Phase transitions of additively manufactured components investigated by *in situ* X-ray diffraction at high temperatures

INDUSTRIAL PILOT PROJECT

THE INDUSTRIAL CHALLENGE

Höganäs AB is the world's largest producer of iron- and other metal-based powders for powders metallurgy but also has a focus on developing alloyed steel powder materials for Additive Manufacturing (AM). In order to make full use of AM techniques for making parts of complex geometries, one has to have a detailed knowledge of the influence on composition and microstructure during AM processing.

WHY USING A LARGE SCALE FACILITY

The goal of the project is to showcase how neutron- and synchrotron based techniques can assist industrial alloy development for additive manufacturing by allowing in situ analysis. The high intensity provided at e.g. the Petra III synchrotron in Hamburg, in combination with a large area detector, makes it possible to collect the time resolved data needed for the successful interpretation of these measurements. The time resolution needed is typically in the seconds range.. Furthermore, the neutron is unique in how it interacts with matter, which makes it possible to distinguish properties invisible to other probing tools, such as elements/ ions with similar or equal number of electrons.

HOW THE WORK WAS DONE

Structural changes as a function of temperature were investigated at the P02.1 beamline at Petra III, using a custom-built sample cell (λ = 0.207 Å). Samples were placed in single crystal sapphire capillaries and heated to 900 °C in Ar atmosphere using a Kanthal wire coiled around the capillary, followed by rapid cooling. (Figure1). Images of the scattered X-rays were recorded on a PerkinElmer XRD1621 fast area detector, and the resulting 2D images were azimuthally integrated to 1D diffraction patterns using the software Fit2D. Instrument peak shape parameters and zero-point error were obtained from refinements based on data from LaB_6. Neutron scattering at the powder diffractometer MEREDIT at the Neutron Physics Institute (NPI) in Rez, Czech Republic was used to obtain complementary crystallographic information.

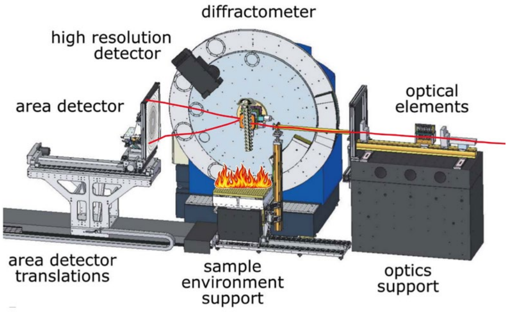

Figure.1 Experimental setup at P02.1. Image adapted from J. Synchrotron Rad. (2015). 22, 675–687.

THE RESULTS AND EXPECTED IMPACT

The results clearly show that in situ X-ray diffraction is an excellent tool to investigate phase transitions in AM-components. Figure 2 display the possibility to evaluate phase stability (composition, microstructure etc) as a function of temperature with high resolution and accuracy. The combination of neutron and X-ray scattering should be highlighted, where the X-rays provide excellent spatial and temporal resolution and neutrons complement with an average value over an entire component. These methods are a great complement to the in house capabilities at Höganäs.

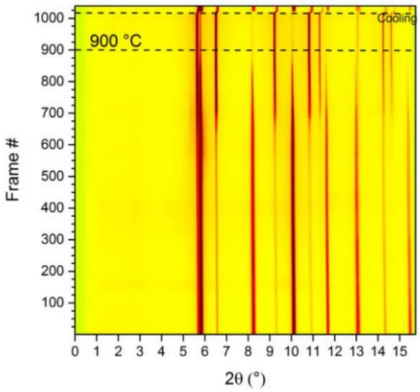

Figure2. An example of *in situ* X-ray diffraction as a function of temperature.

"It is clear that these measurements at large scale infrastructures provide a unique opportunity to understand structure-property relations. We will be back for more!" /Hilmar Vidarsson, Höganäs AB

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