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Single Scan Track Analyses on Aluminium based Powders

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Abstract
Powder bed additive manufacturing technologies gained much attention in past years not only thanks to design freedom but also because of the peculiar microstructures and mechanical properties that can be obtained thanks to the extremely high cooling rate. However the phenomena that arise during the laser scanning are not yet deeply understood.
In this work the effect of the main building parameters and of powder properties on the shape, the microstructure and the properties of Al-based LPBF single scan tracks was evaluated. The experiments were carried out with three different powders in order to understand of the effect of the material thermo-physical properties on the consolidation phenomena.

Introduction
Laser Powder Bed Fusion (LPBF) is a powder bed additive manufacturing (AM) process that enables the production of complex metal components by means of a layer-by-layer process. The processability of various alloys by this technology has been described in many previous papers. Zhang et al. (2011 and 2016) for example processed various titanium based alloys and metal matrix composites, Marchese (2016) et al. demonstrated the feasibility of Inconel 625 and Trevisan et al. (2017) described the state of the art on LPBF of aluminium alloys.
The essential operations of an LPBF process are the scanning of the laser beam on specific areas of a thin powder bed layer followed by the lowering of the building platform and the deposition of a new powder layer. Each layer is filled by the laser, based on the scanning strategy, by scan tracks. The quality of final LPBF parts strongly depends on the quality of each single scan track (SST) and on the interaction between them. Because of this reason, the understanding of the laser-powder interaction and of the phenomena that arise in the melt pool is essential for the development of such techniques. Among these phenomena the most important ones are the laser absorption, the heat transfer, the phase transformation, the Marangoni flow caused by surface tension effects and the evaporation of material that, in some cases, causes a recoil pressure and a keyhole melting phenomenon. The relevance of these phenomena strongly depends not only from the powder properties but also from the building parameters such as laser power (P), scan speed (v), hatching distance (h_d), layer thickness (t) and building platform temperature (T).
The correct selection of working conditions is important to avoid the instability of the melt pool which causes many detrimental effects on the quality of the final product. Li et al. (2012) suggested in fact that irregular SSTs can cause the increase in the surface roughness, the formation of pores, a delamination due to poor inter-layer bonding and the formation of an irregular surface which may hinder the movement of the recoater blade. Because of these reasons, in recent years some studies used SSTs experiments to investigate and describe the complex thermo-physical phenomena that cause the instability and the rupture of the molten scan track. Gu and Shen (2009 and 2007) distinguished two types of instability in Cu-based and stainless steel powders: one, generally called balling, arises because of low energy densities and a low contact of the molten phase with the solid substrate, the second takes place when high scan speed