A simplified model for intergranular fracture prediction

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Al-Li alloys and high-strength, metastable Ti alloys are highly attractive candidates for lightweight structures due to their density-normalized strength. Currently, their use is limited as they are prone to room temperature grain boundary fracture, which limits their usefulness in fracture critical structures. Here, we describe a novel methodology for designing material microstructures with improved crack growth resistance for materials that are prone to grain boundary ductile fracture. The proposed methodology is based on a discrete unit event description of the crack growth process. The model presumes that, for a given crack path, the overall crack growth resistance can be calculated using results for the crack growth resistance of a collection of unit events. By describing the network of grain boundaries as a directed graph in J-resistance space, simple graph search algorithms are used to find the various possible crack trajectories and the crack growth resistance associated with them. The model results are verified using finite element calculations of crack growth in the full microstructure. This computationally inexpensive model can be used to design material microstructures with improved intergranular fracture resistance and/or to assess the overall crack growth resistance of materials with a known grain morphology.