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Deformation Mechanisms and Defect Tolerance in the Microstructure of 3D Printed 316L Steel

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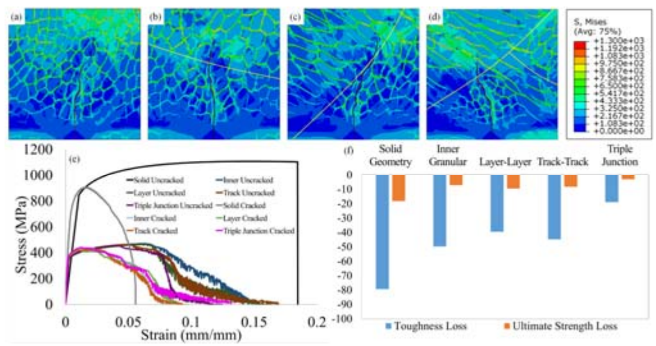
Abstract



This presentation shows a novel approach towards strain field analysis used to investigate the deformation mechanisms at the microstructural level in 3D printed alloys. The complex in-situ heat treatments during 3D printing leaves a unique and complicated microstructure in the as-built 3D printed metals, particularly alloys. The microstructure is made of a hierarchical stacking of some interconnected geometrical shapes, namely meltpools, grains, and cells. These are connected to each other by boundaries that are proposed to have different element compositions, and consequently material properties, compared to the interior region of each geometrical unit. Deformation mechanisms in this microstructure are still highly unexplored, mainly because of the challenges on the way of performing experiments at the micrometer length scale. In this work, we establish an image processing framework that directly converts the SEM images taken from the microstructure of 3D printed 316L stainless steel alloys into CAD models. The model of the complicated microstructure is then scaled up, and the scaled model is 3D printed using polymeric materials. For 3D printing these samples, two polymers with contrasting mechanical properties are used. Distribution of these two polymers mimics the arrangement of soft and stiff regions in the microstructure of 3D printed alloys. These representative samples are subjected to mechanical loads and digital image correlation is utilized to investigate the deformation mechanisms, particularly the delocalization of stress concentration and also the crack propagation, at the microstructural level of 3D printed metals. Besides experiments, computational modeling, using finite element method is also performed to study the same deformation mechanisms at the microstructure of 3D printed 316L stainless steel. Our results show that the hierarchical arrangement of stiff and soft phases in 3D printed alloys delocalizes the stress concentration and has the potential to make microstructures with significantly improved damage tolerance capabilities.

Biography

Matt started his M.S. degree while working concurrently on his senior year in undergrad MSE in Fall of 2017. He is graduating in a month come the end of this semester. He is working under Reza Mirzaeifar in the MultiSmart group at VT, focused specifically on the analysis and optimization of microstructure of SLM printed 316L steel. He has two papers in the submission / review process focused around cells and meltpools.