Understanding Laser Powder Bed Fusion of Stainless Steel: Importance of Considering the Complex Marangoni Effect

Jian Yang[1,2], Lucas Maximilian Schlenger[3], Milad Hamidi Nasab[3], Steven Van Petegem[4], Federica Marone[5], Roland E. Logé[3], Christian Leinenbach[1,2,*]

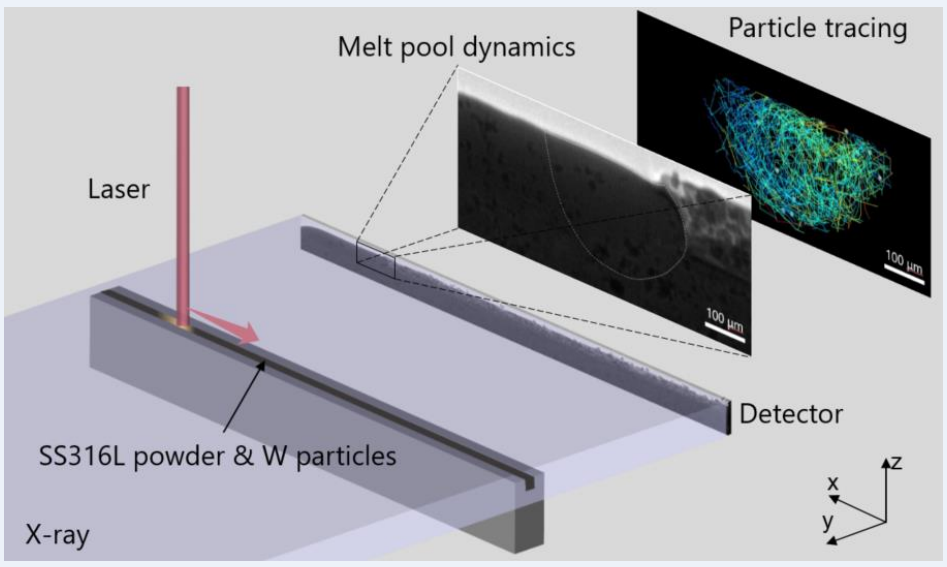
[1] *Empa, Swiss Federal Laboratories for Materials Science and Technology, 8600 Dübendorf, Switzerland*
[2] *Laboratory for Photonics Materials and Characterization, Ecole Polytechnique Fédérale de Lausanne (EPFL), 1015 Lausanne, Switzerland*
[3] *Laboratory of Thermomechanical Metallurgy (LMTM) – PX Group Chair, École Polytechnique Fédérale de Lausanne (EPFL), 2002 Neuchâtel, Switzerland*
[4] *Structure and Mechanics of Advanced Materials, Paul Scherrer Institute, PSI, Forschungs-strasse 111, Villigen 5232, Switzerland*
[5] *Swiss Light Source, Paul Scherrer Institut, PSI, Forschungsstrasse 111, Villigen 5232, Switzerland*

1 Introduction

- In general, **Laser powder bed fusion (LPBF)** operates near the conduction-keyhole threshold to avoid pore defects. Understanding the melt pool dynamics in this regime is essential for process optimization.
- However, observing the melt pool behavior in this regime is challenging, even with synchrotron X-ray imaging, due to the lack of contrast from keyhole and pores.
- The objective of this work is to visualize and quantify LPBF melt flow using **in-situ synchrotron X-ray imaging** with **tungsten tracers**, providing reliable data for calibrating **computational fluid dynamics (CFD)** models.

2 Methods

- In-situ synchrotron X-ray imaging is employed using the MiniSLM machine [1] in TOMCAT beamline at PSI.

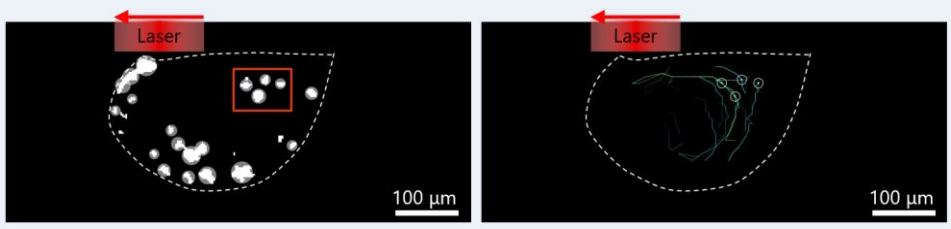


- The material is commercial SS136L powder added by 3 wt.% tungsten particles as tracers.

Chemical composition in wt. % of 316L powder

C	Cr	Ni	Mn	Mo	Cu	P	Si	N	S	O	Fe
0.01	17.60	12.88	1.40	2.43	0.04	0.011	0.51	0.08	0.004	0.05	Bal.

- The melt flow is quantified by automatic particle identification and tracing protocol.

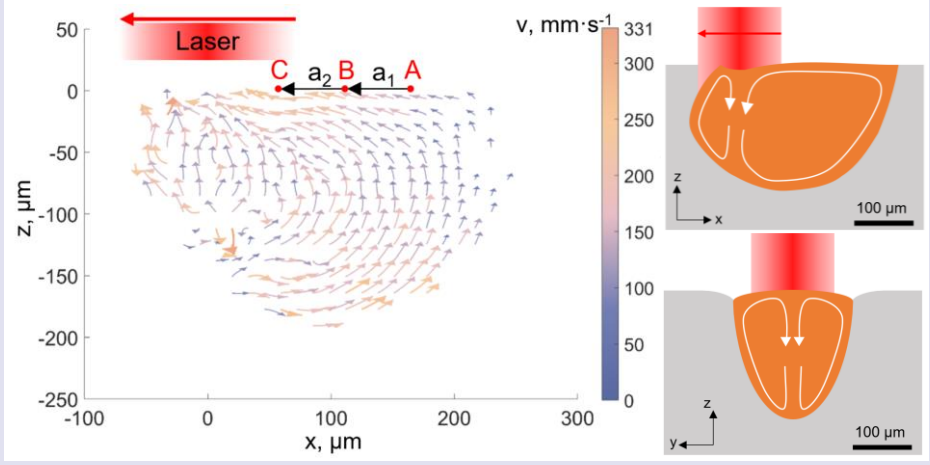


Recognition of moving particles | Trajectories of moving particles

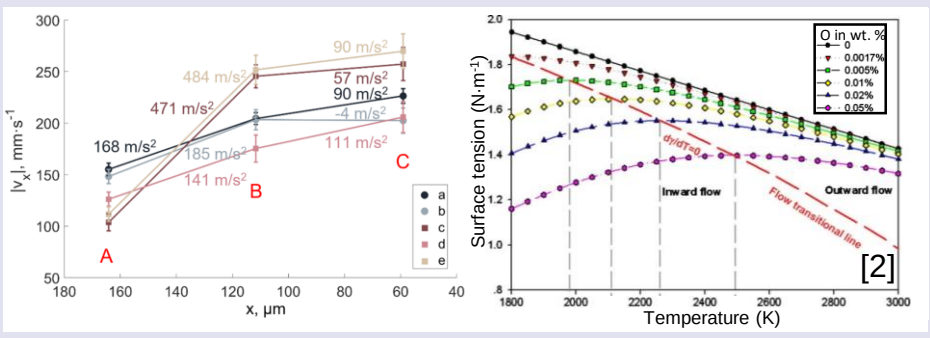
3 Results

3.1. Experiment

- Surprisingly, strong inward flow dominates the melt pool.

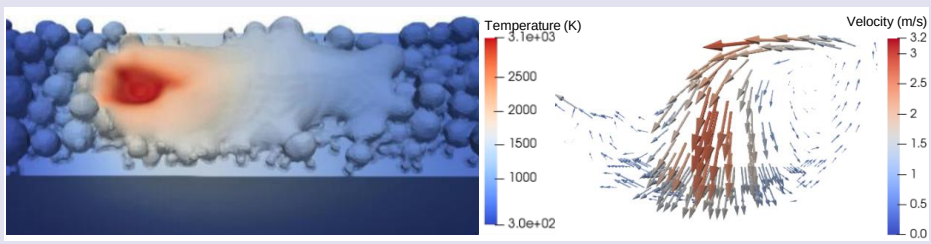


- Mechanism: complex Marangoni effect due to oxygen content.

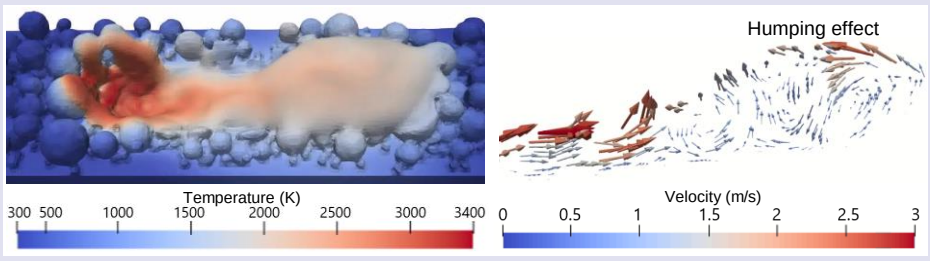


3.2. Modeling

- Implementation in CFD modeling and validation



- Extension to higher scanning speed



4 Conclusion

- The presence of inward Marangoni flow in LPBF with commercial stainless steel
- The complex Marangoni effect plays an important role in melt pool dynamics of LPBF

Pub. in Addit. Manuf.

References

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