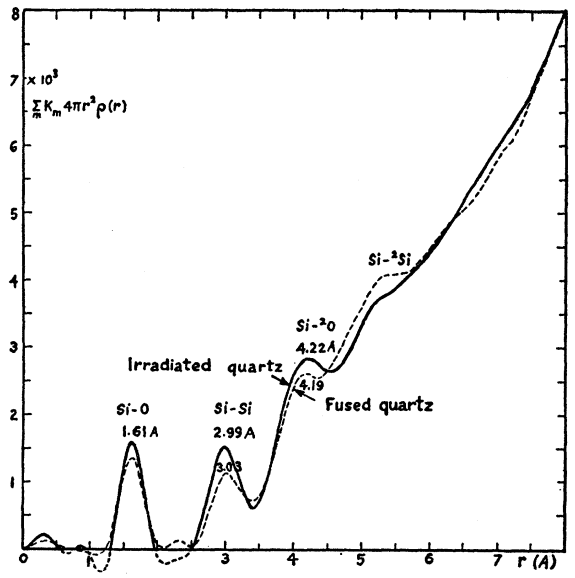

FIG. 1. Distribution of electron density as a function of radial distance from a silicon atom in quartz discovered by fast neutrons of a total integrated flux of 1.4×20^{20} neutrons/cm^2. Dashed line is a radial electron density distribution curve obtained on a sample of fused quartz (unirradiated).

We have investigated by means of x-ray diffraction the structure of natural single-crystal quartz plates and of vitreous silica plates that have been irradiated by fast neutrons (at 38°C) in the Materials Testing Reactor to a total integrated flux of 1.4×10^{20} neutrons/cm^2. Upon irradiation, the density of quartz decreased from 2.650 to 2.306 g cm^{-3} while the density of vitreous silica increased from 2.222 to 2.303 g cm^{-3}.

The x-ray diffraction patterns of solid plates were obtained by means of a recording, Geiger-counter goniometer, using the method of balanced filters. Irradiated quartz and irradiated vitreous silica gave patterns that were identical within the limits of experimental error; however, they were perceptibly different from that of the thermally fused, unirradiated vitreous silica.

The electron radial distribution functions were obtained from the diffraction patterns using the theory developed by Warren and co-workers[4] for glass. In the numerical solution of the scattering integral equation, we used a direct approach rather than performing the Fourier inversion by the usual harmonic analysis.[5] This was made possible by using the Datatron high-speed digital computer for the numerical integrations. The direct method eliminates the errors inherent to the harmonic analysis but it does not avoid the errors resulting from the excessive weighting of fluctuations at large scattering angles. For this reason an appropriate artificial temperature factor was applied.

From the results shown in Fig. 1, we may make the following conclusions. (1) The silicon-oxygen distance in the neutron-disordered quartz is the same (1.61 A) as in vitreous silica. (2) The distance from the silicon atom to the next nearest silicon atom is somewhat smaller in the disordered quartz than in vitreous silica. This indicates that the angles of the Si—O—Si bond is slightly smaller (138°) in the disordered quartz than in the vitreous silica (142°). (3) The radial distances of the oxygen atoms (O—O and the Si—second O) and of the more distant neighbor atoms show a wider distribution in the disordered quartz than in the vitreous silica.

A complete report on this work will be published.

* This research was sponsored by the Owens-Illinois Glass Company, of Toledo, Ohio, whom the author wishes to thank for permission to publish this paper.

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[5] The author wishes to thank Dr. L. Peck for this suggestion and Mr. C. Block for programing the problem for the computer.

Interference Effects in the Electron Microscopy of Thin Crystal Foils*

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ELECTRON microscopic studies of metals thinned by electrolytic polishing and other means to a degree that they become transparent for electrons, were started by Heidenreich[1] and continued by Castaing.[2] These authors studied aluminum and aluminum-copper alloys.

The present paper concerns face-centered cubic chrome (18%)—nickel (8%) steel, which was thinned by electropolishing. The specimen, a circular disk (2 cm. diam; 0.2 mm thick; insulated with a varnish on the edge; connected as anode) was attacked from both sides by pointed cathodes of which the point only was not insulated. At first the cathodes were placed 2 mm from the specimen until a central hole was formed in the specimen; afterwards, the distance was increased to 1 cm, so that preferentially the region near the edge was attacked and a new hole opened. The treatment was continued up to the very moment when the two holes joined. In that region, the specimen showed relatively large areas which could be cut out and observed in transmission in the electron microscope. The cleaning was done by rising in hot water, dissolving all salts in hot sequestrol solution, and rinsing anew in hot distilled water. The electrolytic bath was a mixture of

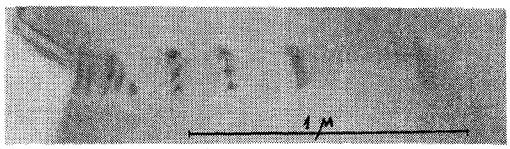

FIG. 1. Sections of dislocation lines crossing a steel foil.

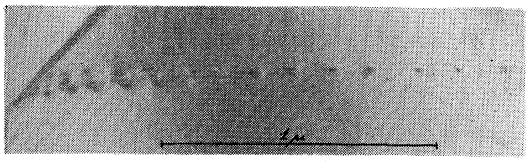

FIG. 2. Small-angle grain boundary or slip band.

60% phosphoric acid and 40% sulfuric acid; the current was 3 amp; the thickness of the specimen could be chosen from the very thin edge (thinner than 100 A) up to about 1000 A; the voltage of the electron microscope (Philips) was 100 kv.

The brightness of an electron micrograph produced by electrons which penetrated a crystal foil is determined not only by incoherent elastic and inelastic scattering and absorption but also by diffraction effects. The theory of these diffraction effects is described in detail by Heidenreich.[1] These effects are important when the Bragg condition is nearly fulfilled. Here, the intensity varies periodically with increasing thickness of the specimen and with varying angle. Through these effects an interference electron microscopy is possible showing, for example, the roughness of the surface of a transparent specimen or sliplines, etc.

Deviations of the lattice parameters inside the material, produced by internal stresses, can also be visualized as variations in brightness because these deviations locally change the diffraction situation. On the basis of this idea, it has been possible to make *dislocation lines* visible inside the material. (It has even been possible to take stereoscopic pictures of dislocation lines.) Figure 1 shows some sections of dislocation lines crossing the steel foil. Figure 2 shows either a small-angle grain boundary as discussed by Read and Shockley[3] or a slip band. It consists of a series of parallel dislocation lines which in this case are nearly perpendicular to the metal surface. (The thickness of the specimen diminishes from left to right.) The dislocation lines themselves consist—as in Fig. 1—of a row of points (visible on the left side of the picture), which seem to be related to the periodic variation of brightness with thickness.

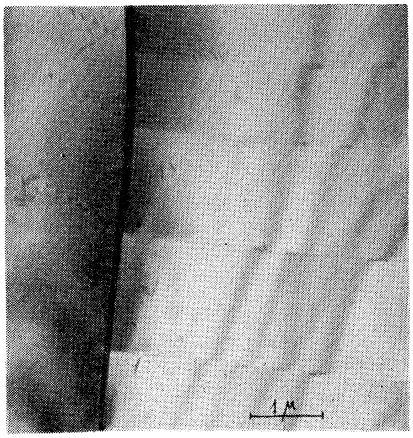

FIG. 3. Probably slip bands in a slightly rolled steel.

Around the dislocation lines a field of distortion is visible. The extension of this field, as can be seen on the picture, will depend on the diameter of the aperture diaphragm of the microscope because smaller deviations than the aperture angle contribute to brightness of the picture and are lost for contrast. Thus, by evaluation of a series of pictures taken with different diaphragm diameters, it should be possible to measure this strain field.

Figure 3 probably shows slip bands in a steel specimen which was slightly rolled before preparation. The rows of parallel dislocation lines in these bands begin at the vertical grain boundary at the left and extend into the two grains. The displacement of the interference lines at the slip bands can be due to a change of the mean lattice parameter at the band.

Applications of this kind of interference electron microscopy can be found, for example, in metallurgy for the study of plastic deformation of metals, and in semiconductors for the study of lattice distortions.

A detailed paper will follow elsewhere.

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Diagrams for Processes Involving Hyperons

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THE success of the Gell-Mann model[1] in providing a scheme for a rational classification of the hyperons and their reactions has been reinforced by the experimental verification of many of its predictions.

In this theory quantum numbers are attributed to the states of the particles, which are algebraically additive and which are conserved in the "strong" and electromagnetic interactions but which may not be conserved in "weak" interaction. They are the number of particles (N), the z component of the isotopic spin (I_3), and the strangeness quantum number (S). For the antiparticle corresponding to a given particle all these quantum numbers change sign.

In a recent paper[2] d'Espagnat and Prentki, by imposing the invariance of the Lagrangian for "strong" interaction under symmetry operations in isotopic spin space, introduced a new quantum number U, the number of isoparticles, such that the charge would be given by

$$Q=I_3+\tfrac{1}{2}U. \qquad (1)$$

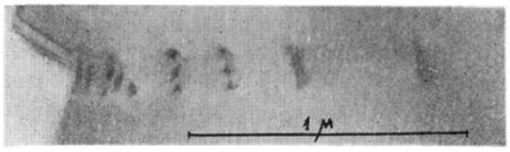

FIG. 1. Sections of dislocation lines crossing a steel foil.

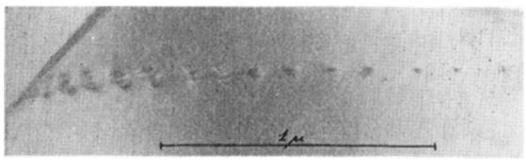

FIG. 2. Small-angle grain boundary or slip band.

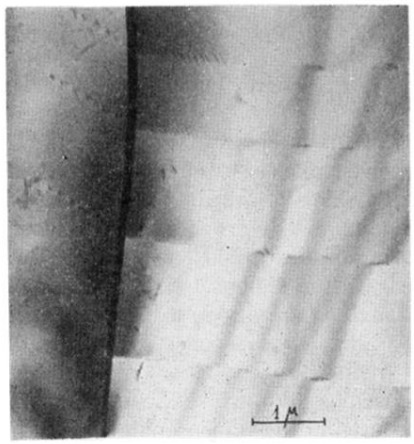

FIG. 3. Probably slip bands in a slightly rolled steel.