

that the dye in the molecular state shows a strong tendency to adsorb on the walls of the containing vessel, and in some experiments such adsorbed films showed the sharp molecular absorption band and associated fluorescence for a minute or so after their preparation, but the effect rapidly disappeared as the film passed into the crystalline state. Dyes adsorbed on filter paper, cotton wool, kaolin, etc., frequently possess an absorption maximum agreeing in position with the molecular band. This seems to indicate that some of the adsorbed dye is present in the molecular state.

A similar type of very narrow absorption band associated with fluorescence of approximately the same wave-length was discovered in the ruby by Ebert, and was examined in detail by Mendenhall and R. W. Wood. The ruby consists essentially of a crystal of aluminium oxide containing dissolved chromium oxide. The method of preparation of synthetic rubies corresponds in principle with the present method of producing the molecular absorption band of 1:1' diethyl- ψ -cyanine dispersed in a solid crystalline substance.

These phenomena are illustrated in the attached spectrograms which were photographed on 35 mm. Panatomic film by means of a grating microspectrograph described elsewhere¹.

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¹ *J. Roy. Micr. Soc.*, 56, 101-112 (1936).

The Beilby Layer on Non-Metals

It is now generally accepted that the polish layer on metals is amorphous. The observations which led Beilby to formulate his famous conception of the vitreous nature of this layer were not, however, confined to metals, but had also been made with non-conducting crystals such as quartz, fluor spar, calcite and others. But Hopkins¹, working in G. P. Thomson's laboratory, has shown that the polish layer on Iceland spar cleavage faces is crystalline; and Raether's² electron diffraction patterns from polished natural faces of rock salt, fluorite, calcite and pyrites are also wholly characteristic of crystalline structure. Nevertheless, the directness and simplicity of his experiments, in particular the exposure by etching of scratches eliminated by polishing, seem to speak convincingly in favour of Beilby's views.

Recently we have examined a wide variety of polished non-metallic single crystal surfaces, with results which go far towards reconciling the apparent conflict of evidence hitherto afforded by Beilby's microscope and the electron diffraction camera. Thus we have found that, whilst polished plane surfaces, cut in quite arbitrary directions from many types of single crystals (quartz, diamond, natural and synthetic sapphires, and mandine and demantoid garnets, topaz, chrysoberyl, epidot, olivine, sphene, andalusite), yield electron diffraction patterns of spots and lines and thus provide irrefutable evidence of the crystalline structure of the polish layer on such surfaces, other crystals, notably white beryl, zircon, tourmaline, cassiterite and hematite, give the pattern of diffuse haloes more or less submerged in background which is so characteristic of liquid mercury, glasses, vitreous silica and of the amorphous Beilby

layer. From other polished crystal facets (brown beryl, moonstone, orthoclase and cordierite) composite patterns were obtained in which the single crystal pattern showed faintly through that due to the amorphous layer. Spinels, both synthetic and natural, yielded either halo patterns or haloes and spots, only faintly distinguishable through the general background scattering. In some cases the structure of the polish layer appeared to be determined by the crystallographic nature of the facet examined. Thus one facet of a blue kyanite yielded a Beilby layer pattern through which single crystal spots were faintly distinguishable, whilst other facets of the same specimen gave single crystal patterns. Again, though the end faces of the prisms of a Zeiss nicol afforded quite good single crystal patterns, those from the junction faces were characteristic of the true amorphous Beilby layer. After etching, which revealed many coarse grinding scratches on all these faces, only typical single crystal patterns were obtained.

These results seem clearly to establish the validity of Beilby's view of the formation of the polish layer. That the layer is, however, often crystalline may be ascribed, except perhaps in the case of the diamond where polishing is possibly the effect of attrition alone, to a ready and spontaneous re-ordering of the molecules, disarranged by the act of polishing, in more or less strict orientation with those of the crystal matrix, whilst the amorphous nature of the polished surfaces of other crystal facets is evidence of the reluctance of the flowed layer to recrystallize; a reluctance which appears to be determined in some cases by the nature of the mineral, in others by the crystallographic direction of the polished facet.

Carborundum affords an example of a chemically formed amorphous polish layer. The untreated crystals, even though possessing perfect mirror-like surfaces, invariably yield typical Beilby layer patterns. Abrasion with fine emery paper (mainly rouge and aluminium oxide) or immersion in hydrofluoric acid appear to have no visible effect; nevertheless, after either of these treatments, carborundum flakes furnish single crystal patterns of quite exceptional clarity. Presumably the raw crystal surfaces are covered by a thin film of glassy silica formed by superficial oxidation during cooling of the charge³.

An important result of these experiments is that the study of the diffraction of electrons by single crystals need no longer be confined to the often imperfect natural or cleavage faces. Any desired type of face can be exposed for this purpose by grinding and polishing, followed by etching in those cases where the polish layer happens to be amorphous. Finally, we have obtained good single crystal patterns from all over the curved surface of a short-focus plano-convex quartz lens. Thus every conceivable crystal plane should be accessible to the electron beam in a single crystal ground and polished as a sphere.

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Nov. 9.

¹ Hopkins, *Phil. Mag.*, 21, 820 (1936).

² Raether, *Z. Phys.*, 86, 82 (1933).

³ Germer, *Phys. Rev.*, 49, 163 (1936), also obtained a halo pattern from carborundum and concluded that this vitiated the usual interpretation of the haloes obtained from polished surfaces; had he, however, removed the glassy film due to surface oxidation, a single crystal pattern would certainly have been obtained.