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New Possibilities in the Customization of Materials to Improve their Performance and Functionality: Hexagonal Laser Texturing

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Introduction

Laser surface texturing (LST) is a surface modification technique used to improve the mechanical, tribological and functional properties of materials for surface functionalization as: biocompatibility [1,2], optical properties [3], wettability tunning [4], hybrid joining [5,6], etc. In particular, 316L stainless steel, an alloy widely used in industrial and biomedical applications, has benefited significantly from this technology.

The use of lasers for surface modification began to develop in the second half of the 20th century, driven by the need to improve wear resistance, friction and adhesion in various applications. With the evolution of fiber and femtosecond laser systems, unprecedented levels of precision and control have been achieved, enabling the creation of customized micro- and nanostructures on metallic surfaces such as 316L steel.

316L stainless steel is highly valued for its corrosion resistance and biocompatibility, making it a key material in industries such as medical, aerospace, automotive, electronics and advanced manufacturing.

One of the most used patterns in laser texturing is the hexagonal pattern, which mimics natural structures such as honeycomb cells. This design offers multiple benefits such as reduced friction and wear (improves lubrication by trapping fluids in its microcavities) and increased hydrophobicity (depending on the laser parameters, the interaction of the textured surface with liquids can be modified). In addition, cell integration in biomedical applications is improved since the hexagonal morphology favors cell adhesion and proliferation in implants and also improves thermal and optical efficiency, useful properties in heat sinks and photonic applications.

In this work, corrosion behavior in highly aggressive environments, simulating marine conditions, of hexagonal textured 316L stainless steel has been studied.

Experimental

The process used is laser ablation. This process is widely used for micro engraving of metallic materials and surface cleaning. It is a process of material removal by thermal attack that creates a groove by vaporising the metal. As a result, some of the molten material that is expelled from the working area is deposited on the outer edges of the groove, forming longitudinal ridges that follow the entire length of the groove.

These recast materials are very similar to the slag deposits that occur in welding processes without shielding gas. This is material that has melted and then solidified sharply.

The study details the results of laser microtexturing on a 40mm x 40mm surface. The pattern used is a 1 mm hexagonal geometry matrix. A Lansen LS30F fiber laser with 500 mm/s speed and a power of 15 W was used. These parameters gave a crater width of 90 µm. The Microtextured area was assessed by analysing the surface for evidence of thermally altered areas or localised corrosion patterns using an Olympus BX51 microscope.

Results and discussion

Fig. 1 shows the geometry obtained at different scales. The microtextured groove is clearly defined, and the thermally altered area on either side does not exceed the wideness of the groove. Concentrated corrosion deposits can be detected in the intervention zone, primarily on the edges. This is attributable to the fact that the part has not been cleaned, with the deposits adhering to the slag created by the laser attack. Nonetheless, the base of the groove is in satisfactory condition.

Fig. 2 shows the bottom of the groove. The laser attack generates a microstructure in the form of ripples and droplets with varying depths, analogous to that which is generated in weld seams. This phenomenon is attributable to the laser pulses. The dimension of this microstructure varies depending on the frequency used, for an equivalent speed and power. As can be seen, there are no corrosion levels higher than those on the surface of the rest of the part.

Conclusions

The development of laser micro texturing is advancing, opening up new possibilities in the customisation of materials to improve their functionality and performance in various industries.

The development of laser technologies is progressing well, and their application to texturing is becoming increasingly accessible. In tests on AISI 316 L stainless steel, laser micro texturing with hexagonal geometries has produced well-defined geometries without exacerbating corrosion patterns.

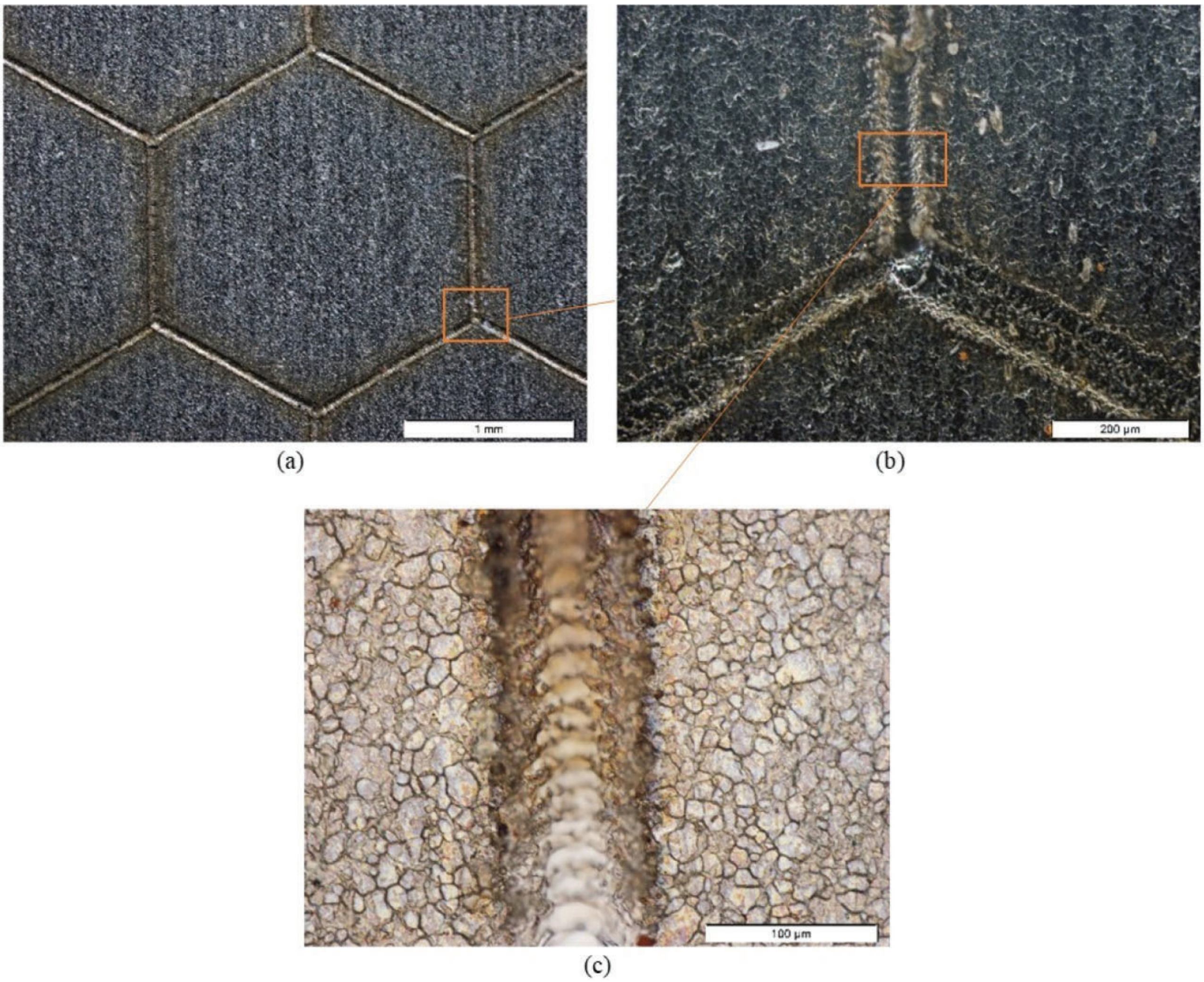

Fig. 1. Finished geometry. **(a)** View of the hexagon pattern (x5). **(b)** View of the textured groove (x20). **(c)** Representation of the surface around the groove (x50).

Fig. 2. View of the base of the groove (x50).

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