Optical properties of Nd$_x$Gd$_{1-x}$Al$_3$ (BO$_3$)$_4$ crystal

TIAN Lili$^1$, WANG Jiyang$^1$, WEI Jingqian$^1$, PAN Henfu$^1$, GUAN Qingcai$^1$, HU Xiaobo$^1$, LIU Yaogang$^1$, C. Q. Wang$^2$ and Y. T. Chow$^2$

1. State Key Laboratory of Crystal Materials, Shandong University, Jinan 250100, China; 2. City University of Hong Kong, Hong Kong, China

Abstract  The optical properties of Nd$_x$Gd$_{1-x}$Al$_3$ (BO$_3$)$_4$ (NGAB) crystal are reported. The refractive index of it were measured by V-prism method. The absorption spectra and the fluorescence spectra of NGAB were also obtained. The optical parameters of NGAB were calculated following J-O theory, the three optical parameters are $\Omega_2 = 1.805 \times 10^{-20}$, $\Omega_4 = 1.85 \times 10^{-20}$, $\Omega_6 = 3.793 \times 10^{-20}$ (RMS = 1.4 $\times 10^{-7}$) and $\beta_6$ ($^4_{3/2} \rightarrow ^4_{1/2}$) is about 0.53.

Keywords: NGAB crystal, optical properties, crystal, laser, NGAB.

Now the lasers are smaller, more effective and more functional. So the study on self-frequency-doubling crystals attracts much attention. Nd : MgO : LiNO$_3$ crystal and Nd$_x$Y$_{1-x}$Al$_3$ (BO$_3$)$_4$ (NYAB) crystal are two of the most important self-frequency-doubling crystals, but they have
some disadvantages which hinder their applications\textsuperscript{[1, 2]}. For the purpose of overcoming the difficulty in the growth of NYAB crystal, people made much effort to explore new host and new dopants in NYAB system crystals. Compared with \(Y^{3+}\), the ion radius of \(Gd^{3+}\) is closer to that of \(Nd^{3+}\), and therefore it is expected that \(Nd_{x}Gd_{1-x}Al_{3}(BO_{3})_{4}\) (abbreviated to NGAB) crystal should have less structure distortion and it should be easier to grow it into high quality crystal. So these years see great interest in NGAB crystal. But there has been no report on the optical qualities and optical parameters of NGAB crystal in detail so far. This note reports the absorption spectra and fluorescence spectra of NGAB crystal at room temperature and the calculation of the optical parameters of \(Nd^{3+}\) in NGAB crystal following J-O theory.

1 Crystal growth

NGAD is an incongruent melt crystal. We chose \(K_{2}Mo_{3}O_{10}\) as flux. A small amount of excessive \(B_{2}O_{3}\) can enhance the solubility of NGAB. PbO and PbF\(_{2}\) were used to make the solution stabler. The raw materials were \(Gd_{2}O_{3}\), \(Nd_{2}O_{3}\), \(Al_{2}O_{3}\), \(B_{2}O_{3}\), \(MoO_{3}\), \(K_{2}CO_{3}\), PbO and PbF\(_{2}\) of high purity. The chemicals were weighted according to the chemical reaction equations.

In this experiment, crystal growth was carried out in a vertical tubular muffle furnace. The raw materials were contained in a 60 mm \(\times\) 70 mm platinum crucible positioned at the center of the furnace. After determining the saturation temperature exactly by seed testing, the seed with high quality was inserted into the solution at 10—15°C above the saturation temperature, then the temperature was rapidly cooled down to the saturation temperature and maintained at that temperature for 20 h. During growth the crystal was rotated at a rate of 30 round/min and the solution was cooled at a rate of 0.4—4°C/d. After 45—55 d, growth, the crystal was pulled off from the solution and cooled down to room temperature at a rate of 300°C/d. Partly transparent and complete cm sized NGAB crystals were obtained\textsuperscript{[3]}.

2 Absorption spectra of NGAB crystal

Using a Hitachi-340-UV-VIS spectrophotometer, we measured the absorption spectra of NGAB crystal at room temperature. The result is shown in figure 1.

![Absorption spectra of NGAB crystal at room temperature.](image)