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The correlation between optical properties and electrical properties of $CsLiB_6O_{10}$ crystal

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1. Introduction

Cesium lithium borate ($CsLiB_6O_{10}$, CLBO) crystal is an excellent nonlinear optical (NLO) crystal for generating deep ultraviolet (DUV) laser. The DUV laser using CLBO crystal has a wide range of application such as semiconductor mask inspection and material processing. However, the UV-induced damage which will shorten the lifetime of CLBO crystal limits its application in comparatively high output power. In previous study, we have already found that water impurities inside the crystal is one of the reasons to cause the UV-induced degradation of the crystal [1], and we also found that Al-doped CLBO crystal has a high resistance to UV-induced degradation [2]. On the other hand, it has been reported that the optical damage resistance of NLO materials (e.g., $LiNbO_3$, $KTiOPO_4$) is strongly influenced by their electrical properties as well [3, 4]. Hence, it is worthwhile to study the correlation between the electrical characteristics and the UV-induced degradation of CLBO crystal.

2. Experiment and results

In this study, two types of CLBO crystals were prepared. One is non-doped CLBO crystal which is grown using SS-TSSG method from a self-flux [5]. The other one is Al-doped CLBO crystal with the aluminum concentration of 700 ppm by weight. The as-grown crystals were cut to the *a* and *c* crystallographic axis, respectively. Au electrodes were coated on both surfaces of the samples. Some CLBO crystals were preheated at 150°C - 160°C for 16h – 36h in order to remove the water impurities.

The temperature dependence of dark conductivity (DC conductivity) of the crystals was shown in Fig. 1. This measurement was carried out in a temperature range from 132℃ to 157℃. Also, because of the water impurities inside the crystal, a preheating process was done in order to obtain the intrinsic dark conductivity of the crystals. As shown in Fig. 1, the dark conductivity of Al-doped CLBO along the *a*-axis is by one order of magnitude larger than that of *c*-axis and non-doped CLBO crystal. Anisotropic dark conductivity was observed only in Al-doped CLBO crystal.

Impedance analysis of CLBO crystals was also investigated using impedance analyzer. As shown in Fig. 2 non-doped CLBO and Al-doped CLBO have the same impedance value before preheating. After a preheating process, the intrinsic impedance value of Al-doped CLBO without water impurities is large by more than one or two order of magnitude compared with non-doped CLBO.

Mg-doped LN crystal with large dark conductivity has high threshold to light-induced damage [4], and this phenomenon is similar with the Al-doped CLBO crystal [2]. Thus it is considered that the larger the dark conductivity is, the higher the resistance to UV-induced degradation is.

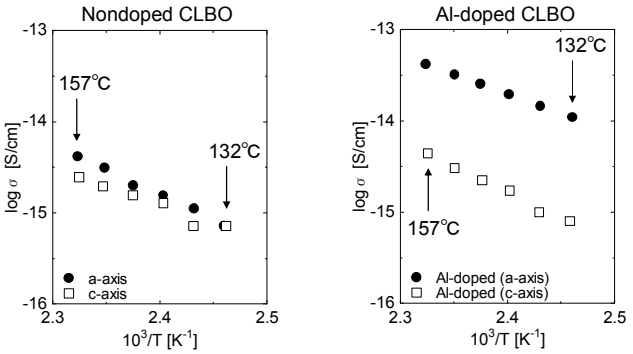

Fig. 1. Temperature dependence of dark conductivities of CLBO crystals.

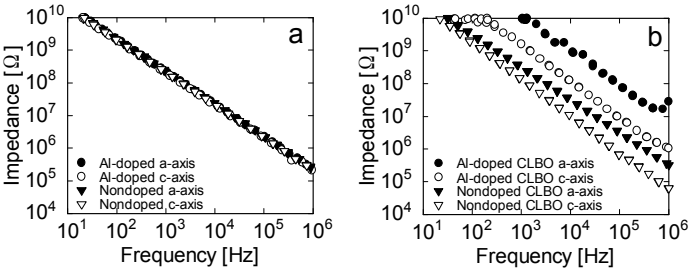

Fig. 2. Impedance analysis of CLBO crystals at room temperature; (a) as-prepared, (b) with a 36-hour preheating treatment at 150℃.

3. Conclusions

Electrical properties of Al-doped and non-doped CLBO crystals were investigated in this study. Anisotropic electrical properties were found in Al-doped CLBO crystal. It might be related to the high resistance to UV-induced degradation.

References

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