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# Measurement of Relative Void Surface Energies in Irradiated Metals by Small-Angle Scattering*

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Voids formed in neutron irradiated metals are faceted on various crystallographic planes. This faceting has been shown to cause significant anisotropy in the small-angle scattering pattern [Epperson, J. E., Hendricks, R. W. & Farrell, K. *Studies of Voids in Neutron Irradiated Al Single Crystals.* I. *Small-Angle X-Ray Scattering and Transmission Electron Microscopy*, To be published; Hendricks, R. W., Schelten, J. & Schmatz, W. *Studies of Voids in Neutron Irradiated Al Single Crystals.* II. *Small-Angle Neutron Scattering*, To be published]. In the case of neutron-irradiated Al single crystals, the voids may be generally characterized as octahedral having (111) faces with a varying degree of truncation on (100) faces. If it is assumed that the voids are in an equilibrium shape (which can be achieved by a low-temperature anneal), the specific surface energies $\gamma_{hkl}$ and the truncation parameter $t$ are related by $\gamma_{100} = \sqrt{3}\,(1-t)\gamma_{111}$. Hendricks, Schelten & Schmatz proposed that the truncation parameter $t$ could be measured by studying the anisotropy of the tail of the small-angle scattering curve. In such an experiment, the scattering is measured at constant $|\kappa|$ in a given plane in reciprocal space as a function of rotation of the crystal about an axis perpendicular to the diffraction plane. In this paper, the sensitivity of the proposed experiment to (i) the distribution of void sizes $N(D)$ and (ii) various crystallographic planes is numerically explored. It has been found that for certain low-index planes, the effect is sufficiently independent of $N(D)$, that reasonable estimates of $t$ can indeed be found. Thus, it is possible to obtain the specific void surface energies from small-angle diffuse scattering data.

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# Small-Angle Scattering in Neutron Irradiated Copper

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Work which has been started at Pelindaba on small-angle scattering in neutron irradiated copper is described. The facility consists of a 15 m long *S*-curved waveguide, which transmits a neutron spectrum with a maximum at 9A and a FWHM of 4A [Hofmeyr, C. & Isebeck, K. (1964). *Nucl. Instrum. Meth.* **117**, 9–16]. The collimator has an angular divergence of 0·01 rad and a comparative measurement is made of a sample against a reference sample. Samples of ASARCO copper purified by annealing at 960 C for 1 hour in a vacuum of $5\times10^{-4}$ torr were subsequently irradiated in the SAFARI reactor to $10^{19}$ and $10^{20}$ n/cm$^2$ ($E > 0{\cdot}1$ MeV) at estimated temperatures of 100 C and 250 C respectively. The small-angle scattering effect was shown to be due to radiation-induced damage through measuring a sample before irradiation, after irradiation and after annealing at 450 C for 10 minutes, which restored the original scattering characteristics. The differential coherent-scattering cross sections ($d\sigma/d\Omega$) have been plotted on a log-log scale against the wave vector **K** (Figure). Samples irradiated to $10^{20}$ n/cm$^2$ show an increase in scattering over the lower-dose-irradiated samples, the increased scattering being particularly strong for $K < 0{\cdot}05$ Å$^{-1}$. For the former, the plot is linear over three orders of magnitude and has a gradient of $-4{\cdot}0$. Such a dependence is expected if voids are present (Porod's equation) provided that they are randomly oriented. In a polycrystalline material this will be true even if the voids are faceted. We therefore conclude that voids have been formed at this fluence and temperature, which accords with