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COMPARISON BETWEEN LASER ADDITIVE MANUFACTURING AND LASER SPOT WELDING OF TITANIUM GRADE 2

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Abstract:

The microstructure and hardness of the melted area in a titanium grade 2 sample processed by Laser Spot Welding were compared to those processed by Selective Laser Melting. The results show that the materials obtained with the two processes have very similar characteristics. On the basis of what had been observed, it can be inferred that the Laser Spot Welding technique could be a low-cost way to verify the possibility of obtaining the desired properties with new alloys processed by Selective Laser Melting.

Keywords: Additive Manufacturing; Laser Powder Bed Fusion; Laser Spot Welding; Titanium Grade 2.

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1. Introduction

The current manufacturing technique known as Additive Manufacturing (AM) was born in the 1980s as Rapid Prototyping (RP).[1] Technology moves quickly with the setting up of various processes and with the application in numerous fields, such as the case of metallic materials.[2] Currently one of the most used techniques for metals is the Selective Laser Melting (SLM). Although this new type of approach to manufacturing has de- veloped with success in different industrial applications, from biomedical to automotive, machinery and aerospace domains, the process parameters which permit to generate products with good properties have been developed only for a limited number of alloys.[3–7] The main reason for the low number of metallic materials currently used must be attributed to the high costs of tests necessary to access if a certain alloy is suitable for being manufactured with the SLM technique. The aim of this work is to evaluate the possibility of obtaining the desired specifications of use, by processing a metal with SLM, employing a low cost operating process i.e. the Laser Spot Welding (LSW).

2. Materials and Methods

With the LSW the material is subject to the same heat treatment of the material processed with SLM: the metal is melted, cooled quickly and then tempered with the subsequent pass.

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3. Results and Discussions

If we do not take in to consideration the energy involved in the releasing of the residual stress during the heating of the powders used in the SLM process, which depends on the preparation methodology and on the granulometry of the powders, the energies involved in the two processes are comparable. For this investigation the examined material is the titanium grade 2 whom correct process parameters are known, both for the SLM and for the LSW. Two specimens have been prepared with both techniques. Through the SLM a titanium grade 2 cuboid with square base of side 10 mm and height 20 mm has been made, under argon atmosphere, Figure 1a. The powder and the process parameters are provided by the manufacturer of the machine. The specimen for the LSW technique has been made with two pieces of round wire 4 mm diameter, welded through laser Nd: YAG under argon flow and filler metal also in titanium grade 2, Figure 1b.

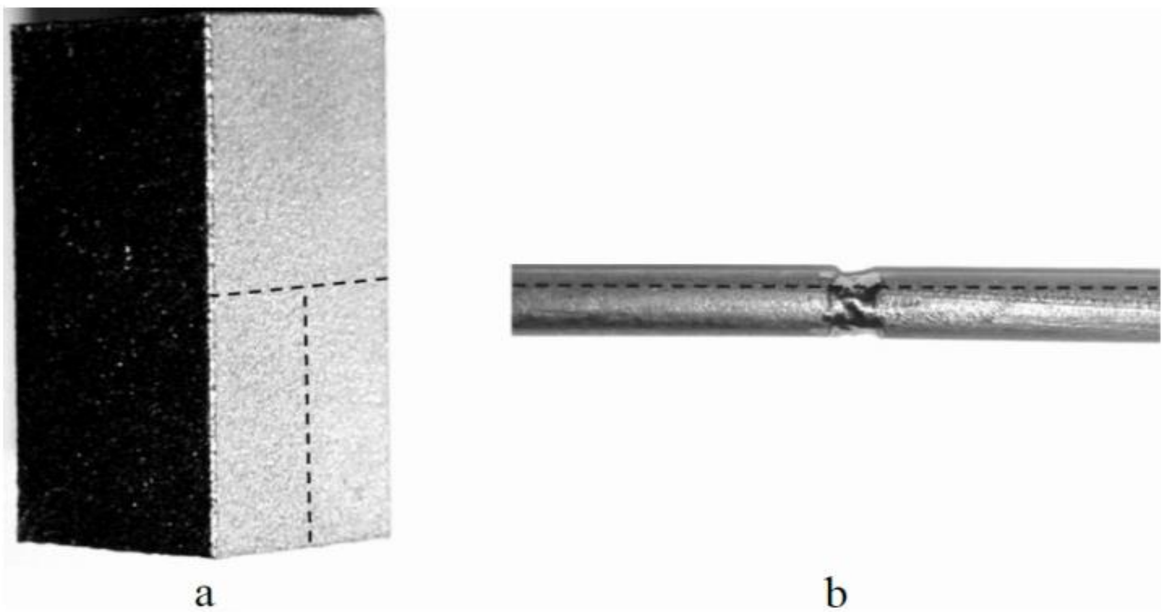

Figure 1: a) cuboid obtained in SLM; b) wires welded by LSW. The dottes lines show the performed sections.

The process parameters for the LSW are: Power 30 W, frequency 3 Hz, pulse duration 5, 5 m sec, spot diameter 0,7 mm. In order to compare the microstructures obtained with the two processes, the specimen made by SLM was sectioned in two mid-thickness halves on the sagittal plane and on the transverse plane. The specimen welded by the LSW was surface ground. All the specimens have been polished with the usual metallographic techniques and then etched with the Kroll solution (etchant 192 ASTM E407-07[8]). In order to evaluate the mechanical properties of the titanium obtained with the two techniques, we have measured the microhardness. The hardness of a metal is strictly linked to its yield strength. Five tests were performed for each sample with a Leits automatic microhard- ness tester, fitted with a Vickers indenter which used a 50gf (490.5 x 10-3 N), indentation load maintained for 10 s. The sample obtained with SLM shows an alpha prime structure (martensite) both on the sagittal plane and on the trans verse plane, Figure 2. The observed martensite plates present a microstructure similar, in morphology

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and dimensions, to one of those founded by Gu et al.[9] and by Attar et al.[10] in specimens of titanium grade 2 processed by SLM. At- tar et al.[11] have obtained a similar microstructure also for the titanium grade 1. The Vickers microhardness values measured are in the range of 280 ± 10 for all samples, Figure 3.

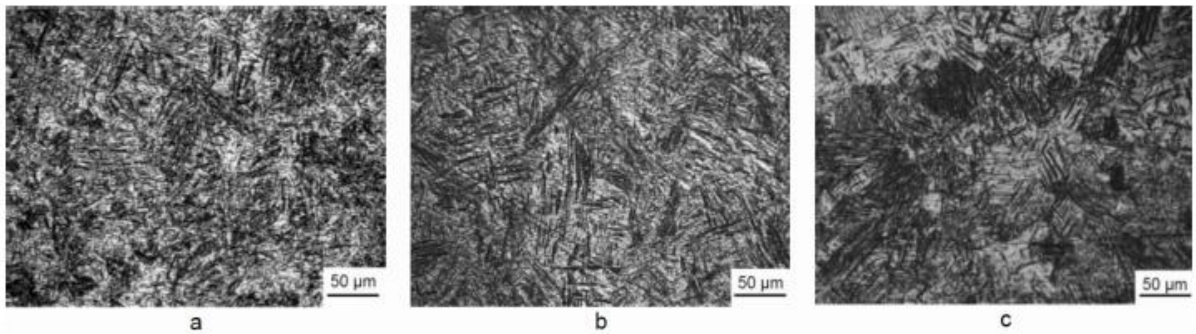

Figure 2: Micrographs of Ti grade 2: a) processed by SLM, sagittal direction; b) processed by SLM, transverse direction; c) deposited by LSW.

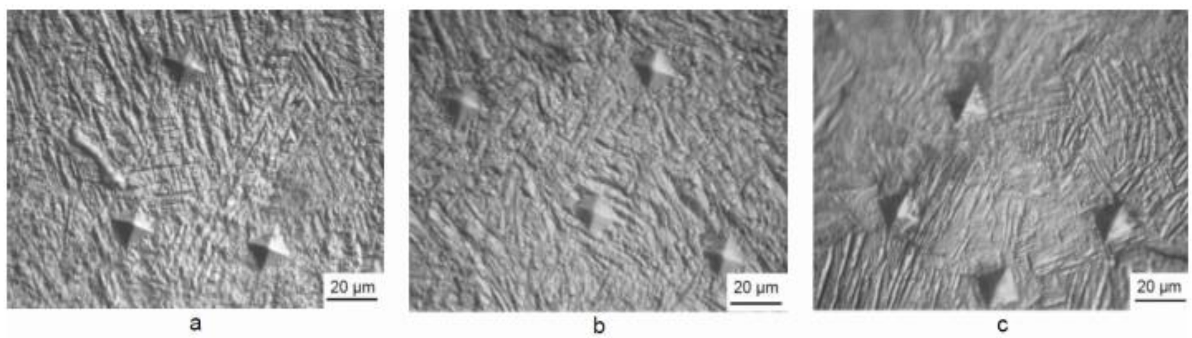

Figure 3: Vickers microhardness tested on specimens: a) processed by SLM, sagittal direction; b) processed by SLM, transverse direction; c) deposited by LSW.

4. Conclusions and Recommendations

The comparison between the obtained materials in SLM and LSW have revealed a similarity between the microstructures and the hardnesses. The LSW technique could be a valid low cost process for successfully miming what is possible to obtaining processing a new alloy by SLM. What observed also suggested the LSW as an excellent welding method for the components in titanium grade 2 made in additive manufacturing, because the weld metal shows the same hardness of the base metal and no residual stresses occur.

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