers Hardness(HV)	1600
Fracture Toughness(MPa1/2)	3-4
Thermal Conductivity(W/mk)	29

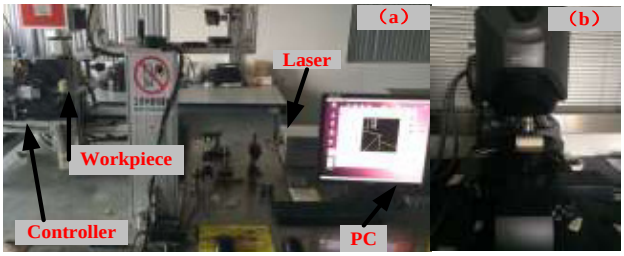

Fig.1. Laser processing and measuring system (a) Laser processing workstation (b) laser confocal scanning microscopy(Keyence VK-X200).

Table 2. Properties of the laser system.

Laser parameters	Value
Wavelength(nm)	527