and then recompresses it back to get an ultra short, 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 Division, a highly stable operation of the Nd:glass regenerative amplifier has been accomplished with a gain of $3x10^7$ in 61 round trips with a shot-to-shot fluctuation in the output less than ± 5%.

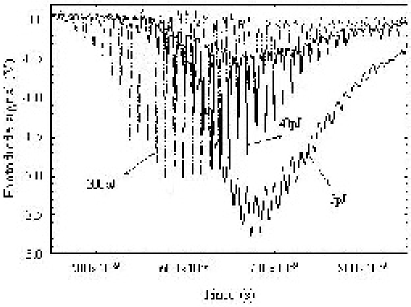

Fig. L.6.1 *Pulse build-up and decay in the regenerative cavity for different seed*

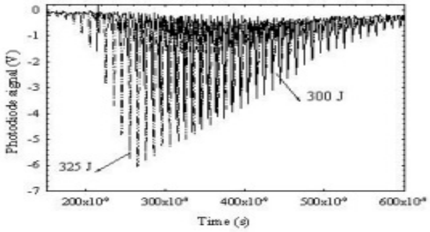

Fig. L.6.2 *Pulse build-up and decay in the regenerative cavity for different pump energies*

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 regenerative 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 regenerative cavity for different seed pulse energies and pump energies are shown in the fig. L.6.1 and fig. L.6.2. 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 [for details see: *A. K. Sharma, M. Raghuramaiah, K .K. Mishra, P. A. Naik, S. R. Kumbhare, and P. D. Gupta, Opt. Commun. 252, 369, 2005*]. 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.

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L.7 Laser light scattering and x-ray emission from laser heated gas clusters

Interaction of intense laser pulses with atomic clusters of noble gases is of considerable scientific interest and has technological applications, such as, production of high-energy electrons and ions, intense x-ray emission etc. These targets, while retaining the advantages of an overall low-density gas and debris-free operation, offer very high local (solid) density, leading to strong laser heating. The dynamics of laser driven cluster explosion determines the details of laser coupling, which in turn affects the production yield of electrons, ions and x-rays. Optical scattering from these cluster plasmas is an important means of characterizing the dynamics of laser-cluster interaction. Our experimental study on scattering of laser light from argon gas clusters irradiated by multi-picosecond Nd: glass laser pulses at a laser intensity of 10^{15} W/cm^2, and the x-ray emission from these clusters have yielded some interesting results and provided a better insight in to the dynamics of intense laser-cluster interaction.

Contrary to the expectation, the space-resolved side-scattered laser light was observed to have only a blue-shifted and broadened spectrum with no red component. Scattered signal intensity and average blue-shift exhibited marked dependence on backing pressure of the gas. At a backing pressure of 70 bar, the maximum blue shift is as large as 6 nm (see fig. L.7.1). The occurrence of large blue shift and absence of any red shift are explained from self-phase modulation accumulated by the laser radiation in its passage through the cluster plasma during resonance interaction phase in the vicinity of three times the critical density. To corroborate this hypothesis, the spectral shift of the laser light transmitted through argon cluster plasma was also studied. The transmitted laser light spectrum also showed blue shift only with some unshifted laser light (see fig. L.7.2). The blue shift was found to be consistent with the one observed in the side scattered light. This blue shift may be useful as a diagnostics for understanding the resonant interaction phase of laser-cluster interaction.

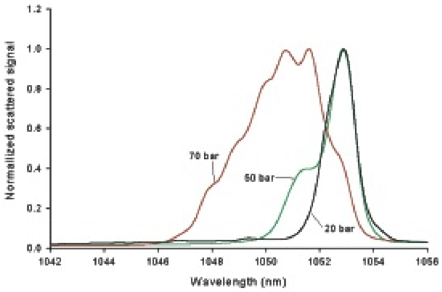

Fig. L.7.1 *Normalized spectra of scattered laser light from argon cluster plasma at different backing pressures*

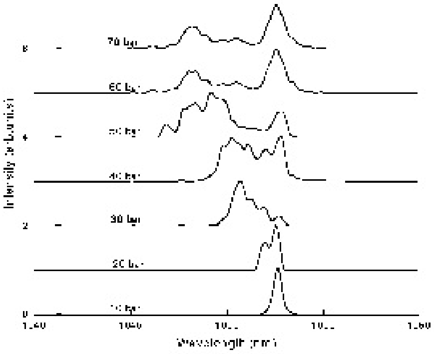

Fig. L.7.2 *Spectrum of the light transmitted through the cluster plasma at different backing pressures*

In addition, relative x-ray emission from nitrogen and argon gas clusters was also studied. High absorption of ~ 80% to 85% was observed for both the gases for pressures exceeding 35 bar. However, it was found that the x-ray line emission from argon clusters was about 40 times higher than in nitrogen clusters. This is explained to be due to formation of larger size clusters in the argon gas, which, after heating, take a longer time to expand and cool. [For details see : *S. Sailaja, R. A. Khan, P. A. Naik and P. D. Gupta, IEEE Transactions in Plasma Science 33, 1006, June 2005*].

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L.8 Setting up of an optical coating plant and some results

Thin film optical coatings play an important role in many areas of R&D. Coatings do have a shelf life and it is advisable not to stock them for long. The solution to these problems is to have a facility where various types of optical coatings as per the requirement can be carried out. We have installed a state of the art optical coating plant. The basic system was fabricated, assembled and computer automated by M/s Elettrorava, Italy as per our design and requirement. It is basically an ion-assisted electron beam and sputter deposition system for multilayer optical coatings. The system is equipped with two electron beam guns (each 10kW), two resistively heated sources (each 3 kW), two sputtering sources (one 600 W RF and one 1.5 kW DC) and one ion gun (40 – 210 eV, 0 – 1 A) with selection of the gas (O_2 and/or Ar) for ion-assisted deposition. Substrate rotation up to 30 rpm and heating up to 350 ^{o}C is possible during deposition. In-situ optical thickness monitor operating in both transmission and reflection modes in the wavelength range 300 to 1700 nm and quartz thickness monitors are used for layer termination. Glow discharge cleaning of the substrate can be carried out prior to deposition.

In a single evaporation run, 40 nos. each of 50 mm diameter and 60 nos. each of 25 mm dia. or 9 nos. each of 150 mm dia. or one substrate of 400 mm dia. can be coated. Very high thickness uniformity of ±5% is routinely attained on large size substrates. Simultaneous evaporation or simultaneous sputter deposition of multiple dielectric materials and metals are possible in the system. Substrate rotation during sputtering results in very high thickness uniformity (< 2%) on 150 mm diameter substrates. Fig. L.8.1 shows the view of the coating unit. The system can be utilized for large variety of dielectric and metallic coatings, e.g. antireflection coatings, highly reflecting coatings (dielectric and metal), broad band pass (>30 nm) and narrow band pass (<30 nm) filters, edge filters, beam splitters, neutral density filters, polarising coatings. A thin film characterization laboratory with the following instruments has also been developed:

1.Spectrophotometers: VARIAN CARY5000; Wavelength: 175-3300nm, Modes: Transmittance, specular reflectance, variable angle specular reflectance, diffuse reflectance and absorbance; VARIAN CARY50: Wavelength: 190-1100nm, fibre optic attachments for transmittance and specular reflectance measurements. 2. Abrasion Testing Kit: As per US MIL standards of abrasion, hardness and adhesion. 3. Scanning Probe Microscope (NT-MDT SOLVER PRO): Non-contact, contact, etc. 4. Variable angle spectroscopic ellipsometer (SOPRA): Wavelength: 240-1700nm, Angle of incidence: 20-90^{o}, Modes: ellipsometry (n, k & d) and inhomogeneity.