On the reliability of metallic alloys processed by additive manufacturing

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Metal additive manufacturing (AM) has been in focus of academia and industry for several years. Due to increased productivity of the systems employed, serial production as well as manufacturing of large components at reasonable cost are feasible now. For near net-shape components mostly processes employing a powder bed are used, i.e. selective laser melting (SLM) and selective electron beam melting (EBM). For both processes in principle any metallic alloy can be applied, however, most studies report on a given number of widely used materials, i.e. stainless steel 316L, Ti-6Al-4V, Al-Si-base alloys and Ni-base superalloys such as Inconel 718. For most of these alloys solid process-microstructure relationships are established. Furthermore, evolution of microstructure and mechanical properties upon post treatment, studied under monotonic loading, have been reported numerously such that a deep knowledge allowing for monotonic strength optimization is available.

However, properties under complex in-service loading conditions contemplating residual stresses, surface conditions, fatigue strength, crack growth, creep as well as combined loadings have been only rarely addressed so far. Microstructure evolution imposed by rapid solidification and intrinsic heat treatment, however, leads to unique microstructural conditions severely affecting the alloy performance, especially under loading scenarios detailed before. For safe and reliable use of AM components in the automotive, aerospace, biomedical and other sectors, thus, the currently prevailing research gap has to be tackled. The paper presented will highlight the most important microstructural features being the basis for the performance and, thus, reliability and integrity of AM components processed by SLM and EBM. Moreover, pathways for adequate post treatments and alloy development for AM will be drawn.

Biography

Dr.-Ing. Thomas Niendorf is Full Professor at the Institute of Materials Engineering at University of Kassel (Germany) since October 2015. Dr. Niendorf studied Mechanical Engineering at University of Paderborn (Germany). In 2010 he did his doctorate. In his thesis he reported on the reliability and structural integrity of ultrafine-grained materials processed by severe plastic deformation. In 2011 he published his first work on materials processed by additive manufacturing, a work conducted in collaboration with the Direct Manufacturing Research Center at University of Paderborn.

Dr. Niendorf's research interests are in the interrelationships of process, microstructure, mechanical properties and reliability of metallic materials. Analysis of residual stresses,

microstructure evolution and fatigue performance are key aspects of research projects conducted. Materials in focus are steels, aluminum alloys, high-temperature materials, shape memory alloys as well as hybrid materials. Currently, he is supervisor of more than 20 PhD Students.
Research activities in the field of additive manufacturing (AM) comprise powder bed techniques (EBM and SLM) as well as laser metal deposition. Realization of microstructurally graded samples for improved functionality as well as thorough characterization of integrity and reliability of AM components are Dr. Niendorf's actual fields of research in AM.
Dr. Niendorf published more than 130 peer-reviewed papers in renowned journals. Furthermore, he holds several patents and has been invited speaker in many conferences. He has been scientific board member and session organizer in several European conferences focusing on AM. He will be on the Scientific Committee of the ASTM 4th Symposium on the Structural Integrity of Additive Manufactured Parts to be held in Washington DC during October 2019. For his young career achievements he received several distinguished awards, e.g. the Heinz Maier-Leibnitz-Award by German Research Foundation.