Reports of the Academy of Sciences of the USSR

CRYSTALLOGRAPHY

1968

SovietRxiv

Abstract

Full Text

Reports of the Academy of Sciences of the USSR
1968. Volume 181, No. 6

UDC 539.211

CRYSTALLOGRAPHY

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RIGHT- AND LEFT-HANDED GROWTH SPIRALS IN ARTIFICIAL DIAMOND

In solid-state physics, spiral growth of diamond is known only for artificial crystals obtained at high pressures and temperatures ([1]). Rounded disks observed on the faces of natural diamonds are considered by some investigators to be the result of growth, and by others to be the result of dissolution. There is no proof of the dislocation nature of the growth of these disks.

One of the methods for revealing dislocations is etching or growth of crystals. The etchants usually used reveal, as a rule, trigonal pits or hillocks on the (111) face, for example, and sometimes hexagons. In experiments connected with the growth of diamonds under metastable conditions, there have been no indications of spiral growth.

The authors of the present work carried out experiments on growing diamond under metastable conditions on natural seed crystals, under conditions of slight supersaturation of the melt–solution. When the seed diamonds were examined after the experiment, characteristic circular and oval figures were found on their surface (Fig. 1). The paired arrangement of the circles and their enclosure by other curves, with a large radius of curvature, is noteworthy; as a result, ovals arise. In the center of individual circles, dark points can be noted. The enveloping curves, as a rule, begin on one circle of a given pair and end on the other.

Table 1

R, mm	17	27.5	32.5	39.5	41.0	48.0	51.5	57.5	68.5
$I_{exp.}$	100	50	30	5	20	30	30	5	20
$d_{exp.}$, Å (k = 34.80)	2.05	1.265	1.07	0.881	0.805	0.725	0.678	0.605	0.508

Fig. 1

Figure 1: Fig. 1

Fig. 2

Figure 2: Fig. 2

R, mm	17	27.5	32.5	39.5	41.0	48.0	51.5	57.5	68.5
$d_{\text{tabl.}}$, Å (diamond)	2.05	1.26	1.072	0.885	0.813	0.721	0.680	0.597	0.507
$I_{\text{tabl.}}$	100	50	40	10	25	40	20	20	3

The synthesis of diamond under metastable conditions was recorded by chemical, gravimetric, optical, electron-microscopic, microdiffraction, and electron-diffraction methods. An electron diffraction pattern from the grown layer is shown in Fig. 2. The indexing of the electron diffraction pattern is given in Table 1. The instrumental constant $k = 34.80$ was determined using a magnesium standard. On the basis of an analysis of the results obtained, the authors came to the conclusion that in the growing diamond they had found right- and left-handed spirals corresponding to positive and negative dislocations, possibly interacting by the mechanism of a Frank–Read source.

Growth dislocations are, as a rule, a continuation of dislocations emerging from the seed crystal, and therefore all the regularities found also apply to natural diamond. Indeed, upon etching diamonds in liquid metal under conditions of slight undersaturation of the solution, similar patterns were found, as is evident from Fig. 3. Along the perimeter of the circles, ordinary trigonal pits are clearly visible.

Fig. 1. General view of an accumulation of dislocations at the edge of a crystal. 120×

Fig. 2. Results of an electronographic study of the diamond surface after overgrowth: electron diffraction pattern from the deposited layer

Fig. 3. Circular dislocations on natural diamond, revealed by etching under conditions of slight undersaturation of the solution–melt. 900×

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Fig. 3

Figure 3: Fig. 3

Figure 1 shows the crushed edge of the seed crystal, which had undergone some deformation even before the experiment. In this region of the crystal the dislocation density increased, which led to their detection during the overgrowth of the seed. Thus, the mechanism of dislocation interaction in natural diamond crystals also, apparently, obeys the Frank–Read source mechanism.

The authors express their deep gratitude to A. V. Kochergin and Yu. B. Smirnov for their help in carrying out the experiments.

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Received
29 IV 1968

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Note: Figure translations are in progress. See original paper for figures.