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An 850 J, 150 ns Narrow-band Krypton Fluoride Laser

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An 850 J, 150 ns Narrow-band Krypton Fluoride Laser

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ABSTRACT

We report laser experiments on a 248 nm KrF laser with a 30x40x120 cm gain volume and an injection locked unstable resonator cavity. The volume is pumped by six 450 kV, 90 kA electron beam generators using water pulse forming lines.

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Electron-beam-pumped rare gas halide excimer lasers offer high efficiency at short wavelength. We have constructed an electron-beam-pumped KrF laser system to explore the pulsed power and laser issues associated with scaling these systems to large sizes for laser fusion.

Figure 1 shows the laser amplifier before optics were installed. The 30x40x120 cm laser gain volume is pumped by six electron beams generated in vacuum diodes driven by 450 kV, 90 kA, 150 ns water Blumlein pulse forming lines. These lines are charged by Marx generators located in the oil tanks under the lines in the photograph. The total electron beam energy is 36 kJ of which 14 kJ (39%) is deposited in the laser gain volume when the volume contains two atmospheres of a typical laser mixture of argon, 5% krypton, and 0.3% fluorine.

We conducted laser experiments using an injection-locked near confocal unstable resonator cavity with a magnification of five. The injection source is a narrow linewidth KrF discharge laser oscillator-amplifier system which injects 100 mJ in 20 ns into the unstable resonator cavity just before the gain begins to rise in the amplifier. The amplifier radiates 20-50 J in the first 10-20 ns of the pulse into a highly divergent flash of amplified spontaneous emission. This flash is suppressed when the injected signal reaches full saturation and the laser output into the unstable resonator mode is then 850 J in 150 ns. The spectrum of the laser output shows that about 90% of the output is controlled by the injected signal and has its narrow bandwidth. The output beam divergence is controlled by the flatness of the antireflection coated laser cell windows and is about 100μrad.

KrF laser kinetics are dominated at high intensity by competition between laser exctraction and absorption in the medium. It can be shown that the maximum possible intensity in a KrF laser $I_{max} = (\alpha/\gamma_s - 1)I_s$, where α is the small-signal gain per unit length, γ_s is the saturated loss per unit length, and I_s is the laser saturation intensity. A measurement of I_{max} therefore tests our understanding of these parameters. We measured I_{max} in this amplifier by installing a low-loss cavity around a section of the amplifier aperture near the region of peak electron beam deposition per unit volume of about 1.3 MW/cm^3. The maximum intensity was 46 MW/cm^2 which agrees reasonable well with our calculated value[1] of 44 MW/cm^2 at 1.5 MW/cm^3 deposition.

In summary, we observe 850 J narrow band output from an injection locked unstable resonator regenerative amplifier system having a stage gain of about eight thousand. The KrF intrinsic efficiency (laser output/energy deposited in gas) was about 6% and the "wall plug" efficiency about 2%.

References

1. K. S. Jancaitis, "Kinetic Modeling of Krypton Fluoride Laser Systems", Thesis, Dept. of Physics, U. of Calif. at Berkeley, 1983.

Figure Captions

1. Photograph of the KrF laser amplifier before optics were installed. Three water Blumlein pulse lines on each side generate electron beams which pump two facing sides of the laser volume.

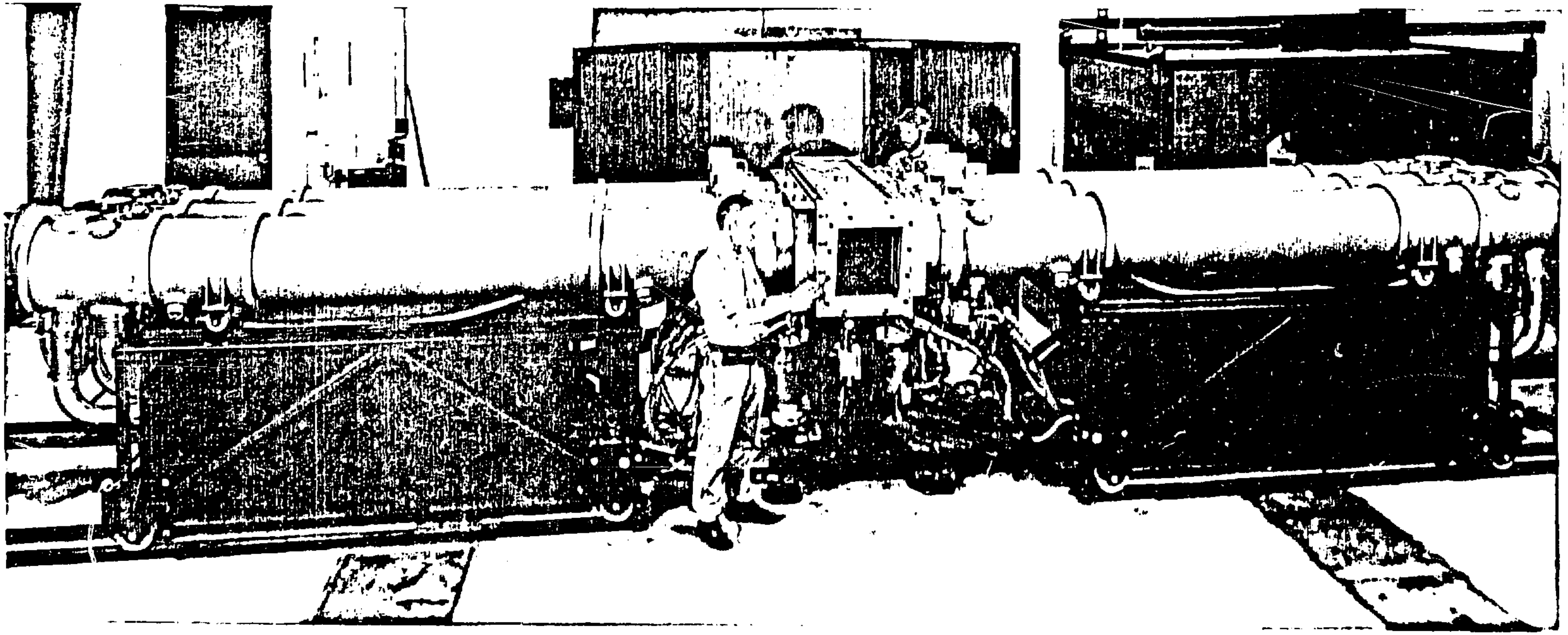

Figure 1