13.2 Performance Characteristics of the SAIL-1 Atomic Iodine Laser, T. D. Padrick, R. E. Palmer, M. A. Palmer and M. E. Riley, *Sandia Laboratories, Albuquerque, N. M. 87115*

(*15* min)

At present, CO_2 and atomic iodine are the only two lasers with demonstrated properties that make them candidates for a repetitively-pulsed laser fusion system. However, there are uncertainties for each of these lasers which must be evaluated to project large system performance. At Sandia, we are conducting experiments to evaluate properties of the atomic iodine laser pertinent to its possible use in a laser fusion system. The results presented below were obtained from the SAIL-1 facility, which consists of an actively mode-locked oscillator, a 1-cm diameter × 100-cm long preamplifier and a 7.5-cm diameter × 350-cm long final amplifier.[1]

The subnanosecond atomic iodine oscillator developed by Jones *et al.*[2] has been modified to produce pulses with more reliable beam quality. This is accomplished by pumping faster and allowing the oscillator to gain-switch 6 μsec after flash initiation. Therefore lasing occurs before the onset of the gas dynamic disturbance which occurs in the lasing volume at ~10 μsec after flash initiation. The beam profile was photographed 20 m from the oscillator and is nearly Gaussian with no hot spots. Also, data from a shearing plate interferometer indicate that there is no detectable phase distortion across the wave front and that the oscillator output is nominally diffraction limited. The reproducibility of the SAIL-1 oscillator (an important consideration for laser fusion) is good, approximately ±10% in amplitude and pulse width.

Temporal pulse distortion can occur in an iodine laser amplifier because of gain saturation and/or insufficient bandwidth for short pulse amplification. Data were obtained which demonstrate the range of pulse distortion versus bandwidth in an unsaturated amplifier. Working with sufficient bandwidth to give true pulse amplification, the pulse distortion due to gain saturation was characterized. In both cases, the data were used to check a computer code which models pulse propagation in an iodine amplifier.

Good beam quality and focusability are essential for laser fasion. In an iodine amplifier, the beam quality can be affected by gas dynamic disturbances or anomalous dispersion in a saturated amplifier. Using a shear plate interferometer amplified pulses from the preamplifier were found to have $<1/2$ wave phase distortion. Calculations indicate that this amount of phase distortion will not affect the focusability. In addition, data were obtained with the shearing plate interferometer for a saturated beam in the large amplifier. Also, the beam profile of the output from the large amplifier was photographed at various degrees of focus.

The efficiency of an atomic iodine laser is determined by the pump source, the coupling of the source to the laser medium, and by the energy extraction ability from both upper laser levels. The oscillator on the SAIL-1 system operates only on the $^2P_{1/2}(F = 3) \rightarrow {}^2P_{3/2}(F = 4)$ transition. Since collisional equilibration between the upper levels is slow,[3] pressure broadening (which causes the lines to overlap) is the only means of extracting energy from the $^2P_{1/2}$ $(F = 2)$ state with a single-line oscillator. Data obtained for the gain at high argon pressures is in agreement with calculations of the contribution from the $F = 2$ state. For maximum extraction efficiency, argon pressures in excess of 4000 torr are required. System optimization requires a compromise between efficiency and saturation flux.

The overall efficiency of the SAIL-1 final amplifier is ~.2%. Several areas of investigation[4,5] aimed at improving this efficiency will be discussed.

[1] R. E. Palmer, T. D. Padrick and E. D. Jones, *SPIE*, vol. 76, 1976.

[2] E. D. Jones, M. A. Palmer and F. R. Franklin, *Opt. Quant. Elect.*, vol. 7, p. 231, 1976.

[3] E. A. Yukov, *Sov. J. Quant. Electron.*, vol. 3, p. 117, 1973.

[4] M. A. Gusinow, *Opt. Commun.*, vol. 15, p. 190, 1975.

[5] R. E. Palmer, T. D. Padrick and R. B. Pettit, unpublished.

13.3 Rare Gas Halide Lasers—Pumping Technology (*Invited*), J. H. Jacob, J. A. Mangano and M. Rokni, *AVCO Everett Research Laboratory, Everett, Mass. 02149*

(*30* min)

No summary.

13.4 Amplification of UV Picosecond Pulses in High Pressure XeF Discharges, I. V. Tomov, R. Fedosejevs, M. C. Richardson, W. J. Sarjeant, A. J. Alcock and K. E. Leopold, *National Research Council of Canada, Division of Physics, Ottawa, Canada*

(*15* min)

In recent years the development of pulsed coherent light sources in the UV and VUV has advanced along two fronts: nonlinear upconversion of powerful picosecond visible or infrared laser pulses and the direct excitation of high pressure molecular and excimer lasers. The latter are intrinsically efficient, have high gain, and should be scalable. Unfortunately their present short gain duration (<50 ns) prevents the effective application of conventional mode-locking techniques for the production of ultrashort pulses. We report here the combination of the two above approaches by generating, for the first time, picosecond duration UV laser pulses through the amplification of third harmonic Nd:glass picosecond laser pulses in a high pressure XeF discharge.

The UV pulses were produced by conversion to third harmonic (353 nm) of the 1.06 μm pulse produced by an Nd:glass laser. This actively mode-locked, *Q*-switched, Nd:glass ring laser[1] emits a 200 ns (FWHM) train of ultrashort pulses synchronizable to within 100 ns with the short ~20 ns gain duration of the XeF discharge. By cascade upconversion in two ADP crystals a train of third harmonic pulses having a 100 ns (FWHM) envelope was generated, each pulse having a duration of 200 ps and a Gaussian spatial profile with a beam divergence of 0.3 mrad. The latter was directed into a UV preionized double discharge XeF amplifier at an input intensity of 10 to 70 W/cm^2. The XeF amplifier was filled with a 250:2.5:1 mixture of He:Xe:NF_3 at 2 atmospheres pressure. Simultaneous recording of the input and output pulse trains permitted measurement of the gain in the XeF medium. With a fresh gas mixture peak gains of 0.128 cm^{-1} and peak powers of 50 kW have been measured. Due to the short gain duration in the XeF discharge usually only a single pulse of the input pulse train was amplified.

Currently investigations are underway to study the amplification of pulses of only a few ps (<20 ps) duration in XeF as well as the extension of this technique to the amplification of picosecond pulses at other wavelengths in the UV and VUV.

[1] I. V. Tomov, R. Fedosejevs, M. C. Richardson and W. J. Orr, *Appl. Phys. Lett.*, vol. 29, p. 193, 1976.

13.5 Operating Parameters and Discharge Characteristics of Double Discharge KrF, ArF, and XeF Lasers, T. R. Loree, R. C. Sze and R. Begley, *Los Alamos Scientific Laboratory, Los Alamos, N. M. 87545*

(*15* min)

The electric discharge KrF, ArF, and XeF lasers are usable and portable sources of unfocused megawatts of coherent photons at 2485 Å, 1930 Å, and 3511 Å, 3532 Å respectively with repetition rates better than 1 Hz. Among other applications these are excellent sources for inducing interesting photochemistry.[1] The double discharge lasing of the noble gas-monofluorides was first done with moderately fast risetime devices.[2] We will discuss the general characteristics of UV preionized, 20–200 ns risetime discharge lasers. Topics will include detailed parametric studies and voltage-current and impedence characteristics of these devices.

For the sake of space we will concentrate specifically on the KrF lasers in this summary. The others are qualitatively similar. Lasers of this type all produce output energies in the 100 mJ range in pulses of about 20 ns FWHM. The optimum gas mix for maximum output at 30 psia is 0.2% F_2/5.0% Kr/1.0% Ne/93.8% He by pressure. It is possible to change the optimum pressure somewhat by keeping the F_2/Kr/Ne ratio constant and varying the He content. The

[1] R. K. Sander, T. R. Loree, S. D. Rockwood and S. M. Freund, *Appl. Phys. Lett.*, in press.

[2] R. Burnham and N. Djeu, *Appl. Phys. Lett.*, vol. 27, p. 707, 1976.