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A CORRECTION TO "IRRADIATION CREEP BY THE CLIMB-CONTROLLED GLIDE MECHANISM IN PULSED FUSION REACTORS"*

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In a previous publication by Gurol and Ghoniem[1] concerned with irradiation creep by climb-enabled glide in pulsed fusion reactors, a relationship between the point defect fluxes to dislocations and their average climb velocity included an inappropriate numerical factor. Here we give the appropriate correction. The distinction is important because the relationship applies to different physical situations, depending on the value of this factor. Derivations of these relationships together with descriptions of their regimes of applicability are contained in a paper by Mansur.[2]

It is the last equation on p. 104 of ref. 1, on which the development in ref. 1 is based, that is to be changed. That equation in turn is a slight simplification of Eq. (16) of ref. 2. Equation (16) of ref. 2 can be written, using the notation of ref. 1 for simplicity, as

$$V_c = \frac{2}{3b}\left[Z_i^A D_i C_i - Z_v^A D_v (C_v - C_v^A)\right] \quad , \qquad (1)$$

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where V_c is the dislocation climb velocity, b is the Burgers vector, and Z_i^A and Z_v^A are the capture efficiencies for interstitials and vacancies of dislocations whose Burgers vectors are aligned with the stress axis. The symbols C_i and C_v are the interstitial and vacancy concentrations, and $\overset{A}{C_v}$ is the vacancy concentration in thermal equilibrium with aligned dislocations. The symbols D_i and D_v are the interstitial and vacancy diffusion coefficients. Ignoring the thermal vacancy population, $\overset{A}{C_v} \ll C_v$, and setting $\overset{o}{Z_v} = \overset{A}{Z_v}$, where $\overset{o}{Z_v}$ is the capture efficiency of nonaligned dislocations for vacancies, gives the last equation on p. 104 of ref. 1.

$$V_c = \frac{2}{3b}\,(\overset{A}{Z_i} D_i C_i - \overset{o}{Z_v} D_v C_v) \quad . \qquad (2)$$

However, Eq. (1) above is valid only in the steady-state and then only where all generated point defects are partitioned to dislocations according to the orientation-dependent capture efficiencies of the dislocations — the SIPA effect. It is shown in ref. 2 that Eq. (1) above is obtained as a special case of a more general relationship between point defect concentrations and climb velocity only when the following equation is fulfilled,

$$(Z_i^A D_i C_i - Z_v^A D_v C_v + Z_v^A D_v C_v^A) = -2(Z_i^o D_i C_i - Z_v^o D_v C_v + Z_v^o D_v C_v^o) \quad . \qquad (3)$$

Equation (3) above is not fulfilled when the point defect concentrations are not in the quasi-steady-state.

In ref. 1, pulsed irradiation is treated, where the point defect concentrations are often in transient conditions. Furthermore, it is assumed though not stated clearly in ref. 1 that there is no orientation and $Z_v^o = Z_v^A = Z_v$). Thus Eq. (2) above is simply not applicable to the physical case treated in ref. 1.

The appropriate equation for the physical case of interest in ref. 1 is given in ref. 2. The generally applicable expression, Eq. (14) of ref. 2, is written below,

$$V_c = \frac{1}{3b}\left\{ \left| Z_i^A D_i C_i - Z_v^A D_v C_v + Z_v^A D_v C_v^A \right| + 2\left| Z_i^o D_i C_i - Z_v^o D_v C_v + Z_v^o D_v C_v^o \right| \right\} . \quad (4)$$

This expression can be simplified where there is assumed to be no SIPA effect, where $Z_i^A = Z_i^o = Z_i$ and $Z_v = Z_v^A = Z_v^o$, to give the last equation on p. 501 of ref. 2,

$$V_c = \frac{1}{b}\left[Z_i D_i C_i - Z_v D_v (C_v - \overline{C}_v^d)\right] , \quad (5)$$

where $\overline{C}_v^d$ is the average thermal vacancy concentration at a dislocation. Note that there is no steady-state assumption incorporated into Eq. (5) above. When thermal vacancy emission is neglected, $\overline{C}_v^d \ll C_v$, Eq. (5) becomes

$$V_c = \frac{1}{b}\,(Z_i D_i C_i - Z_v D_v C_v) \quad . \quad (6)$$

This equation should replace the last equation on p. 104 of ref. 1 (i.e., Eq. (2) above).