Grain size effects in aluminum processed by severe plastic deformation

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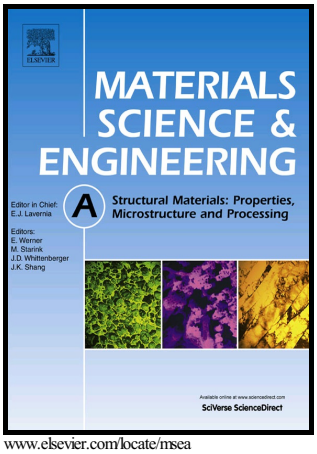

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Grain size effects in aluminum processed by severe plastic deformation

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Abstract

We investigated the effects of the grain size on the yield strength of aluminum using a group of samples with grains successively refined by equal-channel angular pressing (ECAP) and another group of samples produced by 8 ECAP passes and subsequently annealed step by step to produce coarser grains. Tensile tests were performed on all the samples. Adopting a linear addition model for different strengthening contributions, the observed yield strength was resolved into dislocation-related and grain-size-related strengthening contributions. The former was directly evaluated using the Taylor equation with dislocation densities determined by the Williamson–Hall method, and the latter was quantified by subtracting the former and the friction stress from the observed yield strength. It was found that for the as-ECAP-processed samples, the degree of the grain size-related strengthening relative to the observed yield strength was consistent with an extrapolation of the conventional Hall–Petch relation, and marked extra strengthening, which was clearly related to the grain refinement, appeared after annealing.

Keywords: Equal channel angular pressing (ECAP); Hall-Petch relation; Dislocations; Strengthening; Annealing