Question Sheet 4, Solid–State Transformations

1. Explain the difference between mechanical twinning and annealing twins. How would you distinguish the two types of twinning using optical microscopy?

   In cubic–close packed (c.c.p.) metals, the twin plane is $\{1\ 1\ 1\}$ and the twin direction is $< 1\ 1\ \overline{2} >$. Calculate the twinning shear.

   What is the maximum number of different twin traces that you might expect to find in any given grain of a severely deformed sample of a c.c.p. metal?

2. Describe an application of secondary hardening steel and explain why the secondary hardened condition is appropriate for that application.

   A Fe–0.3C–2.0V wt% steel reaches peak hardness during tempering at 600 °C for 1 h. This is due to the formation of fine vanadium carbide plates (VC) containing 81 wt% vanadium. Estimate the plate thickness assuming that the carbides grow at rate controlled by the diffusion of vanadium in the ferrite. The diffusivity of V in α–iron is given by $D_0 = 0.01\,\mathrm{m^2\,s^{-1}}$, $Q = 274\,\mathrm{kJ\,mol^{-1}}$. Describe your assumptions in reaching the estimate.

3. How would you measure the displacements associated with displacive transformations in (a) metals; (b) ceramics?

4. Explain why a shape memory metal (a) tends to lose its reversibility after many cycles; (b) why there is a limit to the amount of reversible strain in any given cycle. State two applications of shape memory metals.

Numerical answers:

1. The twinning shear is $1/\sqrt{2}$. Four traces.
2. Carbide plate thickness about 3.8 nm

Full answers to AQ3 and AQ4 will be distributed with BQ1 and BQ2 respectively.

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