Laser induced damage threshold measurements of bonded single and poly-crystalline Nd:YAG gain medium

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The development of petawatt (PW) laser systems allow scientists to bring the cutting-edge research around the globe [1]. But it also introduces various challenges for those who develop high power systems. One of which is to improve the material quality to withstand the high peak powers reached during the laser operation. The laser crystal growth quality and preparation procedures could play an important role in high power laser operations. Various defects inside the bulk of a crystal or dust particles on the surface could initiate the crystal damage. The consequence of it could be critical and costly for the entire laser system. One of the components for PW laser is the Ti:sapphire amplifier system comprised of high energy nanosecond pump source. The pump source itself is made of an amplifier system consisting either of a slab [2] or of thin-disk crystals [3]. We propose to implement the distributed face cooling (DFC) approach. By periodically bonding Nd:YAG gain medium to sapphire crystal we can operate at room temperature. The heat generated inside the gain media would be removed effectively through the surface of a sapphire crystal. By use of two 21-crystal DFC chips in the main amplifier, 2 J operation at 25 Hz repetition rate was achieved [4]. Because the system consists of multiple bonded interfaces, concerns regarding high power operation could arise and comparison between the bonded interface and bulk crystal damage is required. In addition, it is unclear if lower damage threshold of a crystal surface would affect the bonded interface.

In this work, for the first time we have evaluated the interface damage of crystals bonded by the SAB method: single crystal and poly-crystalline Nd:YAG and compared it to the surface and bulk threshold values. For this experiment, sub-ns passively Q-switched Nd:YAG gain aperture microchip laser [5] operating at 1064 nm wavelength and 100 Hz repetition rate was used with 5 mJ pulse energy, 590 ps duration and $M^2 < 2$. The beam was focused to waist diameter of 24 µm by using a 19 mm plano-convex lens. Tight focusing is used in order to increase the beam divergence and prevent crystal surface damage during bonded interface measurement. For the laser induced damage threshold we implemented a “500-to-1” method and used mechanical shutter to facilitate the measurement. The shutter was opened for 5 seconds in order to provide 500 pulses required for the test. After including the self-focusing correction, the bulk fluence values for single crystal and poly-crystalline Nd:YAG were equal to 161.2±2.1 J/cm^2, 123.9±1.9 J/cm^2, respectively. During experiment, the damage fluence of bulk and bonded interface did not degrade for the both types of Nd:YAG material and it is suitable for the high power laser operation (Fig. 1).

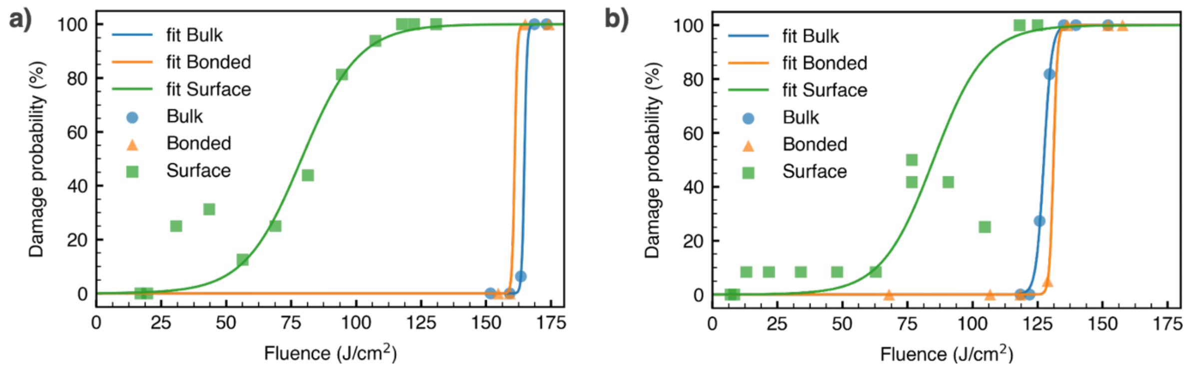

Figure 1. Experimental results for the damage threshold experiment of Nd:YAG single crystals (a) and polycrystalline Nd:YAG ceramics (b) with 590ps microchip laser.

This work was partially supported by JST-Mirai Program Grant Number JPMJMI17A1 and Innovative Science and Technology Initiative for Security Grant Number JPJ004596, ATLA, Japan

References

1. A. J. Gonsalves, K. Nakamura, J. Daniels, C. Benedetti, C. Pieronek, T. C. H. De Raadt, S. Steinke, J. H. Bin, S. S. Bulanov, J. Van Tilborg, C. G. R. Geddes, C. B. Schroeder, C. Tóth, E. Esarey, K. Swanson, L. Fan-Chiang, G. Bagdasarov, N. Bobrova, V. Gasilov, G. Korn, P. Sasorov, and W. P. Leemans, Phys. Rev. Lett. **122**, 84801 (2019).
2. M. Divoký, J. Pila¥vr, M. Hanuš, P. Navrátil, O. Denk, P. Severová, P. Mason, T. Butcher, S. Banerjee, M. De Vido, C. Edwards, J. Collier, M. Smrž, and T. Mocek, Opt. Lett. **46**, 5771 (2021).
3. J. Ogino, S. Tokita, S. Kitajima, H. Yoshida, Z. Li, S. Motokoshi, N. Morio, K. Tsubakimoto, K. Fujioka, R. Kodama, and J. Kawanaka, Opt. Lett. **46**, 621 (2021).
4. A. Kausas, R. Zhang, X. Zhou, Y. Honda, M. Yoshida, and T. Taira, in *Laser Congress 2020 (ASSL, LAC) (2020), Paper ATu2A.2* (Optical Society of America, 2020), **2020**, pp. 2–3.
5. V. Yahia and T. Taira, Opt. Express **26**, 8609 (2018).

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