Recent Progress in XeF (C-A) Excimer Laser Technology

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The development of the XeF (C-A) eximer laser has been motivated because of its broad wavelength tunability in the visible region which can be utilized for the amplification of ultrashort injection and tunable narrow spectral bandwidth laser pulses.

The main objective of the present work have been concerned with the scaling of an electron beam pumped XeF (C-A) laser to higher energies, improvement of the pulse repetition rate, and demonstration of a broad tuning range. Further, the study of novel cavity configurations was emphasized, in particular injection controlled external and off axis resonators. Injection control permits convenient wavelength and linewidth control by using an external control laser. Furthermore, the injection of a seeding signal enhances energy extraction by more effective photon flux build up and bleaching of transient absorption species. The only proviso to such improved performance is to prevent back coupling of the XeF (C-A) laser to the seed laser.

XeF(C→A) Laser Scale-Up Objectives

Previous laser system:

- Active volume 10 cm x 1.6 cm diameter ~ 0.02 liter.
- Single shot experiment.
- Unstable resonator M ~ 1.1 optics.
- Tuning range of 460 - 510 nm.
- Maximum energy output ~ 30 mJ (1.5 J/l).

Scaled laser system:

- Active volume 50 cm x 3.5 cm diameter ~ 0.50 liter.
- Repetition rate of 1 Hz.
- Unstable resonator M ~ 2 optics.
- Tuning range of 460 - 510 nm (greater range expected).
- Maximum energy output > 500 mJ.

Fig.1

The scaling to higher energies was based on previous experiences with a 30 mJ transversely electron beam pumped XeF (C-A) laser device [1]. A summary of the scale up objectives is listed in Fig.1.

All the experiments were performed based on appropriate data obtained from a newly developed numerical model for the photon flux especially adapted to the unique properties of the XeF (C-A) laser [2]. Guidelines for the electron beam energy deposition in the laser gas and the resulting time dependent gain and absorption profiles were obtained from kinetic modelling. The dependence of the output energy on the pumped gas volume was assumed to be linear. In order to obtain an output energy in the 0.5-1 J range, the laser cell had to be increased from 20 cm^3 to 500 cm^3. Because of the limited penetration depth of the electron beam in highly pressurized gas,

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the increase in volume had to be accomplished by enlarging the electron beam area, mainly be increasing the laser cell length. The e-beam generator was carefully designed to yield approximately the same electron energy deposition of 120 J/l in the gas mixture as in the previous experiments. The electron energy was 650 kV with a peak diode current of 80 kA in a Maxwell Laboratories Pocobeam machine. The short electron pulse duration of 10 ns was set in order to produce a high peak gain in the electron beam pumped active medium. This is particularly important for subsequent tuning experiments in the far spectral wings of the gain profile.

The increased cavity length and the resulting larger round trip time and gain require a specially designed resonator. The optimum configuration was obtained by means of computer modelling. The cavity for the new cell as well as the old cell consists of a positive branch, confocal unstable resonator which permits injection of a tunable laser seed signal into a hole in the concave mirror.

First measurements with the new laser system included Faraday probe and energy deposition measurements. The electron current density on the optical axis is 160 A/cm^2, comparable to the average value measured for the original Physics International Pulserad machine. The energy deposition in the gas is 140 J/l, slightly higher than before.Both the current density and the energy deposition are very uniformly distributed over the cavity length, the maximum deviation on the optical axis is less than 20%. The design of the e-beam excitation was successful in providing an equally large pumping power density for the increased gas volume, which is an important factor for scalability.

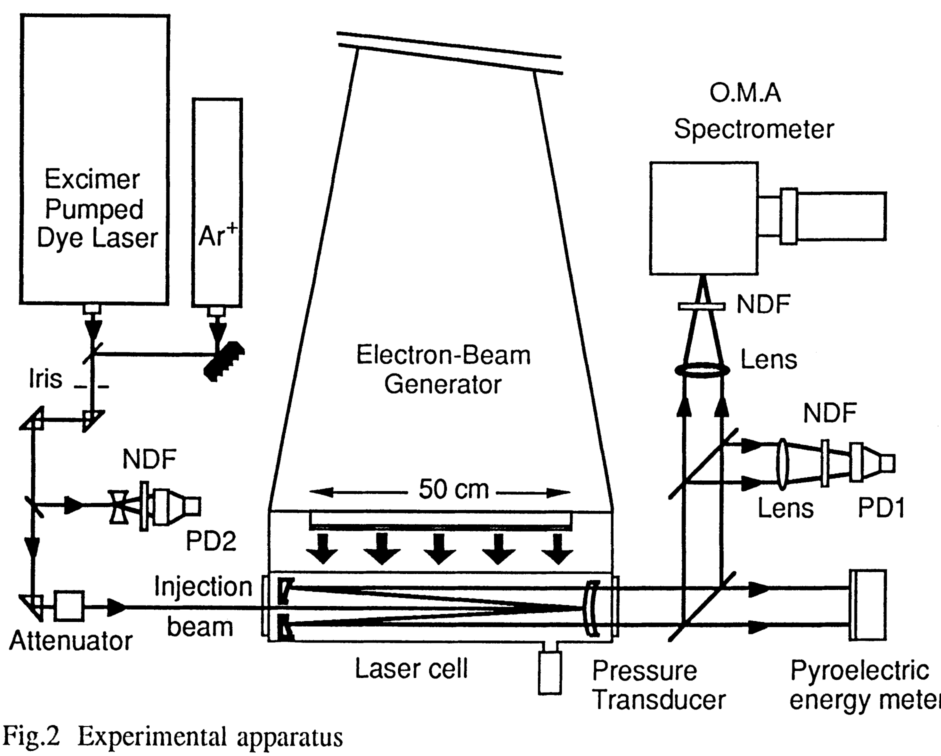

Fig.2 Experimental apparatus