Paper ID: 53925
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IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Advancements in Materials Applications and Rapid Prototyping (5)

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IN-SITU OBSERVATION OF METAL POWDER MELTING BEHAVIOR USING X-RAY AND THERMAL IMAGING

Abstract

This paper investigates the melting behavior of metal powder during laser powder bed fusion (L-PBF) process using in-situ X-ray and thermal imaging. Although L-PBF is an effective method to manufacture complicated metallic parts including aerospace applications, improvement of L-PBF is still required. In particular, unstable melting behavior causes defects of products such as rough surface texture and pores. A past ex-situ experiment showed that melt is spherical after a short irradiation, while it becomes flat after a long irradiation. However, further in-situ observation is necessary to clarify the transformation of the shape in detail. Thus, this study was done with the objective of clarifying a process of changing melt shape through in-situ observation.

Ti6Al4V powder produced by gas atomization process with the average particle size of 45μm was used. The powder set in a sample holder was irradiated by a fiber laser with Gaussian distribution in 100W of power for 4s. During irradiation of laser, a two-color pyrometer measured the temperature distribution on the metal powder bed surface with a pixel resolution of 23μm. X-ray was irradiated to the sample in the vertical direction to the laser irradiation. The transmitted X-ray through the sample was converted into visible light via an image intensifier. The visible light was captured as X-ray images by a CCD camera set behind the image intensifier at 500fps. The brightness and contrast of the obtained X-ray images were adjusted by using an image analysis software so as to distinguish the liquid zone from the metal powder bed.

The images showed that when spatter was immediately generated after laser irradiation, the rapid temperature rose rapidly. A spherical melt was generated and expanded while sustaining the spherical shape. There were narrow gaps between the melt and metal powder bed which indicates that the melt was supported by a point-contact with the metal powder bed. In addition, the melt floated from the metal powder bed completely and then fell down. After that, it contacted the surrounding metal power bed and changed into an elliptical shape.