Ductile fracture in FCC and HCP metals

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For several years we have used X-ray computed tomography (XCT) to visualize the internal structures of bulk metallic materials during tensile deformation to investigate the processes associate with ductile fracture in metals, in particular void growth and coalescence. It is generally quite challenging to analyze void grwoth and coalescence in ordinary engineering materials due to the stochastic nature of the nucleation process. To avoid these difficulties, our research group succeeded in producing a class of model materials containing an artificial array of internal voids. The effect of work hardening exponent, stress triaxiality and the configuration of voids on void growth and coalescence/linkage events were systematically investigated, by producing a variety of model materials from pure copper and Glidcop. The plastic strains at the linkage or coalescence of voids were extracted from the results of XCT and compared with the existing void coalescence models to assess their validity. This comparison revealed that the models provide good predictions under geometric conditions that mimic the assumptions of the model. However, even a modest amount of shear can significantly reduce the strain required to initiate coalescence. This helps to clarify the limitation of the models. When these methods are applied to magnesium a completely new class of behaviours is observed. Damage linkage occurs prematurely enabled by twinning and grain boundary processes. A completely new approach to damage model in these materials is needed. In this case a crystal plasticity approach has been applied to the observed microstructure to elucidate the local deformation that lead to premature coalescence.

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