

Crystallographic phases of NiTi scaffolds fabricated by selective laser melting

T. Bormann^{1,2}, R. Schumacher¹, B. Müller², M. de Wild¹

¹*School of Life Sciences, University of Applied Sciences Northwestern Switzerland, Muttenz, Switzerland.* ²*Biomaterials Science Center, University of Basel, Basel, Switzerland.*

INTRODUCTION: FDA-approved NiTi¹ belongs to the shape memory alloys (SMA) which exhibit superelasticity and the shape memory effect. The reason behind is a reversible phase transition from the low-temperature martensite to the high-temperature austenite. As the shape memory effects and therefore the physiological reactions are intrinsically linked to the crystal structure, we have used x-ray diffraction (XRD) to characterise the specimens. In this study, we used the additive manufacturing technique of selective laser melting (SLM) to fabricate free-form NiTi parts (Fig. 1) with shape memory properties and different phase transition temperatures.²



Fig. 1: NiTi samples produced by SLM.

MATERIALS & METHODS: NiTi-specimens were manufactured from NiTi-powder (MEMRY GmbH, Weil am Rhein, Germany) using the SLM Realizer 100 (SLM-Solutions, Lübeck, Germany). Different energy densities within the fabrication process as well as subsequent heat treatments at 800 °C were applied to generate specimens with different phase transition temperatures. Differential scanning calorimetry (DSC) and x-ray diffraction (XRD) measurements were accomplished at the NiTi-powder and two samples whose phase transition temperatures lie beneath and above room temperature, respectively. The austenite peak temperature A_p of Sample 1 was -3 °C whereas A_p of Sample 2 corresponded to 50 °C. XRD measurements were done at room temperature using CoK α radiation.

RESULTS & DISCUSSION: As expected, the preliminary XRD measurements reveal differences in the spectra depending on the measured phase transition temperatures. The peaks of Sample 1 mainly relate to austenite with a cubic crystal lattice (see Fig. 2). This is not surprising, since the phase transition takes place below room temperature, i.e. the material is in its high-

temperature austenitic phase at room temperature. For Sample 2, whose A_p lies above room temperature, mainly martensite phase with a monoclinic crystal lattice is expected. The spectrum, however, not only shows martensite but also austenite peaks, as illustrated in Fig. 2. That means in Sample 2 both phases are in coexistence. The DSC investigation on Sample 2 reveals that the starting point of the phase transition lies already at 26 °C. A reason for the austenite phase in Sample 2 could therefore be a start of phase transition due to a slight increase in the sample surrounding temperature, caused e.g. by the XRD investigations itself.

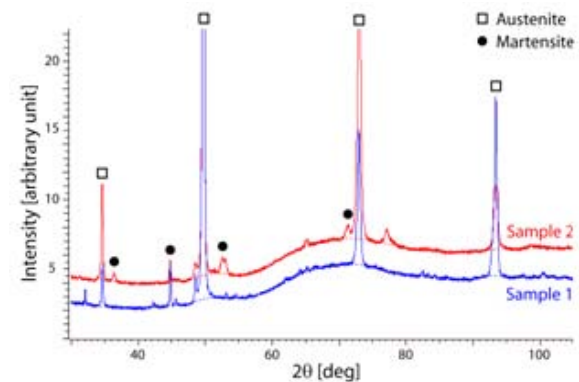


Fig. 2: XRD-spectra of two SLM samples with different process histories.

CONCLUSION: In this preliminary XRD study, we find differences in the crystallographic structure of our SLM samples, which have been produced by different processing procedures. Quantification of the two phases and correlation with the ability for the shape memory will contribute to our final aim, the realization of complex-shaped NiTi-implants with advanced performance.

REFERENCES: ¹ASTM International, F 2063 - 05. ²T. Bormann *et al.*, Proc. of SPIE **7804**:78041.

ACKNOWLEDGEMENTS: The multi-disciplinary team gratefully acknowledges the financial support of the Swiss National Science Foundation within the program NRP 62 ‘Smart Materials’.