Implementation of neutron characterization techniques for in-situ metal additive manufacturing

Summary- Additive manufacturing (AM) new processing routes have shown high potential for enhancing the design of new materials properties and functionalities in a wide range of applications in sectors such as in energy, medicine, aerospace and automotive. However, the relationships in AM between raw materials, processing parameters and final product properties have proved to be different from those of traditional processing routes, hindering the further establishment of this technology at the industrial level. During 3D printing of AM components, complex temperature gradients raise depending on multiple new fabrication parameters. The consequences are heterogeneous 3D development of phases, porosity and deep gradients of residual stresses within the bulk playing a critical role, even after post-processing. AM therefore requires the implementation of a new characterisation approach considering fundamental in-situ tests in order to disclose the controlling mechanisms and influence of fabrication parameters.

Project Details- The aim of the project is to propose a guideline for a new characterization approach for metal additive manufacturing. Fundamental and in-situ neutron diffraction (ND) experiments will be designed and conducted at ILL towards AM advanced characterization by means of neutron powder diffraction and neutron strain mapping. By assessing the in-situ evolution of phases and strain gradients upon fabrication, the control of parameters vs governing mechanisms will enhance a deeper understanding and control over new fabrication designs, safety and durability of such products. Tuned combined AM+ND set ups and measurement parameters have to be found together with a probable implementation of data treatment.

The only non-destructive technique suitable for bulk RS characterization of the complete stress tensor is neutron diffraction. Moreover, the evolution of principal stress directions and heterogeneous microstructures may be characterized (phase specific). The implementation of in-situ manufacturing during neutron powder diffraction characterization aims at disclosing the evolution of phases upon cyclic melting and solidification and to provide a reliable unstrained reference for later strain analysis.