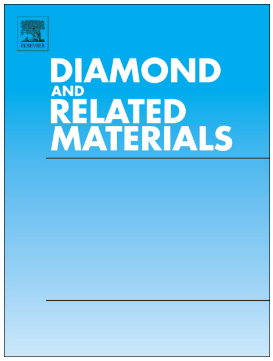

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PII: S0925-9635(16)30531-3
DOI: doi: 10.1016/j.diamond.2017.01.016
Reference: DIAMAT 6806

To appear in: *Diamond & Related Materials*

Received date: 27 September 2016
Accepted date: 24 January 2017

Please cite this article as: N.M. Kazuchits, M.S. Rusetsky, V.N. Kazuchits, A.M. Zaitsev , Cathodoluminescence of synthetic diamonds annealed at high temperature without stabilizing pressure. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. Diamat(2017), doi: 10.1016/j.diamond.2017.01.016

Cathodoluminescence of synthetic diamonds annealed at high temperature without stabilizing pressure

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Abstract

Nitrogen-containing synthetic diamonds heated at temperatures 1800, 2000 and 2500°C in hydrogen atmosphere (LPHT annealing) have been studied by cathodoluminescence (CL). After LPHT annealing, the transformations of nickel and nitrogen related defects were found similar to those occurred after annealing under high stabilizing pressure (HPHT annealing). An assumption is made that LPHT annealing may remove yellow color of synthetic HPHT-grown diamonds in areas where nickel and nitrogen have "matching" concentrations. The areas with excessive concentration of nickel, or nitrogen remain yellow even after 48 hour LPHT annealing at temperature 1800°C.

Keywords*: synthetic type Ib diamond, high temperature low pressure annealing, nitrogen aggregation, cathodoluminescence.*

1. Introduction

Annealing at high temperature under high pressure (so-called HPHT treatment) considerably changes defect structure of diamonds. In particular, HPHT treatment has been known for years as an effective method of modification of diamond color [1, 2]. HPHT annealing, when applied to common type Ib synthetic diamonds, reduces their yellow color making them almost colorless [3]. The physical process behind this color conversion is the aggregation of single nitrogen atoms (C-defects) into complexes, the major of which are A-defects. Further aggregation into B-defects and N3 defects may occur too. The temperature of treatment must be high enough (well above 1700°C) in order to facilitate diffusion of nitrogen, whereas the applied pressure must be sufficient to prevent excessive graphitization (over 5 GPa). HPHT annealing, in particular a long time annealing, is a complex procedure, which requires bulky and expensive equipment as well as highly experienced personnel.

An alternative to HPHT treatment is the annealing without pressure in vacuum, inert gases, or hydrogen – so-called low pressure high temperature (LPHT) treatment. LPHT method is technically much simpler than HPHT technique and can be considered as an affordable alternative. LPHT has not been widely used yet, thus no systematic studies of LPHT-annealed diamond have been performed. A few reports are those on reduction of brown color in natural and CVD diamonds [4-7], as well as on reduction of yellow color of synthetic type Ib diamond after LPHT annealing [8, 9].

The aim of the present communication is to report on the influence of LPHT annealing on the cathodoluminescence properties of synthetic HPHT-grown diamond.

2. Experimental

The samples used in this research were a few millimeter size plates cut from yellow single crystal synthetic diamonds (trade mark "Almazot", manufactured by company ADAMAS BSU, Belarus). The plates were prepared by conventional mechanical polishing. The diamonds were synthesized by temperature gradient method in C-Fe-Ni melt at temperature 1350-1450°C and pressure 4.5-5.0 GPa for 60-70 hours [10]. The metal composition was 70 wt. % of iron and 30 wt. % of nickel. Average concentration of nitrogen in the diamonds, calculated from IR absorption spectra [8, 9], was about 200 ppm and the average concentration of nickel, calculated from the ESR spectra [10], and was about 30 ppm. Although the distribution of these impurities is very nonhomogeneous, the information on the average concentration is useful to get an idea on the impurity content of the growth medium. Actual concentration of N and Ni is higher around the seed than at the periphery. Specifically, the total concentration of nitrogen in the central area of crystal and its periphery is about 220 and 150 ppm,