Transactions of the Korean Nuclear Society Spring Meeting
Chuncheon, Korea, May 25-26 2006

Design and Development of 1 kJ Nd:Glass Laser Facility for the Basic Research on Quantum Engineering

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1. Introduction

The one of purposes of high energy lasers, such as NIF, LMJ, Gekko XII and Shen-Guang III, is to investigate the principles of high energy density plasma science [1-5]. The high density plasma produced by the high energy lasers has received vast attention due to its fundamental sciences and variety applications; laboratory astrophysics, the acceleration of high energy electron and proton, equation of state, and the fast ignition of inertial fusion research. The photo-nuclear radiation source by high energy laser opens a new science field of quantum engineering.

The Korea Atomic Energy Research Institute (KAERI) is developing a high energy Nd:Glass laser facility for the basic research of quantum engineering. KAERI laser facility (KLF) is based on the laser components of Gekko IV [6] which was transferred from Institute of Laser Engineering (ILE) Osaka University, December 2004. The system will deliver 4 beam lines with clear aperture of 100 mm and each beam will be more than 250 J at nanosecond regime. The laser system consists of an oscillator, two pre-amplifiers, four double-pass rod amplifiers and four phosphate glass disk amplifiers at the final stage. For a wide application of the system, we plan to build the laser system operated as a kilo-joule laser at nano-second or a hundred TW at pico-second.

The project is in collaboration with the ILE, Osaka University and LFRC, China. Combination of a nano-second high energy laser and a pico-second laser is expected to open a new physics area of high energy density plasma.

2. Optical layout

Re-modeling of the laser building has started in June 2005. The building presents about 480 m^2 of floor space on the ground level, reserved for the laser system and implosion chamber. The rooms on the ground level are equipped with class 10,000 clean rooms. For the cleaning of optical component and laser cavity assembly, a class 100 clean room, about 30 m^2 areas, is also situated on the first floor of the building. The foundation is 30 cm thick layer of concrete, which is separated from the building to avoid the vibration on the site. Capacitor bank and control room are located on the second floor of the building. A steel frame will serve to hold the optical components to provide a stable beam transport to implosion chamber room. The building re-modeling is expected to complete in March 2006.

In parallel to the building re-modeling, preparation of laser installation were made. The basic design of main amplifier was provided by ILE, Osaka University, Japan. A schematic of the 4 beam KAERI laser facility including implosion chamber is illustrated in Fig. 1.

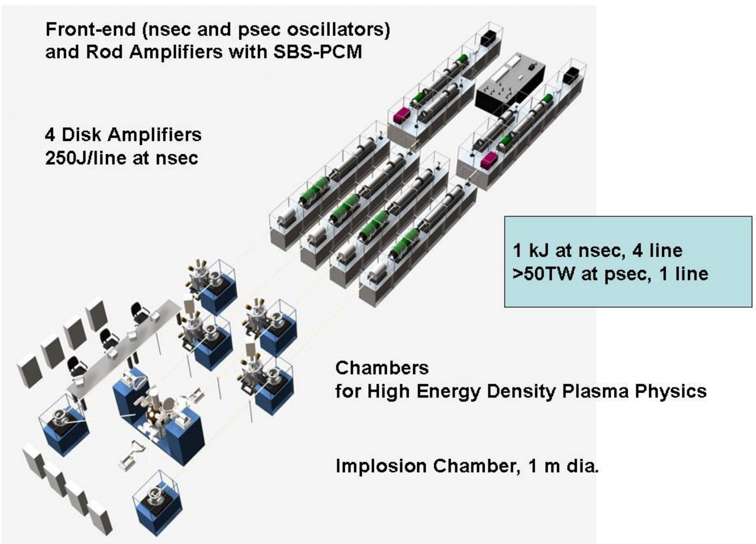

Figure 1. Sketch of KAERI laser facility (KLF).

The basic layout of KLF has been changed from the original single pass line to a SBS-PCM (Stimulated Brillouin Scattering - Phase Conjugated Mirror) double pass configuration. This change was motivated mainly by the recent experimental results of preliminary co-work of KAERI and ILE. In contrast to the conventional folding mirror, SBS-PCM can compensate the thermally induced phase distortion in high energy laser system. The heavy fluorocarbon FC-75 was used as a SBS medium, because of its excellent optical quality; low absorption in wide spectral regime from ultraviolet to infrared, high break down threshold (>100 GW/cm^2), good thermo-dynamic property and good chemical stability. The typical beam pattern reflected form SBS mirror has been compare with the input beam, single pass beam, and double pass reflected beam from conventional high reflection mirror. Near field burn pattern of each beam is illustrated in Fig 2. As shown in Fig. 2, the fidelity of SBS-PCM is much better than that of conventional mirror.

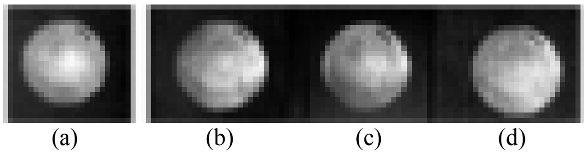

Figure 2. Near field patterns of laser beams (a) input beam, (b) double pass beam with SBS-PCM, (c) double pass beam with high reflectance mirror, (d) single pass beam.

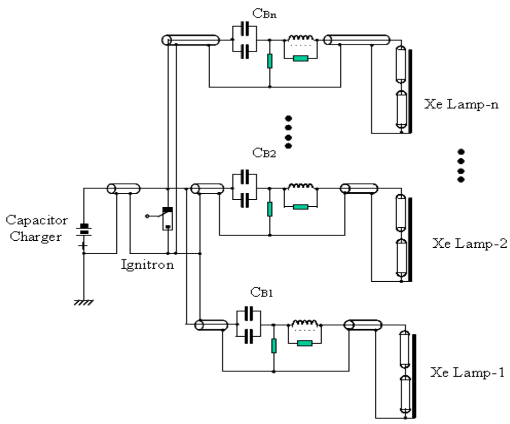

Figure 3. Pulse forming net work (PFN) for the discharge of flash lamp.

3. Pulse forming net work and controllers

The test of the pulsed power system for the main amplifier was performed with the set-up of the capacitor bank and switching mode power supplies (SMPS). The pulse forming network for the flash-lamp discharge is illustrated in Fig. 3. RG217/U coaxial cables are used to connect the capacitor bank to flash lamps. For energy storage 175 μF capacitors with nominal operating 5 kV are used for the two serial UXL-S300 flash lamps, manufactured by Ushio Electric Co. We tested the integrity of flash lamps and pulse forming network without Nd:Glass gain medium to avoid the thermal shock. Current and voltage sensor is preparing to monitor the status of each flash lamp.

New electronic modules based on the micro-processor, 16F74 Micro-chip, are developed to control the SMPS and ignitron switches and the monitoring of flash-lamp discharge. This new modules allows the remote computer control of power supply units, ignitron switches, and the monitoring of current of lamp, gas/water flow, temperature and humidity. The control signals between computer and micro-processor are delivered by optical fiber to avoid electrical noise from the discharge. We replace old laser controller into small board with enhanced functions.

A restructuring of implosion chamber with precision target alignment system is proceeding. The chamber is a 1 m diameter sphere with 16 flanges for lasers, target injection, and diagnostics.

4. Conclusion

The Korea Atomic Energy Research Institute (KAERI) is developing a high energy Nd:Glass laser facility for the basic research of quantum engineering. This laser consists of 4 beam lines with clear aperture of 108 mm and each beam will deliver more than 200 J at nanosecond regime. SBS-PCM was studied to improve the beam quality and energy of KAERI Laser Facility (KLF). All mechanical construction of target chamber will be finished in early 2006 and the installation of optical components including focusing mirror will be finished in 2006 summer.

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