The motivation of the project is to attain a comprehensive understanding of the variation of microstructure and mechanical properties of Ni-based superalloys processed by selective laser melting (SLM). Based on these results a robust processing routine for components made from Inconel 718 will be developed, showing high geometric complexity and an optimized microstructure for high temperature loading. In order to reduce the porosity, hot isostatic pressing (HIP) is highly interesting. Thus, a promising approach for the further improvement of the material properties is functional encapsulation by means of physical vapour deposition (PVD), which uses an electric arc to evaporate a target material.

Microstructural characterization
The microstructure of additively processed material strongly influences mechanical properties such as strength, ductility, hardness etc. and consequently has to be thoroughly studied. In this project, microstructure evolution was characterized using various techniques including optical microscopy, electron backscatter diffraction and X-Ray diffraction. The microstructure of IN 718 specimen (built vertical to the building platform) in different conditions, e.g. as-built (a), solution annealed (b) and hot isostatic pressed (c) are shown in Figure 1. The images obtained from the as-built and the solution annealed conditions are very similar. Compared to the as-built condition, the microstructure is different after HIP (Fig. 1c), which is attributed to the effect of recrystallization during HIP treatment. Especially, the microstructural stability under high temperature quasi-static loading as well as fatigue loading is very important for high temperature applications.

Mechanical Testing
Mechanical experiments were performed under different loading conditions. In a first step, the characterization of the behavior under quasi-static load at ambient temperature shed light on the role of process-induced microstructure, i.e. the general impact of grain shape and texture. In the following, the tests were extended to different sample and loading conditions. Clearly, an artificially aged condition needs to be characterized thoroughly, as only this condition shows good properties in the high temperature regime. The focus was the characterization of the alloy performance under cyclic loading at elevated temperatures to show what the reason of crack initiation is, i.e. where cracks start, and in which ways cracks evolve during further loading.

Summery
Detailed knowledge regarding the fatigue behavior is crucial if cyclic loading is applied to parts at high temperatures. Therefore, the microstructure and mechanical properties of
a SLM processed Inconel 718 superalloy has been investigated. The results helped to identify an adapted material performance for applications at high temperatures. Furthermore, the effects of the hot isostatic pressing on the SLM material were characterized. Moreover, the functional encapsulation of laser melted Inconel 718 by Arc-PVD for post compacting by hot isostatic pressing was improved. On view of these aspects, the results can be summarized as follows:

- SLM processing of Inconel 718 shows a columnar-grained microstructure.
- All aging treatments improved the ultimate tensile strength and yield strength due to the formation of precipitates.
- HIP leads to recrystallization of the SLM processed IN 718 alloy. As a result, the achieved mechanical properties seem to be more influenced by the microstructure. Prior PVD coating does not have a significant effect on the microstructure.
- Precipitation hardening is essential for high temperature application.
- Argon measurements showed an Ar-content of 0.3 ppm. It was concluded that the cavities are in parts filled with argon. The argon could be entrapped during the SLM process or embedded in the powder particles.
- The post-treatments solution annealing, PVD coating and HIP reduced the hardness values of the SLM processed IN 718 specimens. This fact can be explained by the dissolution of precipitates already introduced by SLM processing.