Crystal Growth and Second Harmonic Generation of $YCa_4O(BO_3)_3$

YCa4O(BO3)3 단결정 성장 및 2차고조파 발생

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The properties for self-frequency doubling (SFD) is unique phenomena for a small number of special single crystals. It is known that there are serious limitations to vary the concentration of active ions, for example high doping of active ions from 1 to 50 atomic %, in nonlinear materials. Until now, the Nd:$YAl_3(BO_3)_4$ (YAB) and Nd:(Ce,Gd)$Sc_3(BO_3)_4$ (CSB) crystals with high doping rates are well studied for the application of SFD purpose. They have much useful SFD properties, but also have big problems in crystal growth. In case of YAB crystal, it can be grown by solution melt method with very low growth rates and easy occurrence of inclusions. In case of CSB crystal, it has optically heterogeneity problems because of disarrangement of ions in huntite structure [1]. These problems make above crystals not so attractive for optical applications. Some popular nonlinear materials, such as $LiNbO_3$ (LN), $KTiOPO_4$ (KTP), LiB_3O_5 (LBO) crystals, are impossible to substitute by Rare Earth activators because of their crystallo-chemical problems of structure. When we dope active ions with the requisite concentrations for laser generation, it results in decreasing of optical quality of crystals or destroying of acentrosymmetric structure. [2] From this point of view, new nonlinear crystal $YCa_4O(BO_3)_3$ (YCOB) is perspective material for SFD and for second harmonic generation (SHG). By our experiences, the maximum substitution and concentration for yttrium sites in YCOB by Yb^{3+}, Nd^{3+}, Er^{3+} ions has about 25 atomic % and about 1.1 x 10^{21} cm^{3}, respectively. Further more, YCOB has monoclinic with negative biaxial structure, with broad transparency toward the ultra violet range, with high damage threshold and with nonhygroscopic properties. The aim of this study is to grow pure YCOB crystal and to check the SHG properties of our crystal.

The pure YCOB crystal was grown by the Czochralski method using Iridium crucible with the size of 50mm in diameter and 50 mm in height. $CaCO_3$, B_2O_3 and Y_2O_3 powders with 99.99 % of purity were used as raw materials. The N_2 gas with rate 2.5 l/min was continuously blown to form growth atmosphere. The seed crystal oriented in <010> direction with the dimension of 4 x 4 x 20 mm was used. The pulling and rotation rates to get high quality of single crystal were 1.5 mm/h and 20 rpm respectively. The diameter of grown crystal is 18 mm and the length 90 mm. (Fig.1.)

The cubic with 5.46 mm in each edge was cut from the grown YCOB crystal. And it was prepared with the y-axis phase matching direction for I-type interaction SHG. And then the both of end faces were precisely polished. The I-type phase matching angle for SHG (o+o->e) in YCOB was theoretically calculated to be θ = 32.32° and φ = 0° in the xz plane using of Sellmeier's equations reported by Mori [3]. The measurement of phase matching properties were performed with

Q-switched Nd:YAG laser operated at 5 Hz of repetition rate and 10 ns of pulse width. The cubic crystal was rotated to fit the incident polarization beam for efficient conversion. The experiment was done at the room temperature. The variation of SHG output power of YCOB crystal is shown in Fig. 2. The calculated SHG conversion efficiency of YCOB crystal was larger than 10%.

During this study, we can grow YCOB crystal with high optical quality. The present work shows YCOB is promising nonlinear crystal. And also we can checked that our crystal can be used for SHG purposes.

References:

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Fig. 1. Photograph of grown YCOB single crystal.

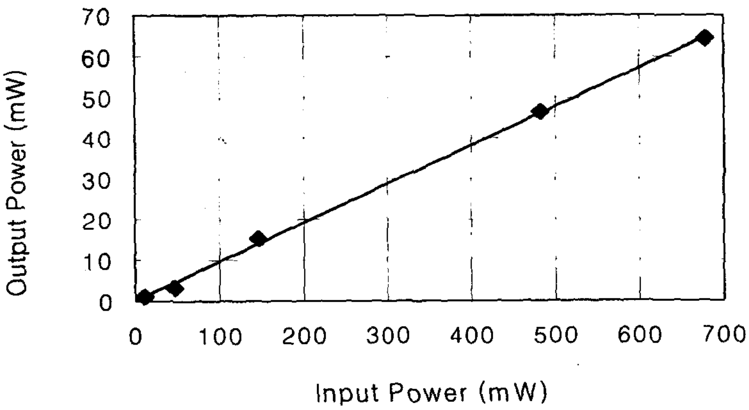

Fig. 2. The variation of SHG output power of YCOB crystal.