Mapping the evolution of microstructure during selective laser melting additive manufacturing of metallic alloys using high-speed *in-situ* diffraction

Vivek Thampy[1], A. Fong[1], A. M. Kiss[1], N. P. Calta[2], A. A. Martin[2], J. Wang[2], P. J. Depond[2] , M. A. Somashekara[3], A. Watts[3], P. Collins[3], M. J. Kramer[3], R. T. Ott[3] , T. van Buuren[2], I. Matthews[2], M. F. Toney[1], J. N. Weker[1], C. J. Tassone[1], K. H. Stone[1]

[1]Stanford Synchrotron Radiation Lightsource, SLAC National Accelerator Laboratory 2575 Sand Hill Road, MS 69, Menlo Park, CA 94025

[2]Materials Sciences Division, Lawrence Livermore National Laboratory 7000 East Avenue, Livermore, CA 94550

[3]Division of Materials Science & Engineering, Ames National Laboratory, Ames, IA 50011

Metal additive manufacturing (AM) using Laser Powder Bed Fusion (LPBF) is an emerging technology that provides significant design flexibility relative to conventional manufacturing techniques and enables the production of highly complex parts at minimal additional cost. However, the underlying physics of the AM build process is still poorly understood, and there is insufficient experimental data to inform modelling efforts. We have developed and commissioned a portable single layer AM testbed to enable *in-situ* X-ray diffraction at SSRL beamline 10-2 during the AM build process in order to track the microstructure and phase of the powder melt as it crystalizes on re-solidification. With Ti64 powder, we have directly observed the disappearance of the alpha phase upon melting, and then the appearance of the beta phase which transforms into the primarily alpha phase upon cooling and re-solidification. We have carried out detailed time resolved studies of microstructural and phase changes to characterize the effect of various build parameters such as laser power, speed and powder feedstock on the temporal evolution of microstructure properties such as grain size, strain, texture. Coupled with high speed *in-situ* imaging carried out at SSRL beamline 2-2, as well as in-line process/part metrology, these experiments will provide essential data to validate, inform, and improve the accuracy of existing process modelling efforts.