CFG3 11:00am

Long-term operation of $CsLIB_6O_{10}$ crystal in fourth-harmonic generation of Nd:YAG laser

K.Deki, Y.Kagebayashi, N.Kitatochi, Y.Ohsako, M.Horiguchi, Y.K.Yap,* Y.Mori,* T.Sasaki,* K.Yoshida,** *Tsukuba R&D Laboratory, Ushio Research Institute of Technology Inc., 5-2-4 Tokodai, Tsukuba 300-26; Email: dekikic@mail.ushio.co.jp*

Long-term operation of fourth-harmonic generation by CLBO was evaluated by two types of lasers. One type of laser produces a high peak power beam at low repetition rate, and the other type of laser produces low peak power but can run at a high repetition rate.

Using the high peak power laser, more than 1000 h of stable operation was observed as shown in Fig. 1. A group of microdamages resembling the incident beam was observed at the back surface of the CLBO, and the small decrease in output was attributed to it.

The Microdamages study showed that ion beam etching of CLBO surface was effective in avoiding the damage. When the etching depth was, e.g., 250 Åno power decrease, and no group of microdamages was recognized at the end of test (after 160 h operation).

In the experiment using the low peak powerlaser, strong focusing was required for effective harmonic generation. When a 532-nm incident beam was focused with an f =100 mm spherical lens to a CLBO, the output power decreased drastically to <50% of the initial power during 15 h of irradiation at room temperature. Although no surface damage was observed in this case, the output beam profile was distorted as the output power decreased. These results lead to speculation that the refractive-index change occurred in the focused area of the CLBO.

As Fig. 2 shows, we observed the abrupt refractive-index change using an optical heterodyne method with a frequency-stabilized transverse Zeeman laser as a probe beam.

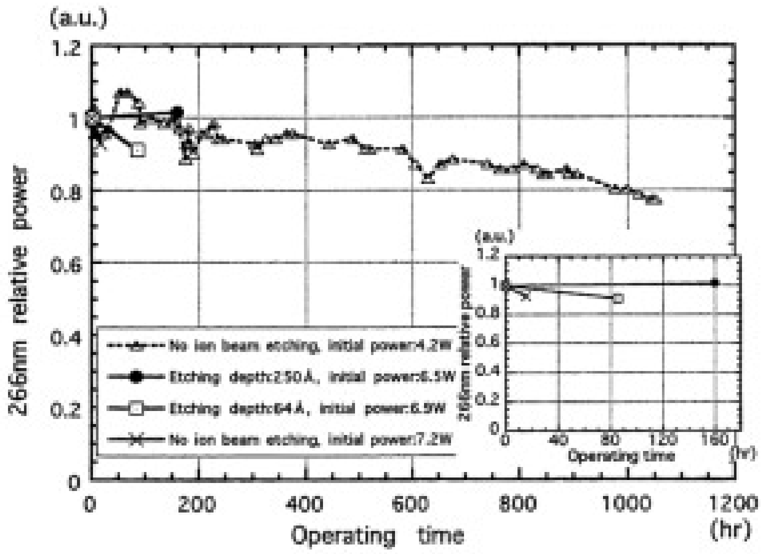
Because the optical heterodyne signal is proportional to the difference of the refractive index between the ordinary and extraordinary waves at the phase-matching direction, the refractive-index change can be the phase-retardation change in the focused region. Therefore, this is considered to be direct evidence of refractive-index change.

When the angle of incidence was detuned from the phase-matching angle to eliminate the fourth-harmonic generation, such retardation change was not observed even though the same amount of focused beam at 532 nm was input to the crystal more than 15 h. Therefore, we can conclude that this refractive-index change was caused by selfheating of CLBO by absorbing 266-nm light.

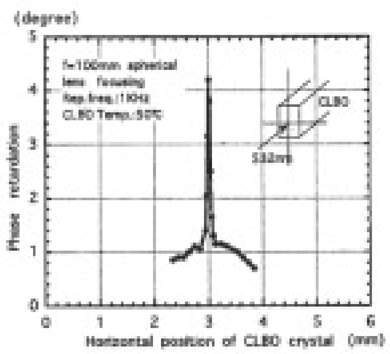
Figure 3 shows the methodology of CLBO for fourth-harmonic generation. Although reported earlier about the necessity of using CLBO at an elevated temperature (> 130℃, it is also important to use CLBO at reduced 266-nm average power density below 2KW/ cm² in order to avoid drastic decrease of output power. Below this density, no refractive-index change was observed.

**Department of Electrical Engineering, Osaka University, 2-1 Yamadaoka, Suita, Osaka 565, Japan*

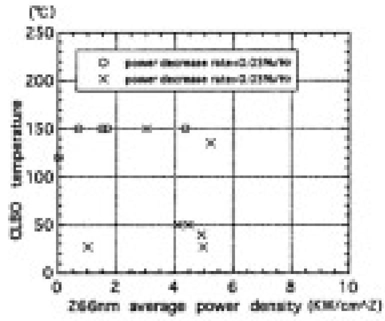
***Department of Electronics, Osaka Institute of Technology, 5-16-1 Ohmiya, Asahiku, Osaka 535, Japan*



CFG3 Fig.1. 266-nm average output power vs. operating time. CLBO temperature was elevated to 120℃ ,and high-purity nitrogen gas was flowed around the crystal at the rate of 0.7L/min to prevent CLBO surface from moisture.



CFG3 Fig.2. Phase retardation at 633 nm in the CLBO vs. horizonal prosition.



CFG3 Fig.3. relation of266-nm power density and temperature at CLBO with respect to avobe and below 0.03%/h of decrease rate.

参考資料

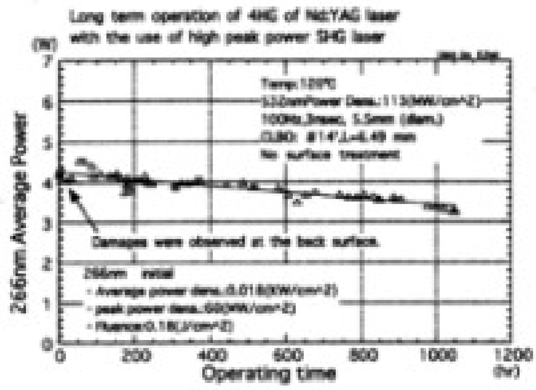
1.Introduction

- CsLiB6O10(CLBO) is a powerful nonlinear crystal for UV coherent light generation.
- Using CLBO
  Nd:YAG 4th harmonics : 10W,
  Nd:YAG 5th harmonics : 4W,
  192nm SFM　　　　: >200mW
- Long term operation study of CLBO is another important subject.

  Two types of Nd:YAG SHG(532nm) Lasers were used for the Experiment.

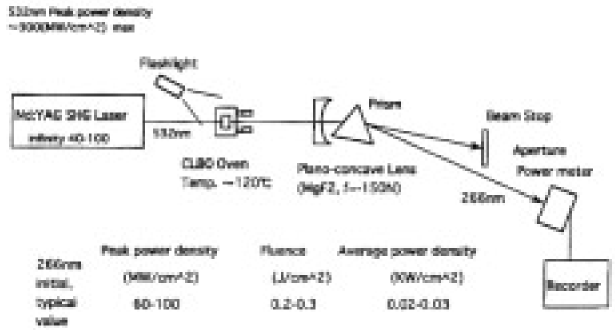
  (1) High Energy, Short pulse width, Low Rep.Rate
  (200mJ/pulse)　(3nsec)　　　　(100Hz)

  (2) Low Energy, Long pulse width, High Rep.Rate
  (0.9mJ/pulse)　(40nsec)　　　(1KHz)

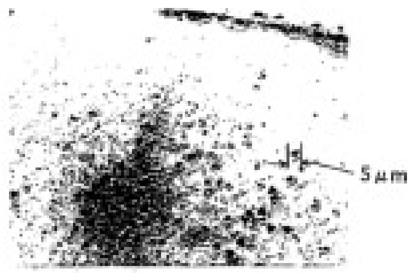


Experiment 1

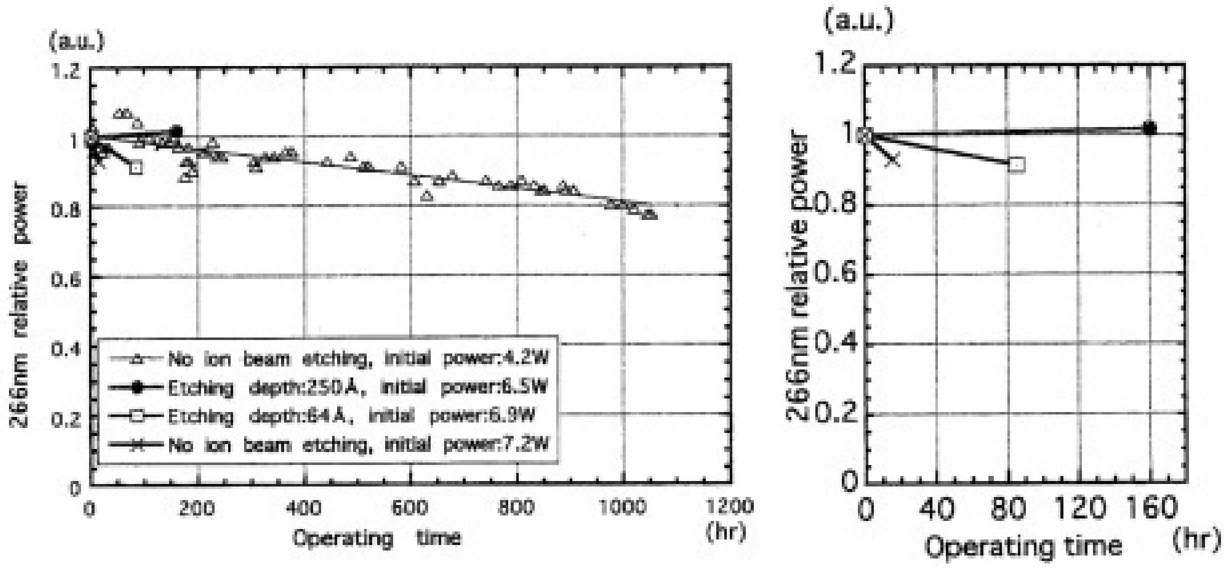
Using high energy, short pulse width, low rep.rate laser



Microscopic photograph of surface damage of CLBO



photographed by Prof.Komatsu Tohoku University

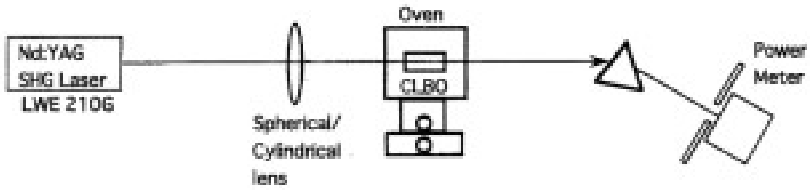


参考資料

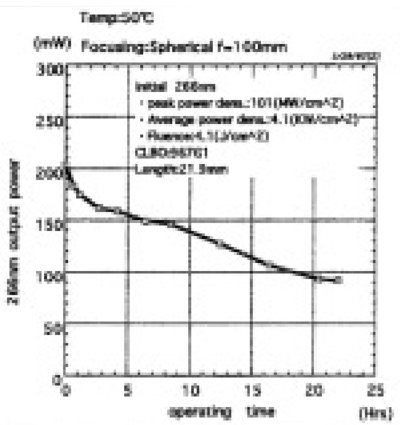
Experiment 2:

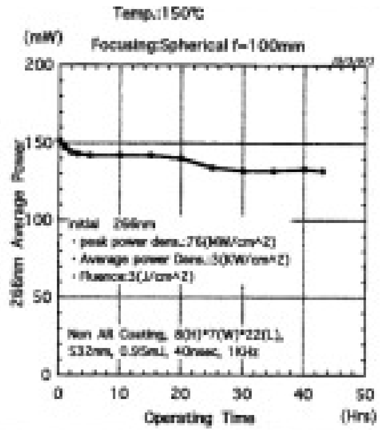
Using low energy, long pulse width, high rep.rate laser
(0.9mJ/pulse) (40nsec) (1KHz)

532nm peak power density without focusing: ~4.5(MW/cm^2)

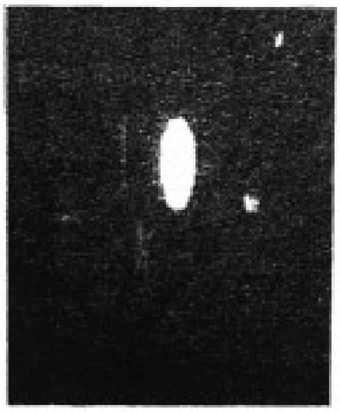


266nm initial values; e.g. f=100mm spherical lens focusing	Peak power density (MW/cm^2)	Fluence (J/cm^2)	Average power density (KW/cm^2)
	130	5	5

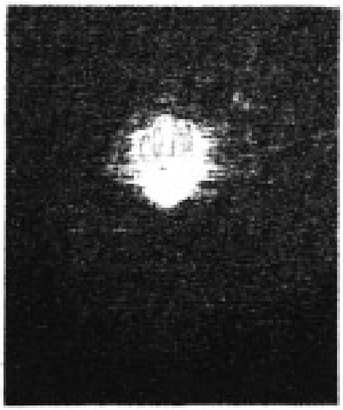




266nm光のビームパターン

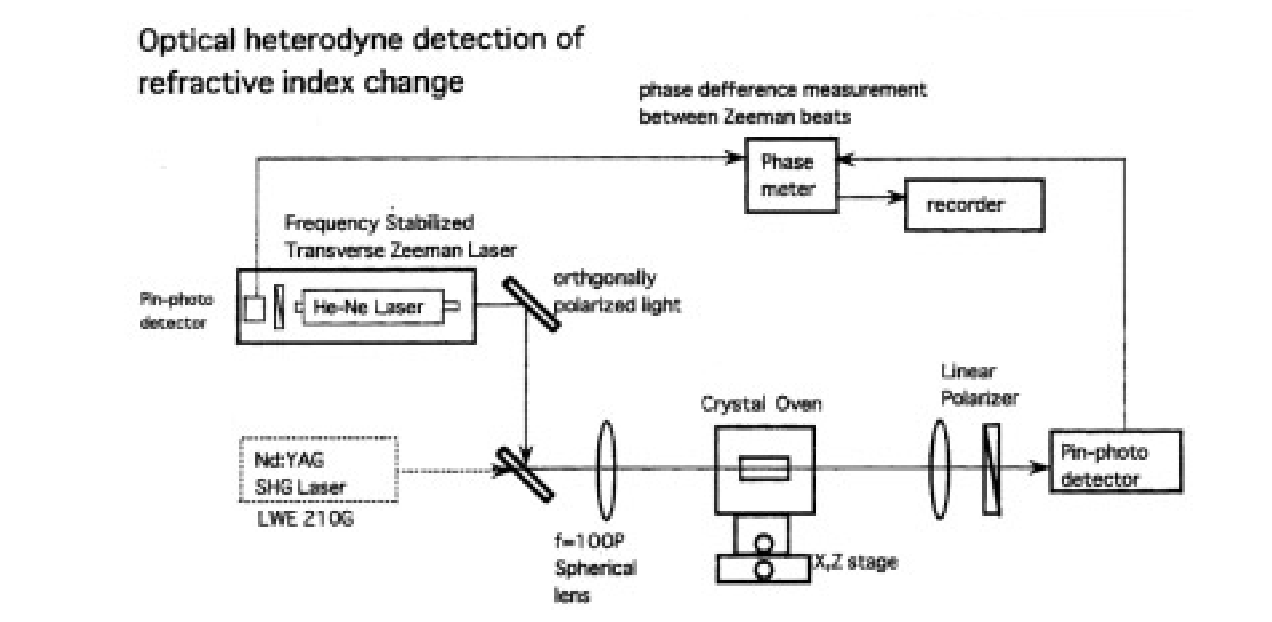


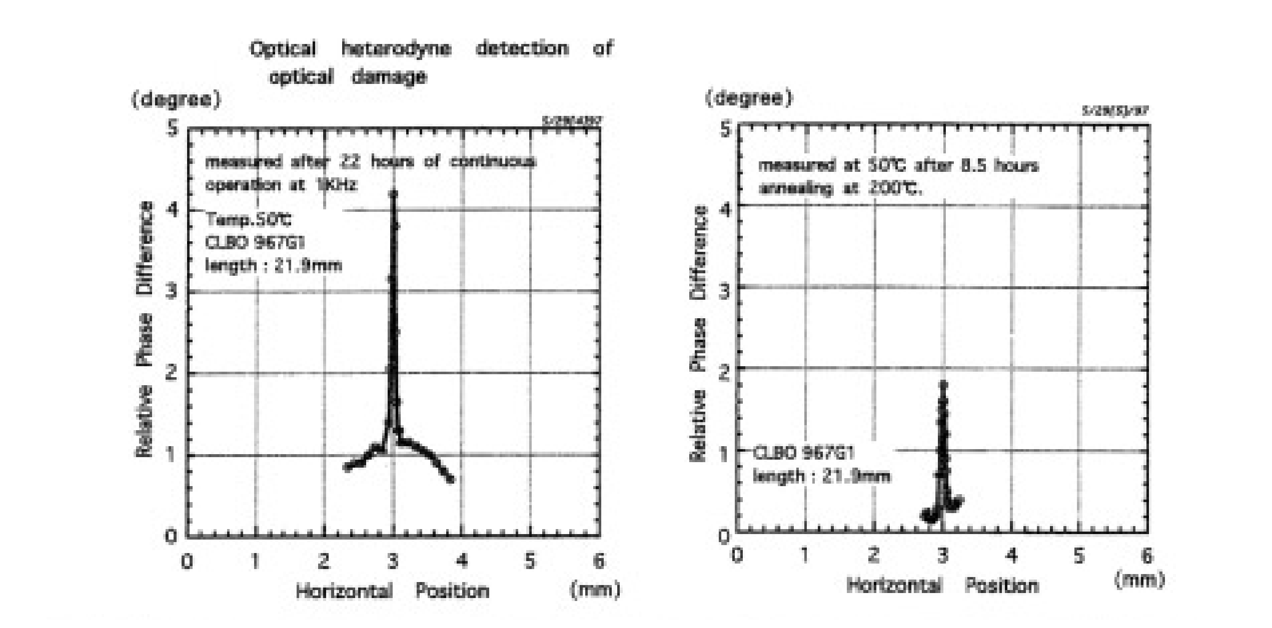
テスト開始直後

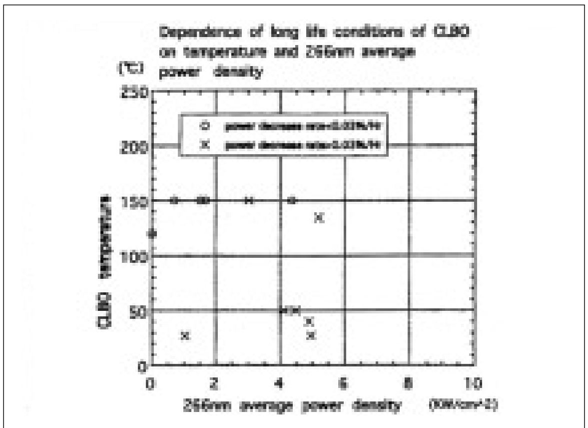


出力半減後

参考資料







Conclusion

Long term operation of CLBO in 4HG of Nd:YAG laser was evaluated by two types of lasers.

By using high peak power laser,

・More than 1000 hours operation was performed with no signifcant power decrease.
・The decrease of output power was attributed to damages of the back surface.
・Ion beam etching of CLBO surface was effective to prevent CLBO from the surface damages and stable long term operation.

By using low peak power laser,

・Strong focusing caused refractive index change in focused region of CLBO.
・The refractive index change was caused by self heating of CLBO by absorbing fourth harmonic light.

The conditions for the stable long term operation of CLBO in the 4th harmonic generation are as follow:

・etching CLBO surface untill the embedded polishing compounds are removed completely
・using CLBO at reduced fourth harmonic average power density below 2KW/cm^2
・elevating CLBO temperature mofe than 150℃.