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DEPTH DISTRIBUTION OF BUBBLES IN He-ION IRRADIATED NICKEL AND THE MECHANISM OF BLISTER FORMATION

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Depth Distribution of Bubbles in $^3He^+$-Ion Irradiated Nickel and the Mechanism of Blister Formation

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EXTENDED ABSTRACT

While the radiation blistering phenomenon has been widely studied, the mechanism of blister formation is still not well understood [1]. The present studies on depth distribution of helium bubbles in nickel were carried out in order to obtain a better understanding of the radiation blistering process. Particularly, the aim was to understand the experimental observation [1,2] that the blister skin thickness for many metals irradiated with He^+ ions of energies lower than 20-keV is a factor of two or more larger than the calculated projected range.

High purity (99.995%) annealed polycrystalline nickel foils were irradiated at 500°C with either 20- or 500-keV $^4He^+$ ions to total doses of 2.9×10^{17} and 5×10^{15} ions/cm^2, respectively. Thin foils suitable for transmission electron microscopy were prepared from the irradiated samples by a transverse sectioning technique described elsewhere [3]. The technique allows one to obtain depth distribution of cavities (e.g. bubbles, voids) from a single specimen.

Figure 1(a) shows a typical bright field transmission electron micrograph (TEM) of the plated and irradiated regions (the interface between the two is marke by arrows) of the 500-keV irradiated sample. The cavities seen at the interface and in the plating are probably due to the trapped hydrogen bubbles generated in the nickel strike solution. The swelling $(\frac{\Delta V}{V})$ due to the cavities (voids or bubbles) were measured from enlarged micrographs as a function of depth at 500 Å intervals and is shown in Fig. 1(b). The solid and dashed curves show the depth distribution of energy deposited into damage, and the projected range calculated according to Brice [4], respectively. Also, the experimentally measured blister skin thickness is plotted with the error bars. It can be seen that the peak in

the swelling agrees well with the peak in the projected range distribution and with the blister skin thickness.

Fig.2(a) shows a bright field of TEM of the 20-keV irradiated sample and the corresponding histogram of the swelling as a function of depth is shown in Fig.2(b). The dashed curve represents the calculated projected range probability distribution. The measured blister skin thickness is shown by the horizontal bar. Here it can be seen that the depth at which the swelling peak occurs is at a much larger depth than the peak in the calculated projected range distribution, but agrees well with the blister skin thickness. These results suggest that the separation of blister skin occurs at a depth where the volume fraction of the helium bubbles is at a maximum. The critical dose for blister formation is reached when interbubble fracture has been initiated in the region of maximum swelling where the interbubble distance has become sufficiently small.

References

[1] S. K. Das, M. Kaminsky, Adv. in Chemistry 158 (1976) 112.
[2] S. K. Das, M. Kaminsky, G. Fenske (this conference)
[3] G. Fenske, S. K. Das and M. Kaminsky, to be published.
[4] D. K. Brice, Ion Implantation Range and Energy Deposition Distribution, Vol. 1, (Plenum NY 1975).

Figure Captions

Fig. 1(a) Bright field TEM of annealed polycrystalline Ni irradiated at 500°C with 500-keV $^4He^+$ for a dose of 5×10^{17} ions/cm^2.

(b) Histogram showing swelling $(\frac{\Delta V}{V})$ as a function of depth from the irradiated surface for the micrograph shown in 1(a).

FIG. 2(a) Bright field TEM of annealed polycrystalline Ni irradiated at 500°C with 20-keV $^4He^+$ for a dose of 2.9×10^{17} ions/cm^2.

(b) Histogram showing swelling as a function of depth from the irradiated surface for the micrograph shown in Fig. 2(a).

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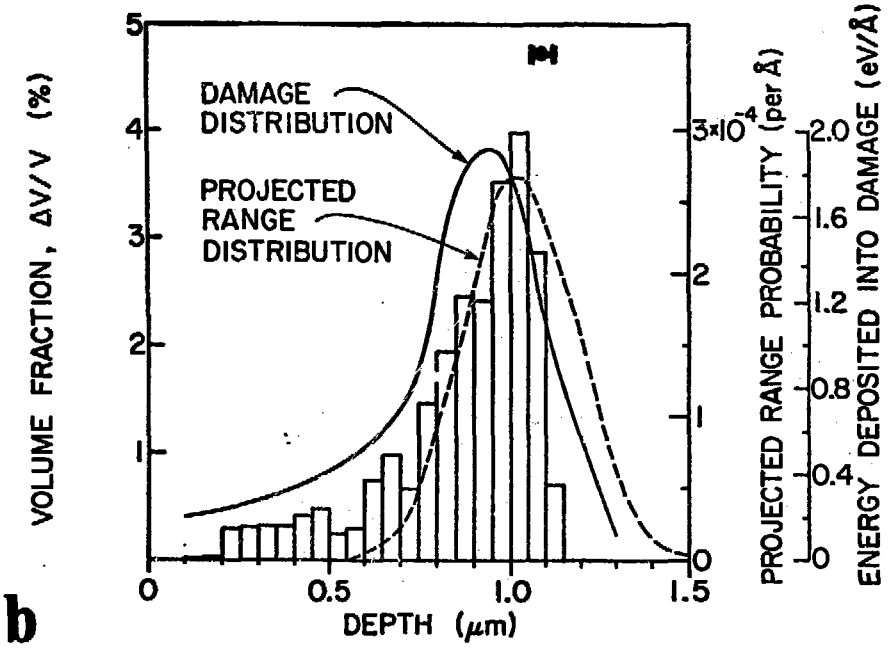
DAMAGE
DISTRIBUTION
PROJECTED
RANGE
DISTRIBUTION
VOLUME FRACTION, ΔV/V (%)
PROJECTED RANGE PROBABILITY (per Å)
ENERGY DEPOSITED INTO DAMAGE (eV/Å)
DEPTH (μm)
0
0.5
1.0
1.5
1
2
3
4
5
3×10⁻⁴
0.4
0.8
1.2
1.6
2.0

b

FIGURE 1

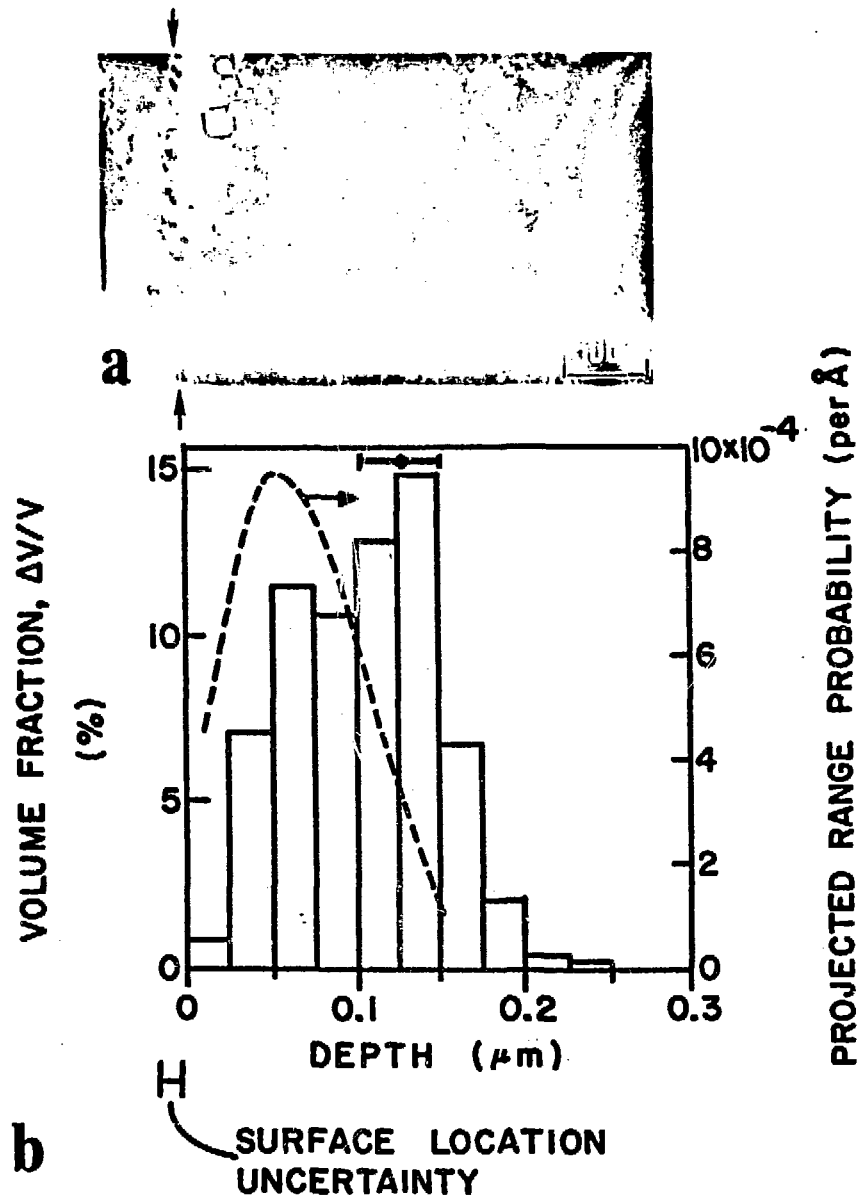
a
b
VOLUME FRACTION, ΔV/V
(%)
15
10
5
0
0
0.1
0.2
0.3
DEPTH (μm)
10x10⁻⁴
8
6
4
2
0
PROJECTED RANGE PROBABILITY (per Å)
H
SURFACE LOCATION
UNCERTAINTY

FIGURE 2