particles in colonies at 1100°C. At higher temperatures the formation of acicular needles decreases and the formation of ferrite particles is favoured.

(ii) Transformation to γ (900°C).

(iii) Decomposition of the austenite into a lamellar aggregate of α-ferrite and Cr_2N (800°C).

(iv) Continuous precipitation of finely divided Cr_2N in the matrix of α-ferrite in 6% Mn steel at 700°C. This does not happen in 8% Mn steel.

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Letters

Generating Electron Channelling Patterns in the JSM-II SEM

A detailed analysis has recently been carried out on the electron optical conditions for generating single crystal electron channelling patterns (ECP's) in the JSM-II scanning electron microscope [1]. Because of the large number of such SEM's currently in service and because of the rising interest in the electron channelling pattern technique, the analysis is summarised here. A general analysis was reported earlier [2] and applied specifically to the "Stereoscan"; the geometry of the JSM-II is sufficiently different to warrant a separate study. The origin and applications of ECP's have been discussed quite extensively in the literature, and the reader is referred to a recent review by Dr G. R. Booker [3]. Suffice it to say that patterns are comprised of orientation dependent lines and bands of contrast, which arise through variations in the back-scattered and secondary emitted electron intensities as the incident beam scans through the reflecting positions for various Bragg planes. ECP's are useful for determining accurately crystal orientations and for assessing crystal (near-surface) perfection.

The important requirements are small beam divergence δ and high beam current i at the specimen. For a practical guide we assume the values $\delta \leqslant 3 \times 10^{-3}$ radians and $i \gtrsim 10^{-9}$ amps. These can be satisfied in several ways depending on the type of beam required. For instance, a narrow focused beam is used to generate simultaneously channelling contrast and contrast from surface features; a wide collimated beam is used for patterns only, since it integrates out of the image contrast due to topographical and other features of repeat distance smaller than about half the beam diameter; an unfocused beam is used only if there are no surface features. The procedures follow:

(*a*) For an unfocused beam the simplest method is to turn off the lenses. The divergence in radians is then given by $\delta = (D_2/800) \times 10^{-3}$ where D_2 is the diameter in microns of the final aperture, and the beam current is given by $i = \beta D_2{}^2\delta^2$ where β is the gun brightness ($\approx 2 \times 10^1$ amps/cm²-sr. at 25 kV); the beam size 1_2 is essentially D_2. For a standard JSM-II, $D_2 \approx 200\ \mu m$.

(*b*) For a focused beam the condenser (lens 1) is operated at long focal length by removing the pole-piece, and the objective (lens 2) is used to focus the beam to a spot onto the specimen. To prevent cut-off during scanning of the beam (now narrow in the plane of lens 2) the final aperture is enlarged, and to satisfy divergence requirements the first aperture, usually about 1 mm, is reduced. In this case $\delta = [U_2D_1/30\ (220\text{-}U_2] \times$

10^{-3} where U_2 in mm is the object distance to lens 2 and D_1 is the diameter in microns of aperture 1; the spot size in microns is given by $l_2 = 5(200 - U_2)/U_2$ and the beam current by $i = \beta l_2^2 \delta^2$. We note that D_1 is an important parameter: once chosen the optical parameters are determined by the condenser setting. A suitable value for D_1 is 30 μm and a typical value for U_1 is 100 mm (lens 1 set about the number 8 position). We also note that the smallest spot size compatible with beam divergence and current requirements for good patterns is limited by the gun brightness to be within about 1 to 5 μm.

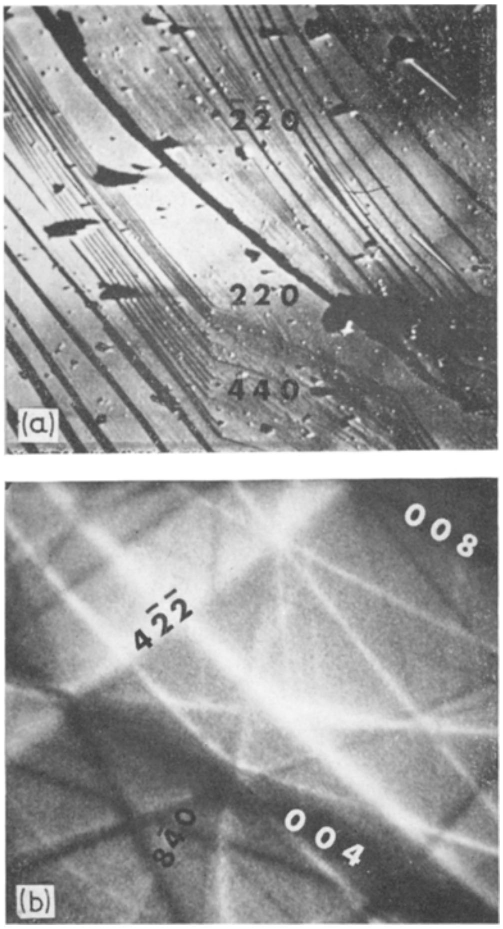

Figure 1 (a) Narrow beam electron channelling patterns from a freshly cleaved NaCl crystal showing ⟨100⟩ cleavage steps. (b) Wide beam electron channelling patterns from a silicon monocrystal.

(*c*) For a collimated beam the set up is similar to (*b*). The lens settings, however, are different: lens 1 is increased (and set about the number 14 position) and lens 2 is reduced so that its focal length equals its object distance, i.e. $f_2 = U_2$. Thus $\delta = 1.5 \times (220 - f_2)/f_2 \times 10^{-4}$, $l_2 = D_2$ and $i = \beta D_2^2 \delta^2$.

An indication of whether the beam conditions are correct for generating patterns can be obtained from the reading on the specimen current ammeter and from the topographical resolution. Since the beam brightness is considered to be constant along the optic axis, we note that the electron optical parameters are not independent, but are related through the expression: $\beta = i/l_2^2\delta^2 =$ constant.

In the above discussion, the numerical parameters are derived from the JSM-II geometry assuming a working distance of 15 mm; more general expressions for any two-lens system are given elsewhere (1).

Examples of patterns generated using 25 kV focused and collimated beams are shown in the figure: in (a) a narrow (10 μm) focused beam was used to generate topographical and electron channelling contrast from a cleaved (100) face on NaCl and we observe cleavage steps running along ⟨100⟩ directions and electron channelling lines and bands; in (b) a wide (500 μm) collimated beam was used to generate only high resolution (10^{-4} radians) electron channelling contrast from a silicon crystal. These examples also illustrate the maximum image angular-width 2γ in the JSM-II, obtained by setting the magnification control to a minimum. At 25 kV, $2\gamma = 2.6$ degrees when lens 2 is off; when lens 2 is on the scanning angle increases with increasing lens setting. Thus figure (a) shows a channelling band since $2\gamma > 2\theta_{220}$ (θ is the Bragg angle); (b) shows only channelling lines. The scan angle also varies with acceleration potential V according to $2\gamma \propto V^{-\frac{1}{2}}$.

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