A megawatt excimer laser of small discharge volume (3.8 cm$^3$)

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We demonstrated intense laser action from a 14 cm gain length, 3.8 cm$^3$ active volume XeCl laser. The laser peak power of 1.3 MW was comparable with the best results obtained from a similar small active volume excimer laser, and the laser energy of 40 mJ per pulse obtained from our device was considerably higher.

We report in this letter some preliminary experimental results of a small active volume (3.8 cm$^3$) XeCl laser under very intense discharge pumping (discharge current density $j = 14$ kA cm$^{-2}$ or a power deposition of the order of 45 MW cm$^{-3}$). A laser peak power of 1.3 MW and a laser energy of 40 mJ per pulse are obtained from our small active volume device. The gain is measured to be $\gtrsim 0.63$ cm$^{-1}$, which we believe is the highest reported value for XeCl lasers. The role of HCl concentration is also discussed.

The apparatus employed in the experiments is essentially the low-impedance ($Z_0 \approx 0.4$ Ω) water transmission line-driven, X-ray pre-ionized device used previously to excite a large active volume (1 litre) excimer laser [1]. The same low-impedance excitation circuit is now used to drive a XeCl laser of much smaller active volume so that the discharge current is orders of magnitude higher. The pre-ionization X-ray is the Bremsstrahlung radiation generated by a cold-cathode electron-beam. The X-ray dosage is about 4 mR per pulse on the surface of the discharge electrode.

A small rectangular (15 cm x 10 cm x 25 cm) discharge chamber was machined from a solid block of aluminium with provisions for mounting optics at the two ends. The discharge electrodes consisted of a nickel-plated, rounded-edged 1.25 cm x 3.75 cm x 17 cm block of aluminium and a flat 0.5-mm thick plate of stainless steel. The discharge was very well controlled by the X-ray so that the discharge geometry was determined by the discharge gap (0.9 cm) and the X-ray aperture situated directly beneath the 0.5-mm stainless steel plate. As evidenced by the pattern left on the electrode after a few pulse discharges, a change in the dimension of the X-ray aperture always induces a corresponding change in the discharge area. For all experiments reported here the aperture dimensions of 0.3 cm x 14 cm were used. The active discharge volume was therefore 0.9 x 0.3 x 14 = 3.8 cm$^3$.

During normal operation of the laser, the low-impedance water transmission line is pulse-charged by a two-stage Marx generator which is d.c.-charged to 30 kV. To achieve a fast rising breakdown voltage, a multichannel rail gap was inserted in series with the water transmission line. The laser output power was measured by a calibrated biplanar photosensor.
In Fig. 1 we show the oscillograms of the discharge current, one- and two-pass Amplified Spontaneous Emission (ASE) for a gas mixture of 5 Torr HCl, 40 Torr Xe and Ne balance to 4.4 atm. The oscillograms of the discharge current and the one-pass ASE are triggered by the firing of the pre-ionization X-ray generator which is seen to precede the main discharge by more than 1 μs. For a nominal pulse charging voltage of 60 kV a peak discharge current of 60 kA was measured and consequently the discharge current density was about 14 kA cm⁻². By replacing the end u.v. window by a flat total-reflecting mirror, we detected the two-pass ASE. The oscillogram is recorded by setting the Tektronix 7104 at the delay sweep mode. Compared with the one-pass ASE, the peak power of the two-pass ASE is almost four orders of magnitude stronger, but the duration is greatly reduced. Since the photodiode was a considerable distance (90 cm) from the front window of the discharge chamber, we can proceed with the method of Silvast and Deech [2] to deduce the net gain g of the laser by comparing the one- and two-pass ASE signals. A gain of 0.63 cm⁻¹ is obtained if the two-pass ASE remains in the small-signal regime. However, the power

Figure 1 Oscillograms of (a) the discharge current j, (b) one- and (c) the two-pass ASE for a gas mixture of 5 Torr HCl, 40 Torr Xe and Ne balance to 4.4 atm.