Evolution of melt pool and porosity during laser powder bed fusion of Ti6Al4V alloy: numerical modelling and experimental validation

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Laser powder bed fusion (L-PBF) is one of the most promising additive manufacturing technologies for metals, in which a laser selectively melts a pre-deposited bed of microscopic metal powders. Nowadays, final build quality is still limited because of the presence of defects like **porosities** that are very hard to be avoided. Numerical simulation has imposed as a powerful tool for defects prediction and process optimization but still its reliability has to be fully demonstrated. In this work, a commercial CFD software, FLOW-3D AM, was used for Ti alloys AM to understand the formation of porosity and experimental tests were performed to validate the model.

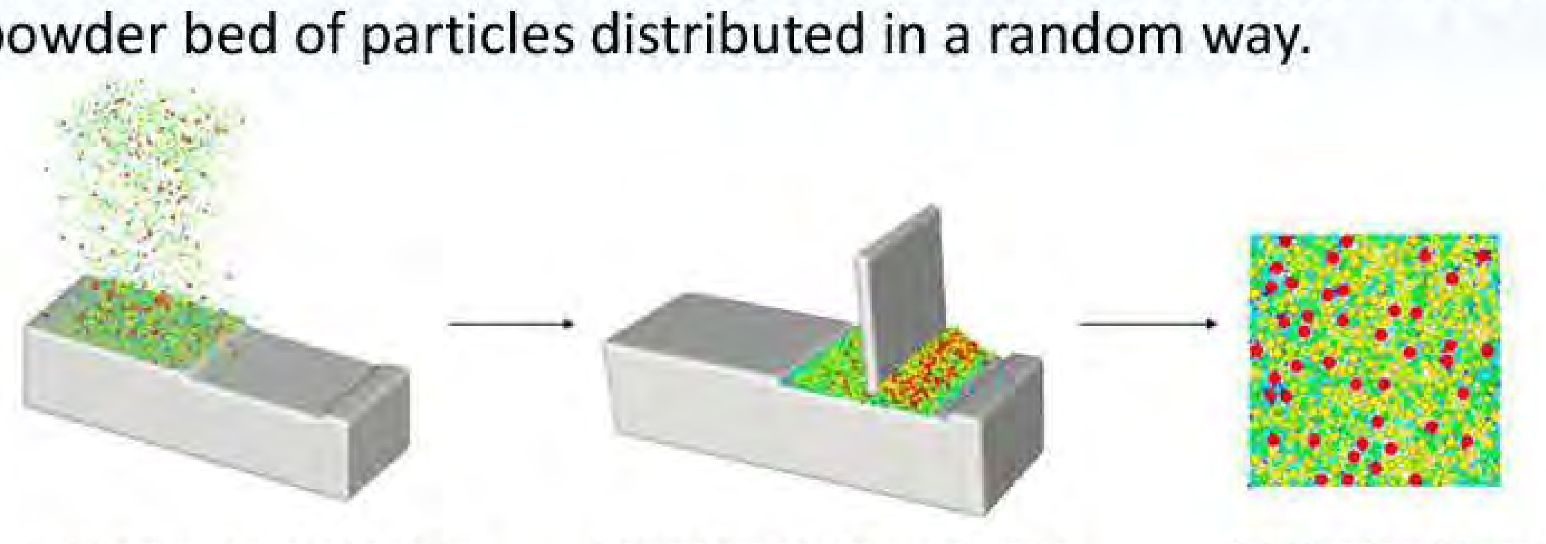
! OBJECTIVES

- *Melt pool dynamics evaluation*
- *Defects prediction (porosities)*

Materials and methods

1- Numerical simulation

The discrete element method (DEM) was used to reproduce a powder bed of particles distributed in a random way.

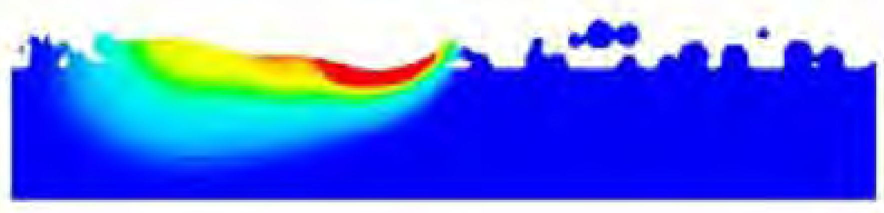


1- Particles freely drop on the building chamber — 2- A blade is modeled to spread powders — 3- A 50 µm layer is formed

Powder layer is converted into STL file and then, imported into WELD interface. Simulation parameters are reported.

Laser radius [µm]	Power [W]	Scanning speed [cm/s]	Layer thickness [µm]	Hatching distance [µm]	Fluid absorption rate
50	300	175	50	75	0,5

Single and multiple scan track simulations were performed. The output from numerical simulation were analysed to obtain shape and size of melt pools, morphology of scan track surfaces and porosity content.

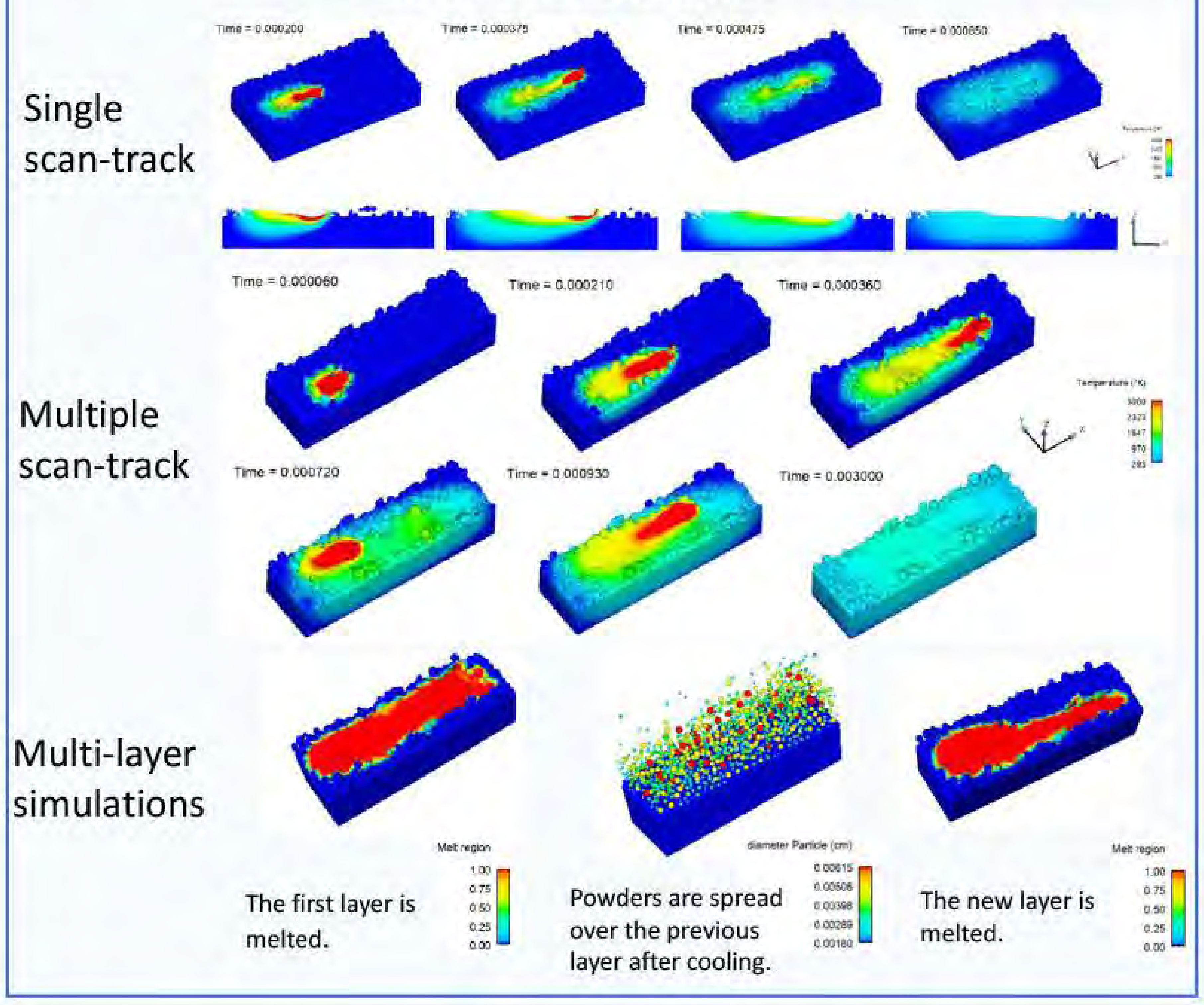


2-Model validation with experimental results

Cross sections were cut from cubic samples made of Ti6Al4V. Grinding and polishing followed by chemical etching allowed to reveal microstructure and melt pools.

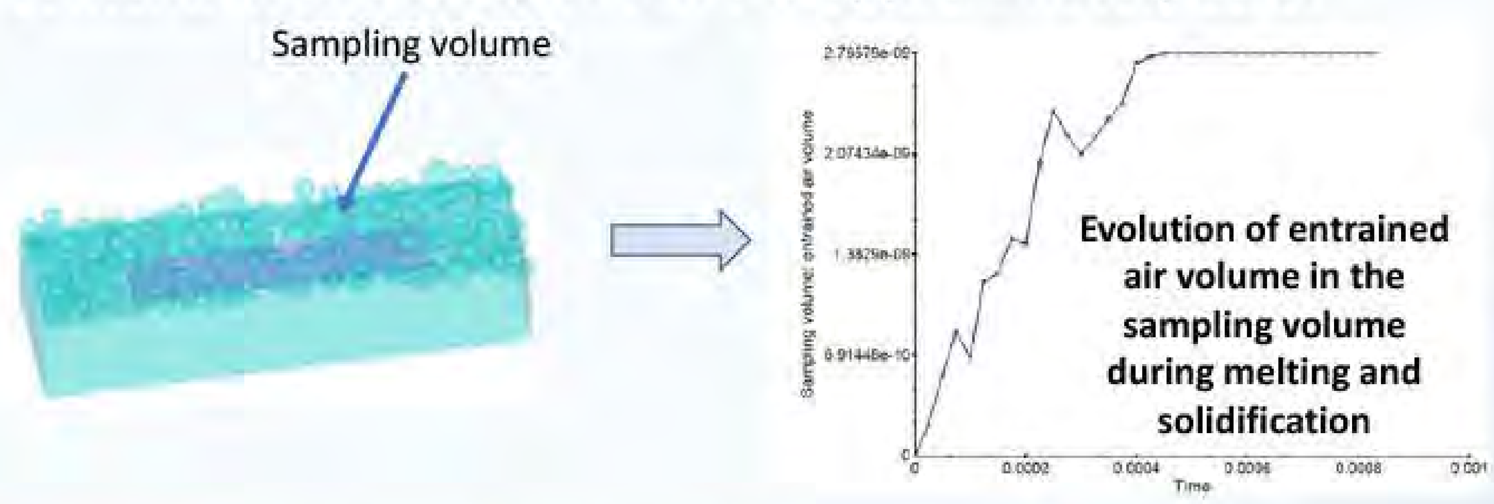
Results

MELT POOL DYNAMICS



POROSITIES PREDICTION

- Entrained air volume is the total volume of air that is trapped in the molten metal because of turbulences. It is evaluated on an arbitrary sampling volume to provide a global index of voids content, expressed in cm^3.
- Volume of voids: it provides a measure of macroscopic voids content. In this case, its value is approximately zero.



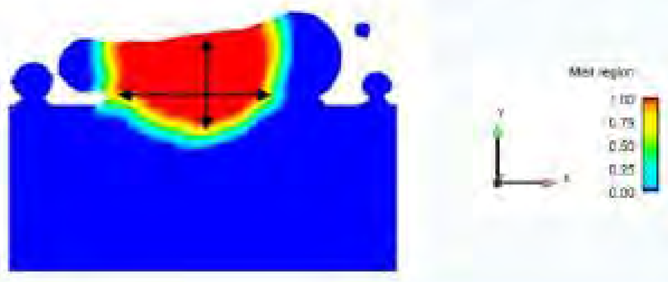
Average porosity content [%]		
Simulation	Calculated from entrainted air volume	0,82 ± 0,08
Experimental results	Calculated from density measurements	0,74 ± 0,3

Error = 11 %

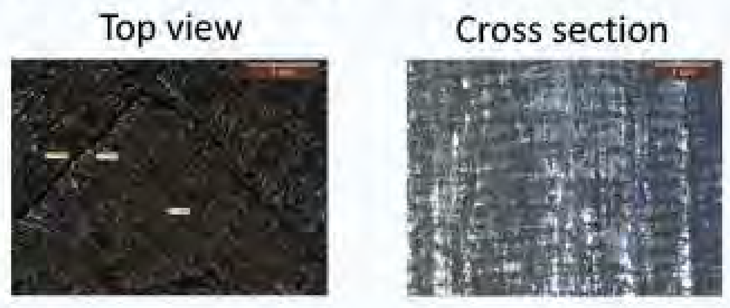
Good agreement between simulation and experimental values!

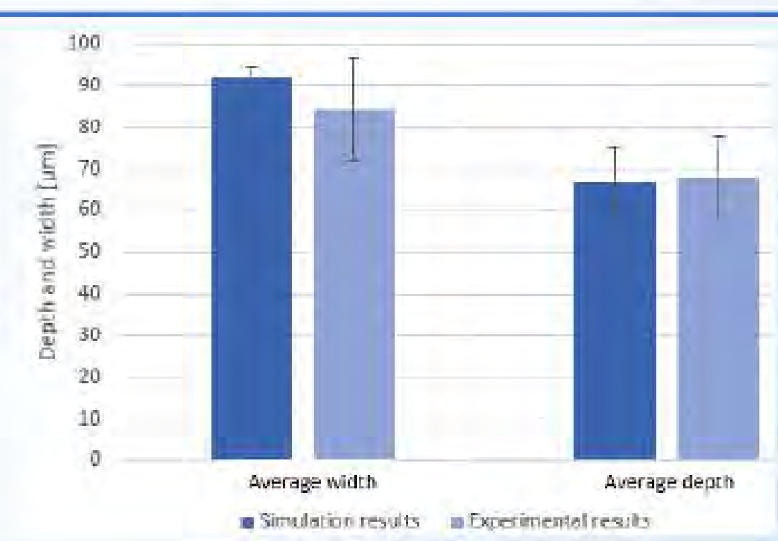
Model validation

Melt pool width and depth measurements were carried out



Microstructural characterization was performed





Good agreement between simulation data and experimental results ensured model accuracy.