Understanding Sample Size Effects on Creep Micromechanics Using *In-Situ* Testing

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Abstract

In this talk, the effect of sample size on the steady-state creep properties of materials will be discussed. Flat dog-bone uniaxial tensile specimens of commercial purity Al in the size range of 0.3 to 2 mm, with one side laid with silver particles for tracking deformation as a function of time, were tested at 250 °C inside a scanning electron microscope (SEM). Digital image correlation (DIC) was used to obtain two-dimensional strain fields and creep curves from time lapse images. A softening as high as 10 times in terms of steady-state creep rates was observed with decreasing sample thickness. The softening effect was more pronounced at low stresses. Accordingly, a lower apparent stress exponent of 3.9 was also observed. Further the post-creep dislocation sub-structures revealed an abnormal substructure sizes near to the free surface (surface affected area, SAR) possibility due to the loss of dislocations to the free surface. The substructure size in the sample interior followed the routine bulk behaviour. However, the strain profile from DIC did not show any gradient in strain as a function of distance from free surface. Finally, a microstructure-sensitive iso-strain model based on load shedding between soft SAR and hard interior was formulated to account for the overall increased strain in the strain rate and non-ideal substructure near the free surface. The critical insights into the creep micro-mechanics obtained in this study, therefore, seamlessly unify the power-law creep response at large and small length scales. The same technique of in situ DIC using SEM micrographs can be used to understand the effect of phase and composition on strain distribution in complex alloys.