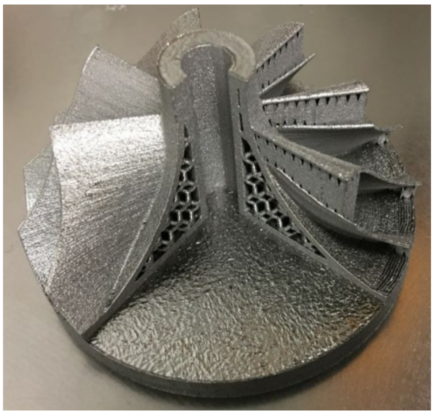
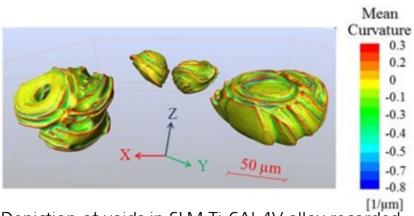
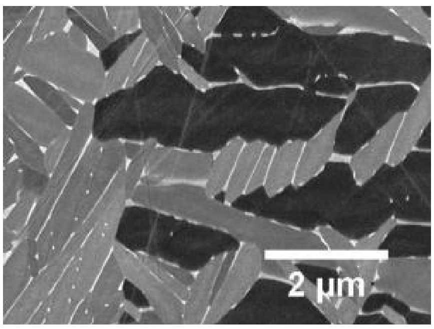
Additive Manufacturing of Metallic Materials and Components



Example of a simple demonstrator turbocharger illustrating the possibilities of AM



Depiction of voids in SLM Ti-6Al-4V alloy recorded with highly-resolving synchrotron tomography



Scanning Electron Image of a stabilized a-b microstructure in a SLM Ti-6Al-4V achieved by operating the build process at elevated temperature of 400 °C

Additive manufacturing (AM) such as for example Selective Laser Melting (SLM) enables generative manufacturing of metallic components from digital models (e.g. CAD files) and alloy powders. The new AM technologies are steadily introducing a paradigm change in design and production of metallic parts in various areas of daily life from transport to medical implants. Additive manufacturing opens fundamentally new possibilities for part design and construction and enables more complex geometries, incorporating e.g. internal structures or bionic designs that were heretofore either too resource intensive or simply inaccessible for conventional manufacturing technologies.

Selective Laser Melting, which is the AM technology primarily used at DLR, belongs to the so called powder-bed methods that build parts up layer-by-layer, i.e. generatively. The powder, which is deposited in layers of 20 to 100 µm height on a base plate, is locally melted by a laser. Subsequent layers are deposited and melted until the metallic part is completed.

the research activities at the institute cover the processing strategies for existing conventional alloys as well as the development and processing of novel alloys that are being custom-designed for the unique metallurgic conditions faced in AM. The alloys being studied include titanium alloys, nickel alloys and titanium aluminides widely used in the aerospace sector. The latter possess great potential for high-temperature applications (operating temperatures of up to 700 °C in contrast to typically less than 550 °C for titanium alloys) such as turbine engines, stationary gas turbines or turbo chargers.

The mechanical performance of AM processed alloys depends strongly on the processing conditions, the obtained microstructures, compositions and thermo (-mechanical) treatments. More-over, due to the capability to produce near-net shape components of complex geometries, the thermal conditions during “printing” can vary locally, leading to changing materials properties throughout one part.

The materials obtained as well as the used alloy powders are characterized extensively with laboratory methods (e.g. SEM, TEM, XRD, EBSD etc.) as well as synchrotron/ neutron imaging and diffraction based methods. A particular focus lies on microstructure evolution during manufacturing and service.

The achieved fundamental understanding of the interplay between microstructures and mechanical properties enables the furthering of the processing and post-treatment strategies and materials. In cooperation with other institutes of the DLR, the gained knowledge is integrated in the design, development and testing of AM components for the aeronautic and aerospace sectors.

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