and general positions, especially in respect of the hydrogen bond configuration. It may be possible to determine this for the potassium compound by a three-dimensional analysis. The reliability factors for the present structure are $R(hk0) = 0{\cdot}212$, $R(h0l) = 0{\cdot}228$, $R(0kl) = 0{\cdot}241$.

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Densities of Trigons and Ultra-Violet Absorption of Diamonds

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Two opposite faces of each of 37 small transparent octahedral diamonds were examined microscopically by phase-contrast illumination for the density of trigons on them. Ultra-violet absorption edges were also determined for the same diamonds.

The two faces of the same diamond were found usually to have about the same density of trigons.

On all the diamonds the faces examined could be classified into two groups with regard to the density of trigons. These results support a conclusion reached previously that critical conditions of growth exist for the initiation of trigon formation.

Analysis of the results, including the ultra-violet absorption edges of the diamonds examined, indicates that the ultra-violet absorption might be correlated with the surface texture shown by the trigons.

Introduction

It is well known (Miers, 1902; Smith, 1930; Williams, 1932; Tolansky, 1953; Tolansky & Wilcock, 1946; Halperin, 1954) that diamonds often have their octahedral faces covered with small equilateral triangular pits, or 'trigons' as named by Sutton (1928). It is now certain that the trigons were formed during the growth of the crystals (Williams, 1932; Tolansky & Wilcock, 1946), and that they are not due to etching, as assumed by earlier investigators (Miers, 1902; Smith, 1930).

The formation of trigons was discussed in a previous communication (Halperin, 1954). The main assumption in the theory proposed to explain the formation of the trigons was that imperfect steps, only a fraction of the lattice unit in height, were formed on the growing surfaces as a result of accumulation of faults in the lattice. It was further claimed that these imperfect steps should grow into observable trigons at certain conditions of growth. Trigons should be formed, on these ideas, only when growth is continued below a certain critical temperature, while at higher temperatures growth does not stop at the imperfect steps when the whole face is covered, and no observable trigons are formed.

Such a process of growth on imperfect steps should affect the texture of the diamond, giving it a 'domain' structure. This involves stacking-fault surfaces, dislocations and other imperfections in the bulk of the crystal, imperfections which might affect the structure-sensitive properties of the diamond. It was therefore suggested (Halperin, 1954) that the well known (Robertson, Fox & Martin, 1934) peculiarities of diamond with regard to its structure-sensitive properties might be connected with the imperfections mentioned.

Now the trigons describe the surface texture of the diamond, and from the above consideration it follows that this is built on the texture in the bulk of the crystal. If this is true, a correlation should exist between the trigons on the surface and the structure-sensitive properties of a diamond. To look for such a correlation, the absorption edge in the ultra-violet was chosen as one of the structure-sensitive properties. Thirty-seven small colourless octahedral diamonds (about 1 mm. thick) were examined for the density of trigons on their faces, and for their absorption edges in the ultra-violet. One pair of octahedral faces was examined on each crystal, and ultra-violet absorption edges were determined for light passing through the crystal at normal incidence to the same faces.

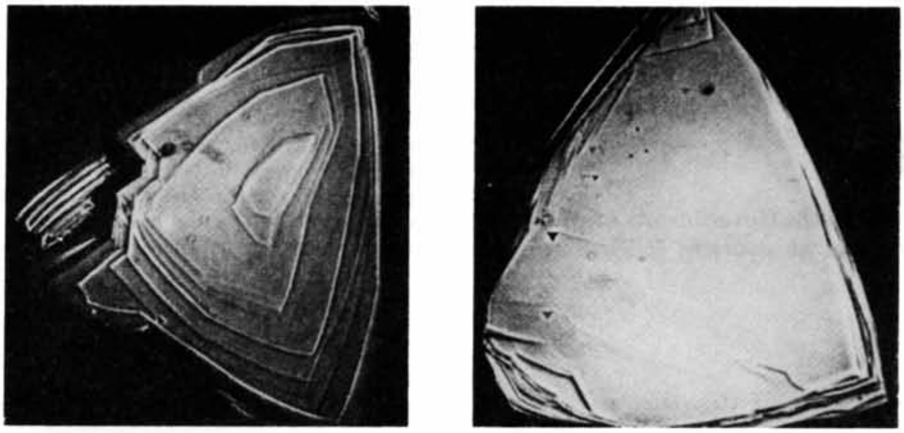

Fig. 1. (*a*) A trigonless diamond face (×42). Absorption edge at 2900 Å. Note the irregularities in the boundaries of the growth layers. (*b*) Another trigonless face (×42). Absorption edge at 2400 Å.

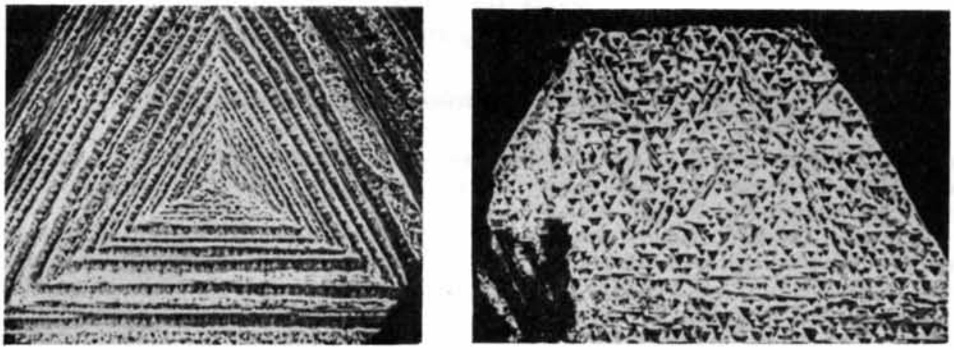

Fig. 2. (*a*) A trigonful diamond face (×42); the terraces of the growth pyramid are packed with trigons. Note the regular straight boundaries of the growth layers. Absorption edge at 2900 Å. (*b*) Another example of a trigonful diamond face (×47). Absorption edge at 2900 Å.

Experimental

As already mentioned, all the diamonds were small; this was in order to minimize possible differences between the texture in deeper layers and that in layers near the surface. Large differences, which are more likely in larger crystals (Grenville-Wells, 1952), should of course be avoided, otherwise the expected correlation would no longer show itself.

The crystals were cleaned by suitable processes, mounted on a diaphragm and placed just before the slit of a Hilger medium quartz spectrograph. A conventional concentrated hydrogen arc was used as light source. Exposures were of such duration that small differences in exposure and variations in photographic processes did not change appreciably the visually estimated absorption edges.

For the microscopic examination, each of the crystals was mounted on a glass plate, silvered by evaporation in vacuum to give 80–90% reflexion, and examined under the microscope by phase contrast illumination (Zernicke, 1942). Microphotographs were taken on high-contrast plates (Kodak B20), and developed with a high-contrast developer. Where necessary, the contrast was still more enhanced by printing on extra-hard printing paper. This procedure enabled trigons on the surface less than 20 Å deep to be observed. This estimate of the limit of step-height still observable was obtained by the methods of multiple-beam interferometry (Tolansky, 1948). After completing examination of one face, the crystal was remounted and the same procedure was repeated for the opposite face of the octahedron. It should be noted that most of the trigons are very shallow and do not appear with the ordinary microscope.

Results

Densities of trigons

Almost all the faces examined could be classified into two groups with regard to the density of trigons. The first group contained faces on which trigons were rare and occupied a very small part (say less than 5%) of the surface area, or up to about 10^4 trigons per cm.^{2}. We shall refer to such faces as *trigonless*. Microphotographs of two faces of this group are shown in Fig. 1. The other group contained almost all the rest of the faces examined, and could be characterized by a high density of trigons, which occupied almost the whole surface area (10^5–10^7 trigons per cm.^{2}). Fig. 2 shows examples of *trigonful* faces.

Only a few intermediate cases were observed. In these cases the same face contained trigonless and trigonful areas (Fig. 3), sometimes with a transition area between on which the density of trigons changed gradually. On such mixed faces the part on the lower level of the face was found to be the one containing the higher density of trigons.

A diagram representing the density distribution of trigons on all the faces examined is given in Fig. 4. The ordinates show the number of faces having a given density of trigons, and the abcissae give the corresponding densities of trigons on a logarithmic scale. The division into two groups is evident, but this might be more pronounced when considering the fraction of the total surface area occupied by trigons. Of the 73 diamond faces examined, 40 had less than 5% of their area occupied by trigons, and 26 had more than 50% of the area covered by trigons. Only on 7 faces did trigons occupy 5–50% of the area. For a pair of faces of the same diamond, the trigon densities were usually about equal on both the faces.

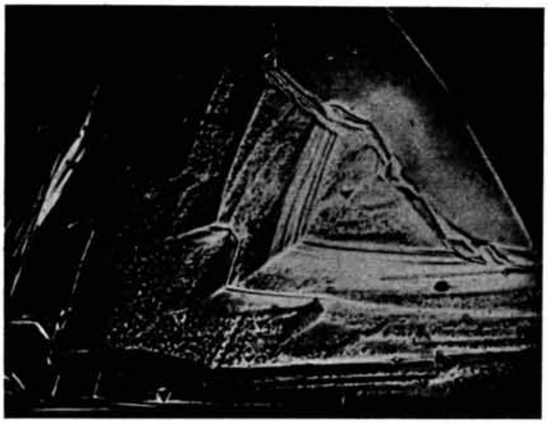

Fig. 3. A mixed face containing trigonless and trigonful areas (×42). Absorption edge 2600–2900 Å.

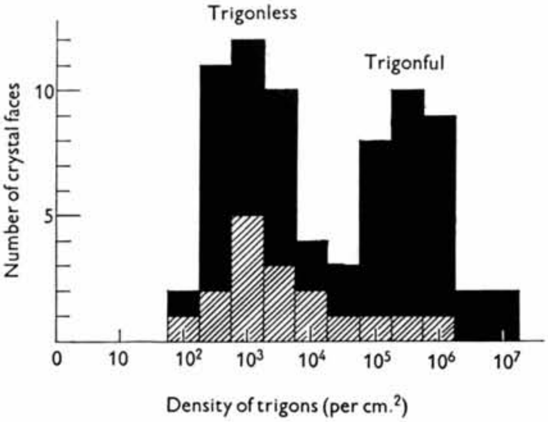

Fig. 4. Distribution in densities of trigons on the diamond faces examined. Black area: Type I diamonds; shaded area: Type II diamonds.

Preliminary measurements of more than two faces of the octahedron on the same diamond were taken on a few diamonds only. These observations indicated that all the well developed faces of a diamond have about the same density of trigons. Observations on small undeveloped faces proved experimentally difficult and were neglected.

Density of trigons and the ultra-violet absorption edge

When estimating the wavelengths of the absorption edges for the different crystal, no correction was made for differences in thickness or in losses of light due to surface-scattering from one crystal to another. Although these effects did not change appreciably the observed absorption edges, not much importance should be attributed to the exact values of the ultra-violet cut-offs as observed on the photographic plates. It seems, therefore, best to divide the different diamonds into two groups according to their absorption edge. Following Grenville-Wells (1952), who worked with diamonds of about the same size and quality, we shall classify diamonds having their absorption edge at wavelengths longer than 2800 Å as Type I, and those having their edge below 2800 Å as Type II.

Of 37 crystals examined, 28½ belonged to Type I and 8½ to Type II. (In some cases only part of the crystal transmitted below 2800 Å; such a crystal was counted as being half of Type I and half of Type II.)

On classifying the diamonds into the two groups with regard to trigon density it was found convenient to take the density of 5×10^4 trigons per cm.^{2} as the lower limit for trigonful faces, all lower densities being classified as trigonless. All the Type I diamonds were about equally divided by this criterion, 15 of them as trigonless and 13½ as trigonful. Turning to the Type II diamonds we find that 7 of them (more than 80%) were trigonless while *only* 1½ were trigonful (see Fig. 4). It is clear that almost all the Type II diamonds are trigonless, a fact which points to some correlation between ultra-violet absorption and the imperfections in the bulk of the diamonds, which we suppose to cause the formation of the trigons. In order to avoid confusion it should be borne in mind, as stated above, that the presence in the body of the crystals of the imperfections mentioned would not necessarily result in trigons on the surface. This point is important in the explanation of the experimental results, as discussed below.

Some support for the expected correlation might also be given by the fact that the diamond whose faces were most densely packed with trigons (some 10^7 per cm.^{2}) had its absorption edge furthest towards the visible (at about 3100 Å). This, however, should be taken with reserve as it might at least partly be attributed to scattering from the rough surfaces.

Discussion

The results of the present investigation may be summarized as follows: (1) Octahedral faces of diamonds (of the quality under examination) are usually either trigonful or trigonless. (2) Diamonds of Type I have either trigonful or trigonless faces. (3) Type II diamonds have mostly trigonless faces, while diamonds with trigonful faces are almost always of Type I (see Fig. 4).

These results seem to be well accounted for on assuming: (i) that critical conditions of growth exist for the initiation of trigon formation; (ii) that the origin of the ultra-violet absorption of Type I diamonds is a high density of certain defects in the bulk of the crystal whose traces on the surface *may* appear as trigons. It follows of course from this assumption that Type II diamonds, which do not absorb in the ultra-violet down to about 2250 Å, should not contain many of these defects.

The first assumption explains the results under (1) and (2) above. By this, no matter what the density of the defects in the bulk of the crystal, the faces should be trigonless unless the crystal continued to grow at conditions at which trigons are formed. In other words, diamonds of Type I, *containing these defects in the bulk*, should have trigonless or trigonful faces according to the conditions prevailing when the layers near the surface grew.

According to the second assumption, one would expect all the trigonful diamonds to be of Type I, and all Type II diamonds to be trigonless. This fits fairly well the experimental results summarized under (3) above. The exceptions (1½ diamonds of Type II having trigonful faces) might be explained as due to differences in texture, the surface layers only being rich in defects. In such a case the surface layer containing the defects seems to be too thin to show the strong absorption characteristic to Type I diamonds, while the surface itself might be trigonful.

That certain diamonds show in fact such a tendency was found by Champion (1952, 1953) on investigating the counting properties of the diamond. Comparing the α- and β-counting properties of some of his specimens, he came to the conclusion that the surface layers in these specimens were richer in electron traps than the interior.

Again, the first assumption is just in accord with a conclusion, obtained elsewhere (Halperin, 1954), by which trigons should start to be formed below a certain critical temperature. Furthermore, the existence of two groups of diamonds with regard to trigons on their faces was clearly shown in the present work, which is difficult to explain unless the existence of critical conditions for the formation of trigons is assumed.

More support for this assumption can be gained when considering the shape of the growth layers on the surface. It is known (Bunn & Emmett, 1949) that the boundaries of growth layers tend to be irregular and curved when growth is rapid, and this is known (Egli & Zerfoss, 1949) to be the case at high temperatures and under conditions of high supersaturation. Examination of the trigonless and the trigonful diamond faces investigated in the present paper shows that the latter have more regular layer boundaries (compare, for example, Figs. 1(*a*) and 2(*a*)).

Most of the experimental part of the present work was carried out in Prof. S. Tolansky's laboratories at the Royal Holloway College, The University of London. It is a pleasure to thank Prof. Tolansky for the facilities of his laboratory given to me and for his continuous interest and encouragement in the course of the work. Thanks are also due to Dr F. C. Champion of King's College, London, and to Mr P. Grodzinski, of The Industrial Distributors Ltd, for the loan of most of the diamonds used in the present study. The work was carried out while on study leave from the Hebrew University, Jerusalem, during the tenure of a Fellowship granted by The Humanitarian Trust and The Friends of the Hebrew University, London.

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