Laser-Induced Damage on Silica Glasses by Irradiation of Soft X-Ray Laser Pulses

K. Mikami[1], M. Ishino[1], N. Hasegawa[1], M. Nishikino[1], S. Motokoshi[2], T. Jitsuno[3], T. Kawachi[1]

[1]*Quantum Beam Science Center, Japan Atomic Energy Agency, Kizugawa, Kyoto, Japan*
[2]*Institute for Laser Technology, Nishi-ku, Osaka, Japan*
[3]*Institute of Laser Technology, Suita, Osaka, Japan*
**E-mail: mikami.katsuhiro@jaea.go.jp*

Abstracts: *Laser-induced damage thresholds (LIDT) on silica glasses were measured by pulse irradiation of soft X-ray laser (SXRL). Silica glasses are one of the typical materials in the field of near-infrared and visible laser systems, and output energy of the systems is limited by material's LIDTs. High-photon energy of the SXRL would have great potential to study with simple discussion for the laser-induced damage mechanisms. The LIDTs on silica glasses measured by 7-ps SXRL pulses are several dozen of mJ/cm^2 as the experimental results and the LIDTs will be discussed by a simple calculations.*

Output energies of the laser systems were limited by laser-induced damage thresholds (LIDTs) of the materials. Laser-induced damage mechanisms (LIDMs) of the materials are studying with various experimental and theoretical approaches to develop high-LIDT optics. However, the wide-bandgap of the materials is leading an extremely complex LIDM and there are a lot of suggested models [1]. In this study, LIDTs on silica glasses were measured by irradiation of soft X-ray laser (SXRL) pulses. Silica glasses are one of the typical materials in the field of near-infrared- and visible-laser systems. High-photon energy of the SXRL would have great potential to study with simple discussion for the LIDMs, in particular, a process of the initial free-electron generation is confined to only single-photon absorption.

As damage-testing laser, we used a fully spatial coherent SXRL generated by TOPAZ (Twin OPtical Amplifiers using Zigzag slab) laser system and the TOPAZ is operating with 0.1 Hz pumped by two 10 J, picosecond lasers [2,3]. The wavelength and pulse width of SXRL generated by TOPAZ were 13.9 nm and 7 ps, respectively. Optical polished fused- and synthetic-silica glasses were prepared as experimental sample and the contaminations including these glasses were greatly differing each other. The LIDTs were measured by 1-on-1, 5-on-1, and 10-on-1 damage testing methods.

The measured LIDTs on fused- and synthetic- silica glasses were several dozen mJ/cm^2 and the LIDTs of the synthetic silica glass was higher than that of the fused silica glass. In the case of the fused-silica sample, the LIDTs at 1-on-1, 5-on-1, and 10-on-1 damage testing were the same value but the damage probability was clearly different. The damage morphology of the fused silica glass was dotted with SXRL irradiation spot. The experimental results of the synthetic-silica glass was used to evaluate effects of the contaminations with comparing that of the fused-silica glass. Additionally, we calculated the LIDT with a simple model. The suggested model is including single-photon absorption and impact ionization processes.

[1] K. Mikami *et al.*, Opt. Express **21** (2013) 28719
[2] M. Nishikino *et al.*, Appl. Opt. **47** (2008) 1129
[3] Y. Ochi *et al.*, Jap. J. Appl. Phys. **48** (2009) 120212