HELIUM ASSISTED TRAP MUTATION IN TUNGSTEN OBSERVED BY MEANS OF PAC

M. S. Abd El Keriem[a)], D. P. van der Werf and F. Pleiter

Laboratorium voor Algemene Natuurkunde, Materials Science Centre
University of Groningen, The Netherlands

ABSTRACT. We have seen with PAC that monovacancies in tungsten decorated with He can mutate to form He decorated divacancies while pushing out self-interstitials.

Thermal Helium Desorption Spectrometry (THDS) measurements on He filled monovacancies in bcc metals have shown that, up to a certain number of He atoms per vacancy, the dissociation energy decreases with increasing occupancy. When more He is added, it seems that the dissociation energy increases[1)]. An explanation of this phenomenon is that the decorated monovacancy tranforms into a decorated divacancy plus an interstitial:

$$\mathrm{VHe}_n \rightarrow \mathrm{V}_2\mathrm{He}_n\mathrm{I} \rightarrow \mathrm{V}_2\mathrm{He}_n + \mathrm{I} \qquad (1)$$

This is called trapmutation. Unfortunately, VHe_n and $\mathrm{V}_2\mathrm{He}_n$ have approximately the same dissociation energies[2)] and, therefore, can not be seen separately with THDS. With PAC it is possible to observe this phenomenon directly because the two complexes will give rise to different frequencies and symmetries in the PAC spectra. Since an In atom is part of the defect structure, reaction equation (1) should be rewritten as :

$$\mathrm{InV}_2\mathrm{He}_n \rightarrow \mathrm{InV}_3\mathrm{He}_n\mathrm{I} \rightarrow \mathrm{InV}_3\mathrm{He}_n + \mathrm{I} \qquad (2)$$

To investigate this process, we implanted two W foils with 50 keV ^{111}In ions to a dose of 7×10^{12} cm^{-2}, and subsequently annealed one of them at 620 K, and the other at 750 K. The PAC spectra show components with hyperfine parameters $\omega_o = 133$ Mrad/s and $\eta = 0$, which is attributed to the InV_2 complex, and $\omega_o = 300$ Mrad/s and

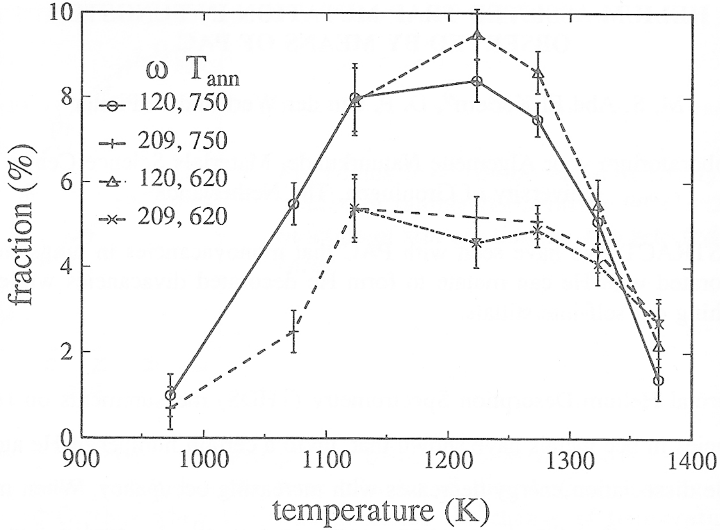

Figure 1 *Fractions of the 122 and the 109 Mrad/s components as function of the annealing temperature.*

$\eta = 1$, which is attributed to the InV_3 complex[3,4]. The fractions of the 133 Mrad/s component were 25% in the former case and 22% in the latter case, while for the 300 Mrad/s component these values were 3% and 9%, respectively. We then implanted the samples with 300 eV He to a dose of 3×10^{15} cm^{-2} and observed that in both samples the fractions of InV_2 and InV_3 decreased by approximately 50 %. Hereafter, we measured the annealing behaviour (see fig. 1), beginning at about 1000 K which is far above the dissociation temperatures of the InV_2 and InV_3 complexes. We saw two distinct components: one with a frequency of 122 Mrad/s and $\eta = 0$, and one with a frequency of 209 Mrad/s and an asymmetry parameter that varied from $\eta = 0.9$ at 1100 K to $\eta = 1.0$ at 1300 K. A tungsten foil which received the same treatment except that the annealing after ^{111}In implantation was carried out at a temperature of 820 K, did not show the presence of InV_2 and InV_3 clusters. After He implantation and annealing above 1000 K no clear frequencies were observed.

We ascribe the 120 Mrad/s and the 209 Mrad/s components to He filled monovacancies and He filled divacancies, respectively. The asymmetry parameter of 0 and 1 is what is to be expected for these defect configurations. The change of η from 0.9 to 1 in the second case is attributed to "cooking off" one by one the He atoms. We see further that both components disappear simultaneously, which is to be expected according to THDS measurements[5]. We conclude from our observations that the 120 Mrad/s and 209 Mrad/s components are generically related to the InV_2 and InV_3 clusters. From the fact that the fraction of InV_3 after preparative annealing of 750 K was significantly smaller then the fraction of He decorated InV_3 (see fig 1), we conclude that trap mutation has occurred indeed.

This work forms part of the research programme of the "Stichting voor Fundamenteel Onderzoek der Materie" (FOM) with the financial support from the "Nederlandse Organisatie voor Wetenschappelijk Onderzoek" (NWO)

[a] Permanent address : Ain Shams University, Cairo, Egypt.

References

[1] Veen, A. van, Materials Science Forum 15-18, 3 (1987)

[2] Veen, A. van, Evans, J. H., Buters, W. Th. M., and Caspers, L. M., Radiation Effects 78, 53 (1983)

[3] Pütz, U., Hoffmann, A., Rudolph, H.J., and Vianden, R,. Z. Phys. B46, 107 (1982)

[4] Post, K., Pleiter, F., Kolk, G. J. van der, Veen, A. van, Caspers, L. M., and Hosson, J. Th. M. de, Hyperfine interactions 15/16, 421 (1983)

[5] Kolk, G. J. van der, Post, K., Veen, A. van, Pleiter, F., and Hosson, J. Th. M. de, Radiation Effects 84, 131 (1985)