

INVESTIGATION OF B1-DEFECTS IN NATURAL DIAMONDS USING DOUBLE-CRYSTAL TECHNIQUE

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The information on B1-defects is available in numerous papers on spectroscopy and some X-ray and microprobe results including the review book edited by Field (1992). Nevertheless, a lack of data on B1-defects still takes place.

For our study we applied a high-resolution double-crystal X-ray technique (asymmetric 511(Si) - monochromator, MoK α_1 - radiation) to observe a diffusive X-ray scattering (DXS) on defects near the Bragg's reflection, the value of half-width ($\Delta\theta_{1/2}$), diffraction profile and integral intensity (I_i) of diffraction rocking curves (DRC).

The natural diamond plates of 0.7 mm thick were prepared with mechanical polishing. The plates were studied using X-ray transmission topography method. None dislocation or other visible topographic defects were found. High concentrations of B1-centers ($\mu_{B1}=1175\text{ cm}^{-1}$) and no A, C, B2 centers were recorded according to the data of infra-red absorption spectra (bands 1282 cm^{-1} , 1130 cm^{-1} , 1370 cm^{-1} , respectively). In the crystals studied the nitrogen concentration as B1-centers was defined from 0.25×10^{20} to $3.7\times 10^{20}\text{ cm}^{-3}$.

The investigation provided to establish the relationship between the nitrogen concentration as B1-centers and features of DRC reflexes 111, 220, 311, 400, 222. All the diffraction curves appeared to be significantly broadened, their integral intensity being increased (Fig. 1a). The diffraction profiles of curves is close to Gauss' law distribution. Such effects can prove the occurrence of dislocation loops. In Fig. 2 the linear relationship between ($\Delta\theta_{1/2}$) and nitrogen concentration (c , cm^{-3}) as B1-centers calculated according to $C_{N(B1)}=7.6\times 10^{18}\times \mu_{B1}$, where μ_{B1} - measured absorption coefficient for 1175 cm^{-1} band. In the plot (Fig. 2) the increase of the concentration of B1-defects is seen to results in the increase of diffraction curve width. Simultaneously I_i grows also. Obviously, $\Delta\theta_{1/2}$ and I_i growth takes place due to DXS at the local defects of rather big radius R (Krivoglaz, 1983). The interpretation the diffraction profiles of reflection using the technique close to that described in papers of Pimentel (1983, etc.) gives the dimension of dislocation loops from 230 to 1300 Å for different samples. This agrees well with direct observations under electron microscope (Sobolev, 1989). On the other hand, the high concentration of minor defects, e.g. A-type ($C_{N(A)}=2\times 10^{20}\text{ cm}^{-3}$), does not result in significant broadening of X-ray peaks (Fig. 1B). For example, $\Delta\theta_{1/2}$ of reflection 220 is 20 times less than for the samples with B1-defects under nearly the same nitrogen concentration.

Thus, experimental results prove that B1-defects, that provide the 1175 cm^{-1} absorption band, are the second class defects according to Krivoglaz's classification (1983), i.e. large dislocation loops (or clusters).

Field, J.E. (1992). The properties of natural and synthetic diamond. Academic Press, London, 710p.

Krivoglaz, M.A. (1983). Diffraction of X-ray and neutrons in non-ideal crystals. Naukova Dumka, Kiev, 408p. (in Russian).

Pimentel, C.A., and Brito Filho (1983). Point defect aggregates in boron doped dislocation-free Czochralski silicon crystals. J. of Crystal Growth, 62:129-140.

Sobolev, E.V. (1989). That harder than diamond. Nauka, Novosibirsk, 190p. (in Russian).

Captions

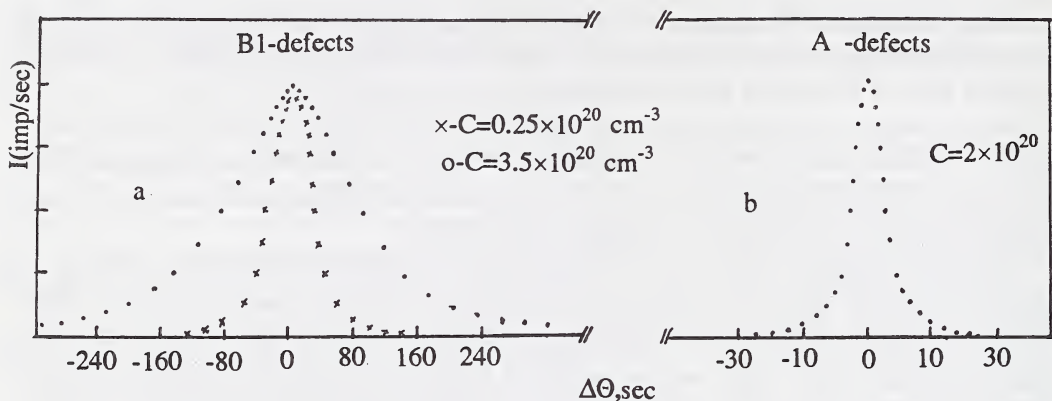


Fig. 1. Diffraction curves for the 220 Laue-set reflections were obtained for dislocation-free natural diamond crystals: (a) 1. $C_{N(B1)} = 0.25 \times 10^{20} \text{ cm}^{-3}$; 2. $3.5 \times 10^{20} \text{ cm}^{-3}$; (b) $C_{N(A)} = 2 \times 10^{20} \text{ cm}^{-3}$.

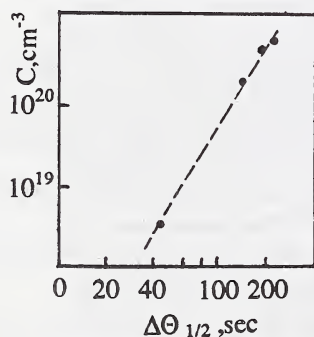


Fig. 2. Relation curve for a half-width of diffraction curve $\Delta\Theta_{1/2}$ versus nitrogen concentration as B1 in dislocation-free diamond crystals.