# MULTISCALE CHARACTERIZATION AND MODELING OF DUCTILE FRACTURE IN CAST ALUMINUM ALLOYS

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This paper will present a multiple scale materials characterization together with multiple-scale modeling for ductile fracture of reinforced metals. The multi-scale modeling provides an estimate of the initial computational model based on the morphological characteristics of the images at different resolutions. Image reconstruction technique is introduced to obtain high resolution microstructures in a large domain, using low resolution, low magnification SEM/optical microstructure images and a few samples of high resolution images. Multiscale characterization tools are proposed with novel characterization parameters, specifically aimed at micromechanical modeling of complex microstructures. The concept of homogeneous length scale is implemented to identify regions of homogeneity and heterogeneity. Using domain refinement functions based on microstructural characteristics, successive domain partitioning is performed to obtain a multi-scale model.

Following the characterization, a multi-level computational model for multi-scale analysis of composite structures with ductile fracture is presented. The method combines macroscopic coupled plastic-damage modeling with displacement based FEM with a microstructurally explicit modeling of ductile fracture by the Voronoi cell FEM (VCFEM). The microstructural model includes a ductile matrix represented by a non-local model of porous plasticity based on the Gurson-Tvergaard model, and an elastic inclusion. Three computational levels of hierarchy with different resolutions are introduced to reduce modeling and discretization errors due to inappropriate resolution. They are: (a) level-0 of pure macroscopic analysis, for which a coupled anisotropic plastic-damage model is developed from homogenization of micromechanical variables that evolve with anisotropic plasticity and ductile fracture; (b) level-1 of coupled macroscopic-microscopic modeling to implement adequate criteria for switching from macroscopic analyses to pure microscopic analyses; and (c) level-2 regions of pure microscopic modeling with explicit particle and matrix cracking. Numerical examples are solved to demonstrate the effectiveness and accuracy of the multi-scale model in predicting ductile fracture failure.

**Keywords**: Multiscale modeling, fracture, VCFEM