5th International Workshop on Laser-Ultrasound for Metals
May 5-6, 2022
Gif-sur-Yvette, France

Analysis of the effect of inline laser-induced ultrasonic waves on the microstructure of materials processed in laser powder bed fusion conditions

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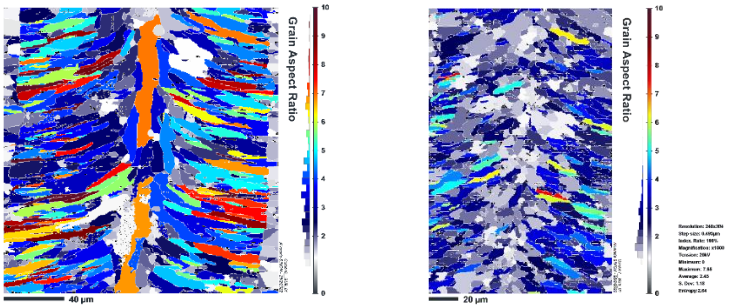
Metallic Laser Additive Manufacturing Processes and, particularly, the Laser Powder Bed Fusion Process, demonstrate a strong and ever-growing potential in a very varied field of applications. However, standard LPBF generally produces anisotropic columnar microstructure [1], induced by solidification conditions, which is unlikely desired. Different approaches have been proposed to produce an equiaxed grain refinement through adaptations of process parameters or a modification of the composition of the alloys that cannot be generalized. Recent publications [2] proposed to extend the well-known grain refinement by ultrasonic waves in casting processes. This has been successfully demonstrated in laser cladding conditions.

This study aims to explore the possibility of generating an equiaxed microstructure for LPBF using online laser-induced ultrasonic waves. This first experimental approach will be carried out on a simplified experimental setup representative of the laser fusion conditions, mainly on stainless steel material. In an initial experiment, the material is initially solicited by an external shear ultrasound transducer during the fusion process. Microstructural analysis demonstrates that this type of solicitation has a clear effect on the final microstructure. Then, new experiments including inline laser-induced ultrasonic waves is made by modulating the processing laser. The influence of process parameters (mainly process speed and laser power) and the ultrasonic signal (frequency, amplitude) is investigated. The microstructures are analyzed by EBSD and clearly evidence that the elongated grains normally generated by solidification conditions are fragmented into smaller grains for a range of frequencies.



(a) (b)

Figure 1: Microstructures analyzed by EBSD (a) without and (b) with laser modulation.

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