APPLICATION NOTE

No. AN41126

Study of austenite in 410 steel from additive manufacturing according to the direction of printing using ARL EQUINOX 100 XRD

Introduction

Additive Manufacturing (AM; 3-D printing of metals) is a quickly evolving new manufacturing technique which enables manufactures to produce parts and components with complex structures conveniently by building them layer by layer from metal powder beds or even with hybrid metal-polymer printing techniques. The technique is applied to several types of metal alloys like Ti64 or AlSi10Mg. Another very common type of material are stainless steels of various types because of their broad range of properties. All these materials have in common that QC/QA procedures are required to control the parameters of the printing process and therefore the quality of the result not only in industrial production and R&D activities but also in academic research.

One of the most commonly used method to asses the microstructure of metal alloys is X-ray diffraction (XRD) where it's possible to directly measure crystallographic structures of related components and quantify their content. This is especially helpful to plan temperature treatment steps, analyze the anisotropy of the printing process or gain indications of the mechanical properties of the parts. By choosing the type of radiation (e.g. Co or Mo radiation) it's even possible to vary the penetration depth and therefore the volume of the analysis.

Figure 1:
ARL EQUINOX 100 X-ray Diffractometer

Instrument

The Thermo Scientific™ ARL™ EQUINOX 100 X-ray Diffractometer employs a custom-designed Co (15 W) micro-focus tube with mirror optics for high flux, which does not require external water chilling.

The ARL EQUINOX 100 XRD provides very fast data collection times thanks to its unique curved position sensitive detector (CPS) that measures all diffraction peaks simultaneously. It is therefore well suited for both reflection and transmission measurements (Figure 1).

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Experimental

For XRD measurements, the 410 stainless steel cube shaped sample from AM was measured (Co Kα radiation) 5 or 15 min in reflection using a SSRZ sample holder with height adjustment and sample spinning for bulk samples. Qualitative and quantitative analysis were carried out using MDI JADE 2010.

Results

XRD measurements longitudinal and transversal to the printing direction show an anisotropy in the microstructure of the steel due to variations in the Austenite content of the steel. Longitudinal to the printing direction no Austenite is detectable (c.f. Figure 2) whereas transversal to the printing direction 1.3 wgt% Austenite can be detected. (c.f. Figure 3).

Conclusion

The ARL EQUINOX 100 benchtop diffractometer is a convenient tool to asses the microstructure of metal samples coming from AM processes in dependence of the printing direction. The latter investigation aimed more on surface effects due to the low penetration depth of low energy Co radiation. By choosing Mo radiation instead it is also possible to collect data from deeper regions of the bulk sample. The combination with MDI JADE 2010 allows even quantification of the Austenite content which could give an indication of residual stress due to the retained Austenite content in the stainless steel sample.

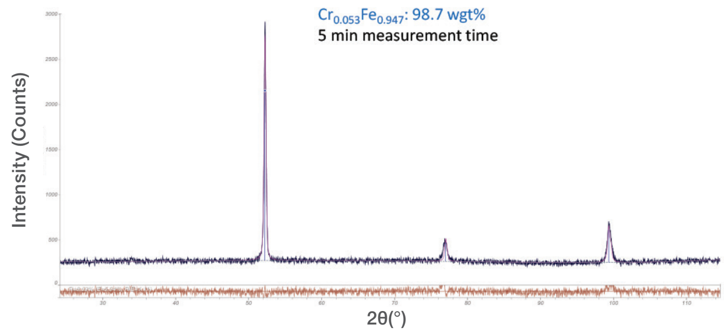

Figure 2: XRD measurement longitudinal to printing direction

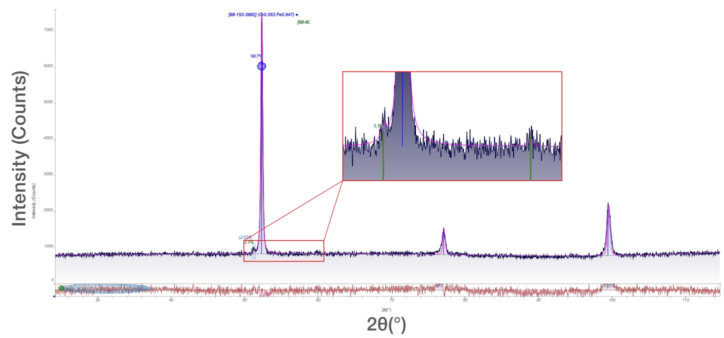

Figure 3: XRD measurement transverse to the printing direction

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