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Hierarchical structural performance models for qualification of metal AM components

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Metal additive manufacturing (AM) provides benefits that include automation and flexibility, enabling fabrication of geometries that otherwise require jointed connections, *e.g.*, bolted or welded. However, AM parts can exhibit a host of material defects that can compromise structural reliability including randomly distributed porosity. Sandia has been developing models and modeling methods to predict performance with the intent to qualify AM components. Experimentally, we have been advancing the state of knowledge with novel micro-computed tomography (uCT) measurements, and novel mechanical properties characterization techniques.

In this talk, we outline a data-driven, hierarchical approach that leverages the advanced uCT measurements, and efficiently provides multiscale estimates of structural performance and reliability. The hierarchy first represents porosity with an internal state variable for void volume fraction in an engineering-scale model to identify hotspots, sacrificing accuracy for computational efficiency. The refined analysis replaces the state variables in the hotspot regions with explicit representation of damage and concurrently couples it to the engineer-scale model. Our discussion attempts to identify the initial conditions that lead to fracture and propagate the uncertainty associated with micro-porosity to predict component reliability for AlSi10Mg.

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