Laser Beam Melting of high performance oxide ceramics

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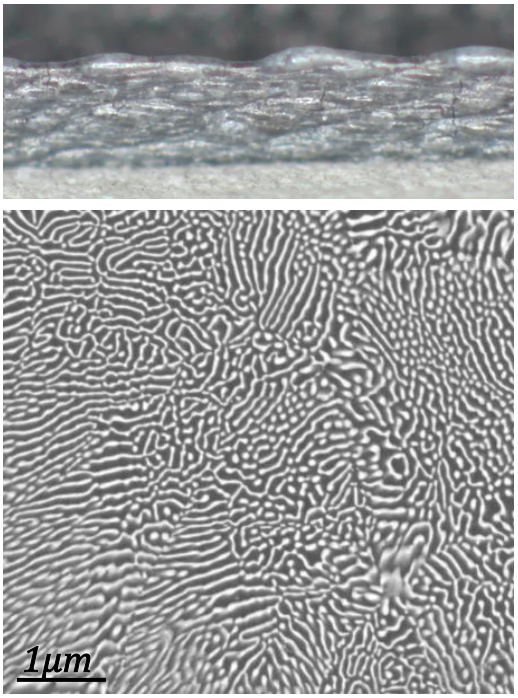

- Direct near-net shape additive manufacturing of ceramics
- Melt pool stability studies : monitoring and parametrical control
- Laser-matter interaction investigations : spectrometric in operando measurements and development of optical models
- Control of thermal gradients and microstructure size and morphology

Abstract:

Compared to other ceramic additive techniques, laser beam melting (LBM) provides direct near-net shape manufacturing, offering simultaneous melting and shaping. Post-processing and machining costs are consequently limited. It offers new shape and microstructure possibilities for complex high strength and temperature resistant structures, needed for example, to improve thermal efficiency of turbomachines. Ceramic LBM has been delayed due to material poor absorptivity in near infra-red wavelength, along with weak thermal shock resistance. Those main issues can be overcome, with addition of a sorbent to ceramic powder and by using preheating systems. High thermal gradients and cooling rates are generated, which enable directional solidification of nano-scale eutectic microstructures, known for their creep resistance.

The effects of process parameters, sorbent nature and content on powder bed properties and melted track stability are investigated. Track shrinkages and powder particle ejections after consolidation by melting are also assessed. These observations are correlated to optical properties. Laser-interaction models based on the analysis of volume interaction are developed. In-operando spectrometric measurements are also performed, in order to monitor the evolution of materials properties during manufacturing. Consequently, optical properties are traced not only at room temperature but also at high temperature, corresponding to solid powder bed and liquid fused material states. Ultimately, process parameters and criteria for stable dense 3D part manufacturing are identified. Proof is made that laser interaction with ceramics shows large differences compared to metals.