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Micromechanical modelling and in situ 3D microtomography characterization of microstructure heterogeneities effects on damage in aluminium alloys

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Ductile fracture results from the nucleation, growth and coalescence of small internal cavities. In aluminium alloys, the void population generally nucleates by the fracture of iron rich intermetallic particles. The objective of this study is to understand and model the effect of microstructure heterogeneities on damage accumulation in three 6xxx series aluminium alloys. The three alloys, i.e. Al 6005A, Al 6061 and Al 6056, exhibit a volume fraction of iron rich particles close to 1%. However, samples of similar yield strengths, owing to appropriate heat treatments, show very different fracture strain for these three alloys.

A sort of cellular automaton type model has been developed to describe the growth and coalescence of voids nucleated from 3D particle fields accounting for the spatial, shape and size particle distributions. The model treats local interaction between neighbouring cavities in a simplified way and captures cluster effects on coalescence. The model parameters are extracted from a detailed microstructure analysis. High resolution 3D X-ray synchrotron tomography is used to characterize the size and position distribution of the iron-rich intermetallics and initial cavities in the three alloys. In addition, a statistical study performed on polished fractured tensile samples allows extracting nucleation stresses and the probability of fracture as a function of the size of the intermetallic particle. The damage model is validated on tensile tests of various alloys tempers and on in-situ tension 3D X-ray synchrotron tomography.