Highly stable operation of regenerative amplifier for Table Top Terawatt Nd:glass laser system

Ultra-short laser pulses of energy several orders of magnitudes higher than that available directly from a mode locked oscillator, are required for many investigations and applications. Such pulses are amplified using the Chirped Pulse Amplification technique. In such a system, one stretches a short pulse in time by frequency chirping, amplifies the same and then recompresses it back to get an ultrashort, ultrahigh intensity laser pulse. A high gain preamplifier (generally a regenerative amplifier) is required to boost the seed pulse energy from a mode-locked oscillator of a few nJ level to tens of mJ level. A highly stable operation of this large gain amplifier is extremely important for a stable output of the compressed laser pulse. For the Table Top Terawatt Nd:glass laser system built at Laser Plasma Laboratory, a highly stable operation of the Nd:glass regenerative amplifier has been accomplished with a gain of 3×10^7 in 61 round trips with a shot-to-shot fluctuation in the output less than $\pm$ 5%.

The above amplifier is basically a flash lamp pumped cavity dumped injection Q-switched Nd:glass oscillator. It comprises of a pulse injector, a resonator cavity, and a pulse ejector. Two major factors which affect its output energy stability are: 1) gain fluctuations and 2) seed pulse energy fluctuation. Gain fluctuation changes the peak output energy and its temporal occurrence, and hence affects output energy. Fluctuations in injected pulse energy primarily change the intra-cavity peak pulse timing, which causes output pulse energy variations when the regen pulse is switched out at a fixed time. For flash lamp pumped systems (like ours), shot-to-shot output pulse energy is mainly limited by the gain (pump energy) fluctuations in the amplifier cavity. Two techniques for energy stabilization namely, negative feed back system and cavity dumping at a fixed energy rather than at a fixed time, are mostly used. All these techniques have their own limitations. We have therefore studied the stability condition both, theoretically and experimentally, considering various sources of fluctuations in gain and losses in the amplifier. Typical pulse build-up and decay in the regen cavity for different seed pulse energies and pump energies are shown in the figures 1 and 2. The output energy fluctuations are found to be reduced by factor of 10 by ejecting the amplified pulse with delay of 5 round trips after the pulse has built up to its peak level. The experimental results were found to be in close agreement with the simulation results. This stable amplification via interplay between the gain and loss of amplifier is advantageous in terms of less complexity and minimum material dispersion in the amplifier compared to using additional control circuitry or active stabilization mechanism.

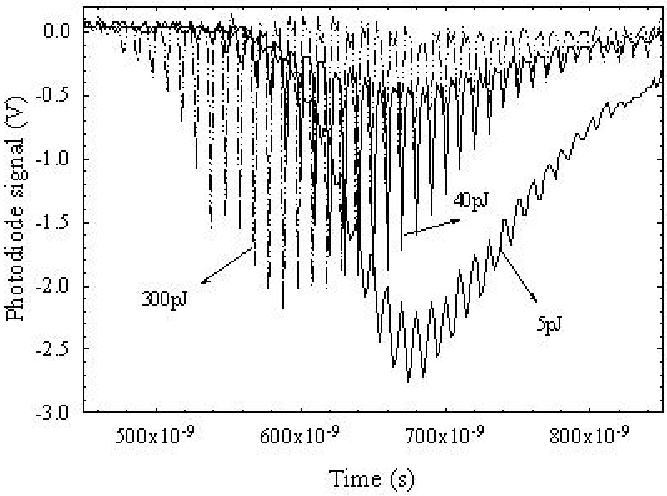

Fig.1 :Pulse build-up and decay in the regen cavity for different *seed pulse* energies

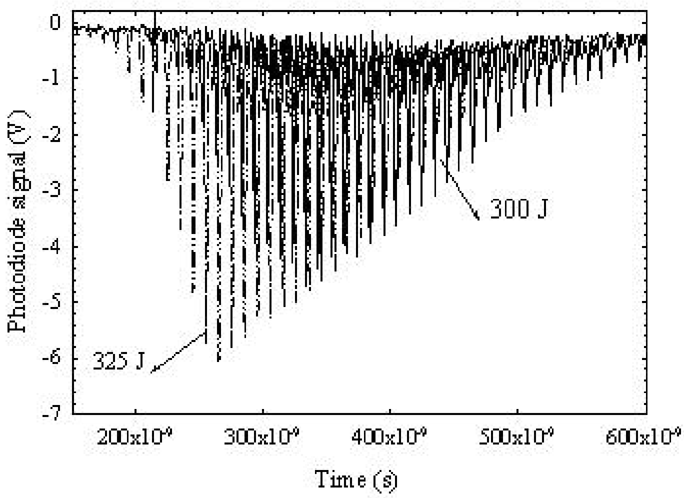

Fig.2 : Pulse build-up and decay in the regen cavity for different *pump* energies

Reference:

1) Characteristics of a stable injection Q-switched Nd:phosphate glass regenerative amplifier for a chirped pulse amplification based table top terawatt laser system
A.K.Sharma, M.Raghuramaiah, K.K.Mishra, P.A.Naik, S.R.Kumbhare, and P.D.Gupta
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