

DIFFUSION IN bcc TRANSITION METALS(*)

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Diffusion in metals and alloys is a defect controlled process. It occurs as a result of solvent (solute) atom-vacancy exchange in the matrix. Diffusion can also occur along short circuiting paths like dislocations or grain boundaries. In all these cases the temperature dependence of diffusivity follows an Arrhenius relationship i.e. $\log D$ vs $1/T$ plot is linear. The diffusivity is written as $D = D_0 \exp(-Q/RT)$ where D_0 and Q are frequency factor and activation energy for diffusion.

Researches in the field of atom movement have revealed that for a lattice vacancy controlled diffusion process, the frequency factor (D_0) and activation energy (Q) follow certain well known empirical rules. For example, for all close packed and some bcc metals $Q = 34 T_m$, where T_m is the melting point, or $Q = K(E_s/\sqrt{Z})$ where (E_s/\sqrt{Z}) is the cohesive energy density; K being a structure dependent constant. Similarly the frequency factor D_0 for vacancy diffusion is of the order of 0.5 and yields a positive value for diffusion entropy. A deviation from these empirical rules suggests a strong probability of an alternate diffusion mechanism operating during the process.

Recent researches in the self and impurity diffusion behaviour in bcc transition metals of group IV B and V B have shown that $\log D$ vs $1/T$ plots in these cases are curved, and exhibit variation in the effective entropy and activation energy with temperature. Further more, in the case of β -Zr, and β -Ti, the entropy of diffusion is negative and $Q < 34 T_m$ in the low temperature range. Similar results have been

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obtained in the case of γ -U also. These results have given rise to serious doubts about the mechanism responsible for diffusion in these cases. It has been variously suggested that effective diffusivity at any temperature is cumulative of two competing processes with different diffusion parameters.

The present paper reviews the various explanations that have been put forward to explain the 'anomalous' curved diffusivity plots observed in some bcc transition metals. Sufficient evidence has been presented by present authors to show that 'anomalous' diffusion in β -Zr, β -Ti etc. could be a manifestation of their intrinsic properties; the diffusion remaining a vacancy controlled process. It has also been shown that on activation volume and other considerations, diffusion in β -Zr and β -Ti resembles the diffusion behaviour of sodium which is relaxed vacancy controlled.

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