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Question Sheet 2 on Alloys

1. Why is Widmanstätten ferrite able to grow by a displacive transformation mechanism at small undercoolings below the equilibrium transformation temperature?

2. Martensite plates generally grow right across the austenite grain in which they nucleate, at least during the early stages of transformation. The strain energy per unit volume of martensite (thickness c and length r) is given by:

$$E = \frac{c}{r}\mu(s^2 + \delta^2)$$

where the shear component of the shape change $s = 0.18$ and the dilatational component is $\delta = 0.05$. The shear modulus is 5×10^{10} Pa. Calculate the thickness of martensite plates which form just below the M_S temperature in two steels with austenite grain sizes 30 and 100 μm respectively. The free energy change for martensitic transformation at M_S is about $-1000\ \mathrm{J\,mol^{-1}}$ and the molar volume $7 \times 10^{-6}\ \mathrm{m^3\,mol^{-1}}$.

3. A c.c.p. crystal contains two intersecting twin variants, the twinning elements being (1 1 1) [1 1 $\overline{2}$] and (1 1 $\overline{1}$) [1 1 2] respectively. Find the direction of the line which remains invariant to both of these deformations.

4. Compare mechanical twinning, annealing twins and martensitic transformations. Comment in each case on the nature of any permanent change in shape, the components of the strain associated with any shape deformation, on whether there is any change in crystallographic orientation, crystal structure, or density, and finally on the morphology.

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