

# SPATIAL DISTRIBUTION OF THE NITROGEN DEFECTS IN SYNTHETIC SINGLE DIAMOND CRYSTALS GROWN UNDER NONISOTHERMAL CONDITIONS

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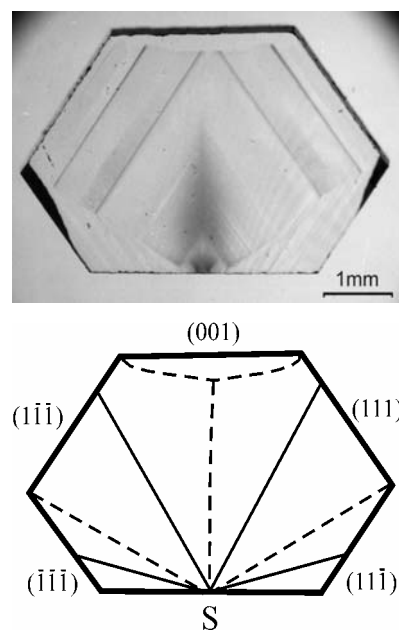
**Keywords:** synthetic diamond, nitrogen, defects

The particularities of the nitrogen defects distributions in synthetic diamond single crystals grown under nonisothermal conditions were carefully investigated. The examined diamond crystals were obtained using "split-sphere" type high pressure apparatus by temperature gradient method in the Fe-Ni-C system at  $P=6.0\text{GPa}$ ,  $T=1370\text{-}1550^\circ\text{C}$  and duration up to 126 hours. The nonisothermal conditions imply some low and high temperature stages (from 6 to 22 hours) during diamond crystal growth with temperature difference up to  $110^\circ\text{C}$  between them. The crystals obtained were cut parallel to (110) plane and polished into plates about 0.4-0.5mm thick. The spectroscopic study of the plates was performed with the use of IR-Fourier spectrometer Bruker Vertex-70 attached to Hyperion 2000 microscope with 50 microns square aperture. The points of spectra inspection were localised in some linear sections of octahedral growth sectors of the diamond plates (positioning accuracy was 1-5 microns). Positions of all points analysed were recalculated to the vector of  $\langle 111 \rangle$  growth sector [1, 2]. The nitrogen contents in the form of C, A and  $\text{N}^+$  centres were derived by decomposing the spectrum in one-phonon region into corresponding components with subsequent calculating of the concentrations using absorption coefficients reported in [3-5].

One of the plates made from diamond single crystal is presented on the fig.1. The zoning obviously observed in the plate allowed us to correlate the temperature regime with the inner plate structure (the zones grown at low temperature begins with dark line; the zones formed at high temperature have relatively light colour without initial dark line). The C, A and  $\text{N}^+$  defects distributions data related to the well developed octahedral growth sectors of the sample considered are presented on the figs.2-3. The dotted broken line represents the temperature-changing sketch during the crystal growth. As follows from the figures, the nitrogen can be represented by C-centres (up to 150ppm), A-centres (up to 245ppm) and  $\text{N}^+$  component (up to 25ppm). Totally, the nitrogen impurity content in the sample varies in the range from 100 to 250 ppm. In view of nitrogen defects distributions and taking in account corresponding temperature the following main regularities were noted:

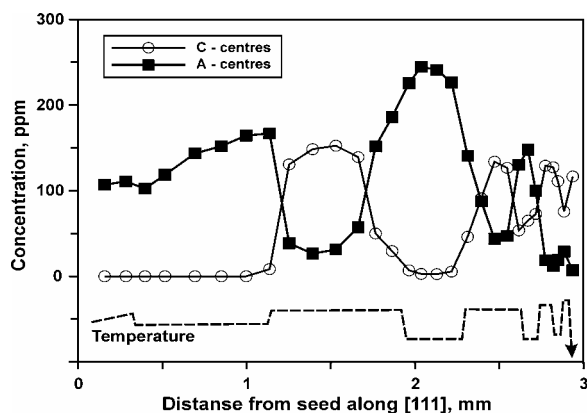
- C-centres are the predominant nitrogen form in the near surface area, but A-centres are abundant in the seed area;
- As for the middle area of the plate the nitrogen aggregation degree (relative content of A-centres) vary in wide range and reach maximum value in the zones of dynamic decreasing of the temperature with relatively high  $\text{N}^+$  content;
- Nitrogen concentration in the form of  $\text{N}^+$  increases in the areas of dynamic temperature decreasing and decrease when the temperature is increasing;
- Total nitrogen content increase with the increasing of the temperature and vice versa.

The mentioned particularities of the nitrogen distribution in the samples are consistent with the model that imply the nitrogen intake in the dispersed form with the further thermal activated diffusive generation of the A-centres as a result of subsequent annealing during crystal growth. The confirmed reverse correlation between the nitrogen content in diamond and the growth temperature [6] was characterised quantitatively:  $100^\circ\text{C}$  temperature increasing led to the 50-60 ppm lowering of the nitrogen concentra-

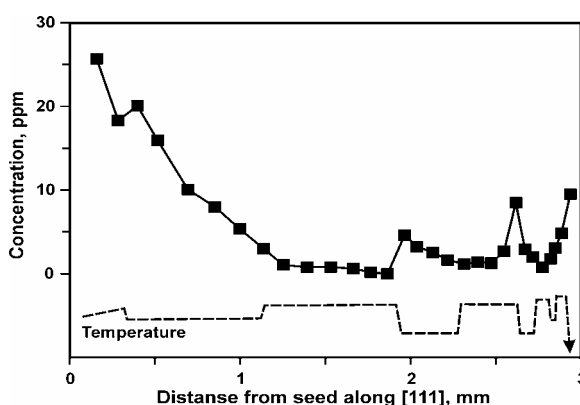


**Fig.1.** The diamond plate and its schematical drawing (dotted lines – the growth sectors boundaries; solid thin line from the seed position S – the sections analyzed)

tion. Additional temperature effect is concerned with the increasing of the N<sup>+</sup> nitrogen form in temperature transition period. Taking into account the data on direct correlation of N<sup>+</sup> and substitutional nickel [5], it can be concluded that nickel enter the diamond structure more intensively under high supersaturation [6-7]. The last sentence is consistent with data [6-7] and is indirectly confirmed by greenish photoluminescence of these zones due to Ni-containing complexes.



**Fig.2.** The distribution of the C and A nitrogen defects in the  $\langle 111 \rangle$  growth sector



**Fig.3.** The distribution of the N<sup>+</sup> nitrogen defects in the  $\langle 111 \rangle$  growth sector

In general, the experimental data presented let to conclude that the temperature and its character of changing are the main factors that determine the nitrogen impurity intake and its further transformation in diamond structure (for the closed chemical system). Additionally the results obtained assume the significant role of the temperature in defect structure formation of natural diamonds that as known have wide range of forms and content of nitrogen.

*The research was supported by the Russian Foundation for Basic Research (project 04-05-64847)*

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Electronic Scientific Information Journal "Herald of the Department of Earth Sciences RAS" № 1(24) 2006  
ISSN 1819 – 6586

Informational Bulletin of the Annual Seminar of Experimental Mineralogy, Petrology and Geochemistry – 2006  
URL: [http://www.scgis.ru/russian/cp1251/h\\_dgggms/1-2006/informbul-1\\_2006/term-11e.pdf](http://www.scgis.ru/russian/cp1251/h_dgggms/1-2006/informbul-1_2006/term-11e.pdf)

Published on July, 1, 2006

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