ON THE CRYSTALLIZATION OF CUBIC BORON NITRIDE

CRYSTALLOGRAPHY

1968

SovietRxiv

Fig. 1

Figure 1: Fig. 1

Abstract

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UDC 548.52

CRYSTALLOGRAPHY

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ON THE CRYSTALLIZATION OF CUBIC BORON NITRIDE

AND SYNTHETIC DIAMOND

(Presented by Academician N. V. Belov on 17 VI 1967)

As is known, cubic boron nitride and synthetic diamond are obtained under conditions of ultrahigh pressure and high temperature.

Studies of the morphology of diamond crystals separated from sinters ([1–3]) and of cubic boron nitride ([4–6]) have shown that crystals of the latter–

Fig. 1. Regions of sinters in polished sections. **a** –diamond crystals in a metallic melt (white); **b** –an intergrowth druse of cubic boron nitride crystals growing from the eutectic layer (white); **c** –a recrystallization druse of cubic boron nitride crystals (after leaching out the mother melt). Reflected light. 70×

···as well as diamond crystals, have a predominantly isometric habit; however, in contrast to diamond crystals, which are perfect in their faceting, cubic boron nitride crystals are bounded by only two faces of the positive and two faces of the negative tetrahedra. Also characteristic is the presence of intergrowths of cubic boron nitride crystals that are not destroyed during chemical treatment of the sinters. This allowed us to suppose that the mechanism of growth of cubic boron nitride crystals differs from that of synthetic diamond crystals.

In order to test this supposition, we subjected polished sections of undecomposed sinters of synthetic diamond and cubic boron nitride, as well as leached crystalline aggregates of the latter, to microscopic examination.

Synthesis of diamond and cubic boron nitride was carried out in the compression chamber of a high-pressure apparatus (7). The initial components of the charge –respectively graphite or hexagonal boron nitride and metals forming solvent melts–were placed in the reaction volume in the usual manner (6).

Fig. 2. Schematic sections of sinters. a—synthetic-diamond sinter; b—cubic boron nitride sinter. Legend: horizontal hatching corresponds to graphite (a) or hexagonal boron nitride (b); oblique hatching—the solvent melt; solid hatching—diamond crystals (a) and intergrowths of cubic boron nitride crystals (b). The arrows indicate the direction of displacement of graphite (a) and of the solvent melt (b).

Figure 2: Fig. 2. Schematic sections of sinters. a—synthetic-diamond sinter; b—cubic boron nitride sinter. Legend: horizontal hatching corresponds to graphite (a) or hexagonal boron nitride (b); oblique hatching—the solvent melt; solid hatching—diamond crystals (a) and intergrowths of cubic boron nitride crystals (b). The arrows indicate the direction of displacement of graphite (a) and of the solvent melt (b).

Fig. 2. Schematic sections of sinters. *a*—sinter of synthetic diamond, *b*—sinter of cubic boron nitride. Legend: horizontal hatching corresponds to graphite (*a*) or hexagonal boron nitride (*b*); oblique hatching—the solvent melt; solid hatching—diamond crystals (*a*) and intergrowths of cubic boron nitride crystals (*b*). The arrows indicate the direction of displacement of graphite (*a*) and of the solvent melt (*b*).

Analysis of polished sections of numerous sinters showed that, at the end of the synthesis experiment, diamond crystals are present as free individuals located in the mother metallic melt (Fig. 1*a*), whereas cubic boron nitride crystals are assembled into growth intergrowths or recrystallization intergrowths (Fig. 1*b, c*); the bases of the intergrowths are in contact with a layer of eutectic melt (7), and the heads of the crystals abut against a layer of hexagonal boron nitride.

Examination of leached intergrowths of cubic boron nitride crystals under a binocular microscope showed that, in accordance with the known principle of geometric selection of directions with the greatest growth rates (8), hemihedral cubic boron nitride crystals usually protrude from the intergrowths with an edge composed of the faces (111) and $(\overline{111})$.

On the basis of these observations and of previously obtained data (2–4, 5, 7), the processes of nucleation and growth of cubic boron nitride crystals and synthetic diamond are as follows. Diamond crystals nucleate and grow from the solvent melt. Cubic boron nitride crystals nucleate with the participation of the solvent melt during the modification transformation α-BN $\rightarrow$ β-BN.

In the process of diamond synthesis, carbon (graphite) diffuses and dissolves in the metallic melt, subsequently crystallizing from it under the appropriate thermodynamic conditions in the form of diamond (Fig. 2*a*). In the synthesis of cubic boron nitride, more complex processes occur (7), accompanied by displacement of the formed solvent melt into the bulk of the hexagonal boron nitride; under the proper thermodynamic conditions, as it moves, the melt impregnates and dissolves ever new portions of hexagonal boron nitride and thereby promotes recrystallization and the growth of crystals of cubic boron nitride (Fig. 2b).

All the foregoing, as well as the schematic sections of sinters obtained in the synthesis of diamond and cubic boron nitride presented in Fig. 2, show that the main reason for obtaining cubic boron nitride crystals whose faceting is less perfect than that of synthetic diamond crystals is the difference in the processes of nucleation and growth of the crystals of the two artificial minerals. Secondary causes are the geometrical factor (the size and configuration of the reaction volume of the compression chamber) and the polarity of the crystal structure of cubic boron nitride.

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Received
10 VI 1967

CITED LITERATURE

1. Bovenkerk, in: *Physics of High Pressures*, Foreign Literature Publishing House, 1963.

2. G. N. Bezrukov, V. P. Buttuzov et al., *Transactions of the All-Union Scientific Research Institute for the Synthesis of Mineral Raw Materials*, No. 8 (1964).

3. V. A. Bezrukov, G. N. Bezrukov et al., *Reports of the All-Union Mineralogical Society*, 95, no. 1 (1966).

4. N. E. Filonenko, V. I. Ivanov, L. I. Feldgun, DAN, 164, no. 6 (1965).

5. N. E. Filonenko, V. I. Ivanov, L. I. Feldgun, *Transactions of the All-Union Scientific Research Institute of Abrasives and Grinding*, No. 2 (1966).

6. Kotsuga Kudaka, Hirosi Konno, Tushio Matova, *J. Chem. Soc. Japan, Industr. Chem. Soc.*, 69, no. 3 (1966).

7. N. E. Filonenko, V. I. Ivanov et al., *Transactions of the All-Union Scientific Research Institute of Abrasives and Grinding*, No. 2 (1965).

8. D. P. Grigor' ev, DAN, 89, no. 3 (1953).

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