In situ Synchrotron Imaging of Additive Manufacturing

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Laser additive manufacturing (LAM) can produce unique, high quality components for aerospace to biomedical applications. However, the solidification mechanisms controlling the formation of continuous, defect free, track are still poorly understood. During powder bed and direct energy deposition (DED) the solidification rates are 10^3 to 10^5 degrees per second, producing non-equilibrium phases that are controlled by kinetics. The solidification conditions can also lead to microstructural features (porosity, epitaxial growth) and high residual stresses that can reduce performance. We present a step change in the methodology used to characterise and optimise the solidification conditions during LAM using fast synchrotron X-ray imaging and bespoke LAM process replicators for both powder bed and DED. Using these unique in situ and operando rigs, we study a range of laser velocities and powers, developing a mechanism map for predicting when the solidification conditions are appropriate for producing high quality LAM components. Further, we capture the solidification mechanisms by which LAM fails, providing new insights into what controls additive manufacturing’s process window, and how to extend it.

Biography

Peter is Professor of Materials Science at University College London, but is based at the Research Complex at Harwell, where he is Assistant Director for Physical Sciences. His research focusses on the computational simulation and X-ray imaging of materials at a microstructural level. He was one of the pioneers of multi-scale and through process modelling (now termed ICME), working at Alcan on the prediction of defects in light alloy components for companies such as Ford and Rolls-Royce. Peter is an avid experimentalist, developing nano-precision rigs that replicate the processing and service performance of materials on synchrotron beamlines, enabling us to see inside materials in 3D as they change in time. His work is revealing how microstructures evolve in processes ranging from additive manufacturing to volcanic eruptions. His experimental techniques and open-source codes have been exploited internationally by aerospace, automotive, energy and biomedical companies to solve important engineering challenges – from developing additive manufactured human joint replacements to light weight automotive components.