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Small Specimen Procedure for Determination of Deformation Maps*

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Abstract

Irradiation hardened metals can undergo changes in their mode of plastic deformation during post irradiation straining. Uniform deformation by dislocation cell formation may be preempted by highly localized strain in the form of dislocation channeling or micro twinning which can substantially degrade mechanical properties. These changes in deformation mechanisms are sensitive to radiation exposure level and temperature, and to stress level, strain rate and degree of strain during the test, in presently ill-defined ways. To determine the interaction of these various parameters and to bring some order and understanding to this complex situation, it is necessary to systematically determine the dominant deformation modes in given realms of parameter space. This can be achieved by building deformation mode maps which display the operating deformation modes in terms of fluence-strain space or other prescribed parameters.

To make these maps, stress and strain are best defined and controlled in tension tests, and the deformation mode is identified via transmission electron microscopy (TEM). The maps require many tests. To streamline the process and satisfy ALARA personal radiation exposure standards the test pieces must be as small as possible. The tensile specimen is a sheet type, 17 mm overall length with a gauge width of 1.5 mm and length 8 mm. The thickness is 0.25 mm which supports bulk mechanical behavior and provides TEM specimens that do not require grinding operations. The possibility of extraneous strains that might arise from pin loading or friction gripping are avoided by loading the specimens under their shoulders in a small, sliding cradle which also prevents accidental damage during remote handling and supports the specimen during the tension test. After straining, three or four TEM pieces each 1.5 mm square are cut from the gauge section in one pass using a slow speed rotary saw fitted with ganged blades. To accommodate these square specimens during electrothinning, the specimen holder is custom modified with a square recess embossed in the platinum anode and with a 1 mm diameter polishing window. Finally, for TEM examination, the thinned specimen is supported in a specially designed molybdenum ring assembly.

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