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Laser surface texturing on ceramic coating

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ABSTRACT – In recent years, ceramic coating with well-defined surface structures have been prepared in order to combine the advantages of protective coatings and the beneficial effects of surface texturing. Surface texturing is a new way to modify surface characteristic that lead to an improvement in properties of material parts particularly for tribological characteristics. The formation of specific patterned surface can be achieved in many ways, for example abrasive blasting, reactive-ion etching, and ultrasonic machining. However, in this paper, only the laser technology will be the main focus topic as it offers the most control and precision over the produced geometry. The technique also did not involve chemical reagents or produce significant waste.

1. INTRODUCTION

The processing, study and use of ceramics coating has great attention due to their excellent potential application and properties. In comparison with metals and polymers, most ceramics possess useful features such as high temperature strength, high wear resistance, lower thermal stability, good resistance to corrosion and oxidation at high temperatures and high bond strength between atoms leads to great hardness, stiffness and strength [1]. In recent years, coating with well-defined surface structures have been prepared in order to combine the advantages of protective coatings and the beneficial effects of surface texturing. Surface texturing, that is introducing specific patterns on coating surface is a well-known approach to improve the coating properties. Such textured coating can be prepared either by depositing the coating material on a textured substrate [2] or directly structuring the coating by laser surface texturing (LST) [3].

LST have great attention recently because it has great advantages such as extremely fast, environmental friendly, and provide excellent control of pattern size and shape [4]. Therefore, this study aimed to summarise the current surface texturing technologies on ceramics coating in order to develop understanding of the process and its applications.

2. LASER SURFACE TEXTURING

LST is a new method that has high potential in improving surface geometry and texture of various types of materials. Among the applications of surface texturing are in biomedical [5], optical properties, surface wettability [6] and adhesion joint strength of materials part. Table 1 shows the wavelength for different types of laser that commonly used for ceramics coating texturing.

Table 1 Wavelength for different types of laser.

Laser types	Wavelength (nm)
CO_2	10600
Nd:YAG	1064
Fibre	1064
Excimer	193 - 351

CO_2 lasers comprised of a combination of carbon dioxide, nitrogen and helium as the laser medium. Its industrial applications are in laser machining, heat treatment and welding. Another type of laser is Nd:YAG laser which is in solid state laser category. The Nd:YAG laser use Neodinium (Nd^{3+}) as dopants and dispersed in complex crystal of Yttrium-Aluminium-Garnet (YAG) which has a chemical composition of $Y_3Al_5O_{12}$. This kind of laser are used in applications that require low pulse repetition rate and high pulse energies. On the other hand, excimer laser is a type of gas laser which made up of gas compound that exist only in an excited state. The example of excimer laser are ArF, KrF, XeF and XeCl. The excimer lasers are usually used for ceramics micromachining, semiconductors and marking thermally sensitive materials [1].

3. SURFACE TEXTURE DESIGNS

Various textures can be designed by using LST such as grid, chaotic, dimpling and groover types. The common texture designs are shown in Figure 1. In LST, the best performance criteria are high material removal efficiency with a small heat-affected zone, good reproducibility and the controllability of the pattern size. All these criteria are strongly dependent on the laser parameters which are wavelength, pulsed duration, scanning speed and peak power [4].The pulse duration is the most important parameter that affecting the processing quality. However, according to Ding, et al. [4] the nanosecond pulsed laser is not suitable for texturing nonmetal hard surface coatings because of an inherent

thermal effect. The thermal stress within the coating layers may reduce the adherence to the substrates.

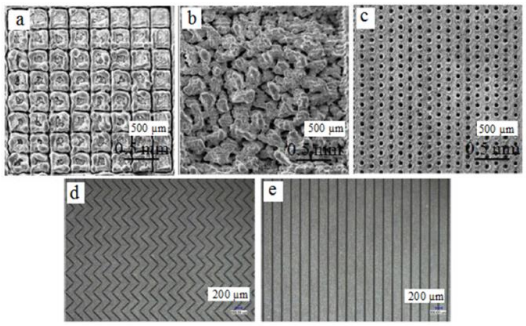

Figure 1 SEM images of surface textures types (a) grid [7]; (b) chaotic [7]; (c) dimpling [7]; (d) wavy groove [8]; (d) linear groove [8].

4. TEXTURED CERAMIC COATING

Wang, et al. [9] observed that the surface texturing of SiC ceramics with a CO_2 laser system induced a ring-like heat affected zone around the pores. According to Hanon, et al. [10] the major problem in laser texturing is the melt material produced in the process. Irregular and incomplete melt expulsion affects the shape of the hole, producing re-solidified material as shown in Figure 2.

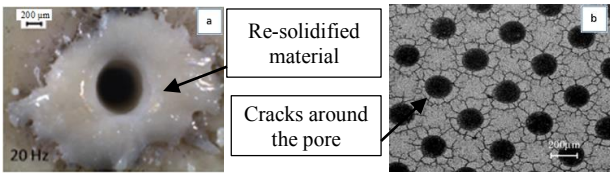

Figure 2 (a) The hole and re-solidified material of Al_2O_3 produced by Nd:YAG laser [10]; (b) microcracks were formed around the pores of SiC surface [9].

The experimental results by Su, et al. [11] indicated that the processing parameters of laser texturing are effected to topography of textures. The topography of the textures can be improved by applying a lower scanning speed and a higher average output power of the laser. The combination of short pulsed and short wavelength is suitable for ceramics such as Al_2O_3 and SiN as reported by Knowles, et al. [12]. This is due to the reduction of the thermal effects that were produced by the laser processing. Moreover, the applied short-pulsed laser may produce small amount of molten material and heat affected zone. These are the advantages of ultrashort pulse laser in which it has the ability to produce high peak power intensities and provide energy into a material before the thermal diffusion occurs [10].

5. FINAL REMARK & FUTURE WORK

The effectiveness of LST process is strictly influenced by process parameters such as the wavelength, pulsed, peak power, output power and also the scanning speed. In future work, the correlation between the LST process and the materials properties will be studied in order to obtain optimum characteristic of surface texture.

Thus, by optimizing the texture and morphology, they can be the key factors for enhancing corrosion resistance of coatings as well as other properties.

6. REFERENCES

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