XIX Brazil MRS Meeting

August 30th to September 03rd

VIRTUAL

IUMRS ICEM 2021

Effects of laser power and speed on keyhole formation during additive manufacturing by laser-powder bed fusion

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Unique microstructures are generated by the laser powder bed fusion (L-PBF) process of additive manufacturing. The moving molten metal pool created by the laser beam leaves a metallographic evidence, here called melt pool profile. The melt pool profile is easily identified in many alloys owing to the severe segregation at the beginning of the epitaxial cellular solidification, on the border of the remelted zone. The resulting microstructure is associated with the laser scanning strategy used in building the piece. Twenty-four different conditions of laser beam speed and power were adopted for a bed of plasma atomized powder of a Nb-48% Ti alloy. Width and depth of the melt pool profiles in the top layer of all samples were analyzed by optical microscopy. For lower energy densities and faster laser scanning speeds, the shape of the melt pool profile is nearly parabolic. When the speed decreases, within a certain limit dependent on the laser power, the shape changes to a characteristic keyhole-type profile, with a larger depth to width ratio. The keyhole profile is due to the presence of a wide, shallow parabolic pool and a narrow and deep pool formed by a transient evaporation cavity. The experimental results are compared to the available literature.