AD-A100 840 STANFORD UNIV CA EDWARD L GINZTON LAB OF PHYSICS F/G 20/5
A MICROWAVE-PUMPED XECL LASER.(U)
JAN 81 A J MENDELSOHN, R NORMANDIN ARO-20-81
UNCLASSIFIED ARO-16996.3-P NL

1 OF 1
AD
A100840

END
DATE
FILMED
7 81
DTIC

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: 16996.3-P	2. GOVT. ACCESSION NO.: AD-A100 840 N/A
3. RECIPIENT'S CATALOG NUMBER: N/A	
4. TITLE (and Subtitle): A Microwave-Pumped XeCl Laser	5. TYPE OF REPORT & PERIOD COVERED: Reprint
	6. PERFORMING ORG. REPORT NUMBER: N/A
7. AUTHOR(s): A. J. Mendelsohn, J. F. Young, R. Normandin, S. E. Harris	8. CONTRACT OR GRANT NUMBER(s): ARO-20-81
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Stanford University, Stanford, CA 94305	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: N/A
11. CONTROLLING OFFICE NAME AND ADDRESS: U. S. Army Research Office, P. O. Box 12211, Research Triangle Park, NC 27709	12. REPORT DATE: 15 Apr 81
	13. NUMBER OF PAGES: 3
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Submitted for announcement only.

DTIC ELECTE JUN 30 1981 S D B

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

AD A100840

DTIC FILE COPY

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified 407640

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

ARO 16996.3-P

A microwave-pumped XeCl* laser

A. J. Mendelsohn, R. Normandin, S. E. Harris, and J. F. Young
Edward L. Ginzton Laboratory, Stanford University, Stanford, California 94305

(Received 9 January 1981; accepted for publication 3 February 1981)

A XeCl* excimer laser excited by 2-μs-long, 9.375-GHz microwave pulses has been constructed. Spontaneous emission times of $\sim$500 ns have been observed, while the maximum laser pulse length was 100 ns. The laser pulse length appears to be limited by the buildup of a transient loss.

PACS numbers: 42.55.Hg, 42.60.By, 52.80.Pi

We have constructed a long-pulse 308-nm XeCl* excimer laser excited by high-power microwave (9.375 GHz) pulses. Electron-beam, avalanche-discharge, and electron-beam-sustained discharge pumped excimer lasers have been studied extensively[1-4] and each have different advantages and limitations. Microwave pumping retains the practical simplicity of the avalanche discharge, while avoiding its extreme sensitivity to discharge conditions. The pulse length and efficiency of avalanche-discharge lasers are limited by the formation of plasma arcs, which make it impossible to maintain adequate excitation rates throughout the volume. The sensitivity to such factors as detailed gas composition, electrode irregularities, degree and uniformity of preionization, and the characteristics of the driving source have been described in detail by Levatter and Lin.[5] They note that, except for their own work[6] using high-power x-ray preionization and very fast rise-time drivers, avalanche-discharge laser pulse lengths have been limited to about 10 ns.

In contrast, microwave excitation of high-pressure gases is much less sensitive to the details of the plasma: the power deposition is nominally independent of gas composition, uniform preionization is not critical, and even a local breakdown or arc does not prevent effective excitation in other regions of the plasma. In addition, the device is easily constructed with high-vacuum, halogen-compatible materials. As a result, we have been able to observe spontaneous XeCl* emission for periods of up to 500 ns and to produce 100-ns laser pulses using a very simple apparatus.

A Varian SFD-303 coaxial magnetron and line-type pulser provides 600-kW, 2-μs-long pulses at 9.375 GHz. The pulses have a rise time of about 100 ns and travel through $\sim$8 m of x-band waveguide pressurized with SF_6 to the active laser region, illustrated in Fig. 1. The microwave energy is coupled from the primary guide into a secondary guide containing a concentric 3-mm i.d. quartz tube holding the laser gas mixture. The gas mixture is slowly recirculated through an all-stainless-steel closed loop system. Although the magnetron is capable of 400-Hz operation, thermal shock effects combined with our slow flow rates limited operation to 10 Hz. In addition, the recirculating pump limits absolute pres-

 0003-6951/81/080603-03$00.50 © 1981 American Institute of Physics

81 6 29 350

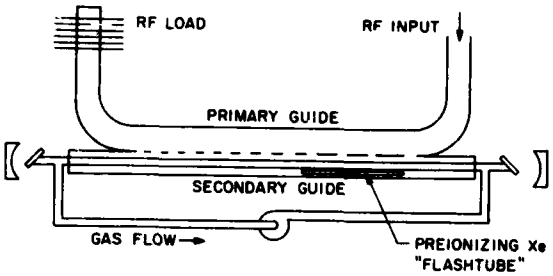

FIG. 1. Schematic of the microwave-pumped XeCl* laser. The Brewster windows are CaF_2 and the cavity consists of 2-m-radius mirrors 1 m apart.

sures to about 2 atm.

The microwave coupler consists of a series of "Riblet Tee" slots,[7] which are spaced to provide nearly uniform transfer of microwave energy from the primary to secondary waveguide along the 40-cm-long coupling region. Using this coupler, 80–90% of the energy in the primary guide can be absorbed in a variety of rare-gas–halogen-buffer gas mixtures at pressures between 1 and 3 atm, yielding a power deposition of $(1\text{–}2)\times 10^5$ W/cm^3. Once the discharge is initiated the power reflected to the source is insignificant.

The microwave discharge is more stable and reproducible if it is initiated by a small amount of preionization. This is accomplished by placing a ~12-cm- long sealed quartz tube containing ~1 Torr of Xe in the secondary guide. This low-pressure Xe "flash lamp" breaks down early in the microwave pulse providing simple, self-timed UV preionization of the laser mixture.

Laser action in XeCl* was observed at several wavelengths centered at 308 nm. The net round-trip gain was just over 20% using a mixture consisting of 0.3% Xe, 0.05% HCl, and 99.6% Ne at a total pressure of 2 atm. Figure 2 shows the relative time behavior of the microwave, spontaneous fluorescence, and laser pulses. The laser pulse length had a maximum value of 100 ns and was inversely proportional to the output coupling (Fig. 3), while the spontaneous emission lasted for over 500 ns. It seems likely that the pulse length was limited by a transient loss which built up during the pulse.[8] Our optimum gas mixture corresponds closely to the one given in Ref. 8, which minimizes such transient losses, while it differs considerably from the mixtures normally used for avalanche-discharge lasers.

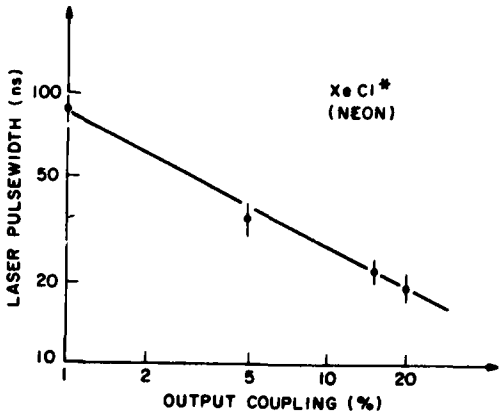

FIG. 3. Laser pulse width vs output coupling, log-log scales.

The peak laser output power was only ~20 W with 5% output coupling, giving an overall efficiency of less than 0.01%. In the present design, however, the efficiency is significantly reduced by the small fraction of the discharge volume which is used by the laser mode. A more useful figure is the formation efficiency, defined as the ratio of the energy stored in the XeCl* exciplex to the input microwave energy. Using the measured 20% gain and the stimulated cross section for XeCl*, this is calculated to be 0.2%. The spontaneous-emission intensity increases with microwave input power and total pressure as shown in Fig. 4, indicating a potential for higher power and efficiency.

We have demonstrated that microwave pumping is a simple technique for producing relatively long pulse excimer

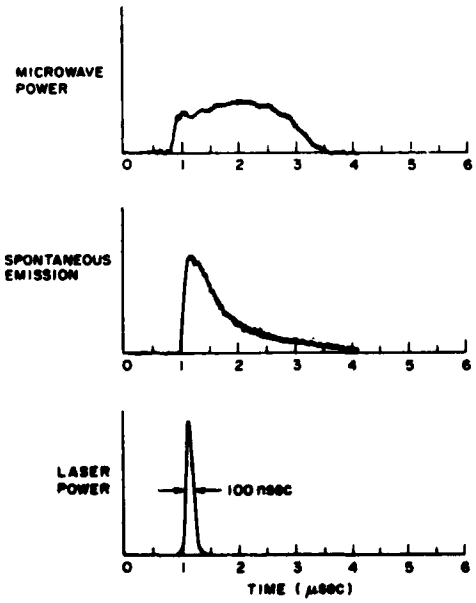

FIG. 2. Relative time behavior of the microwave power, XeCl* spontaneous emission, and laser pulses.

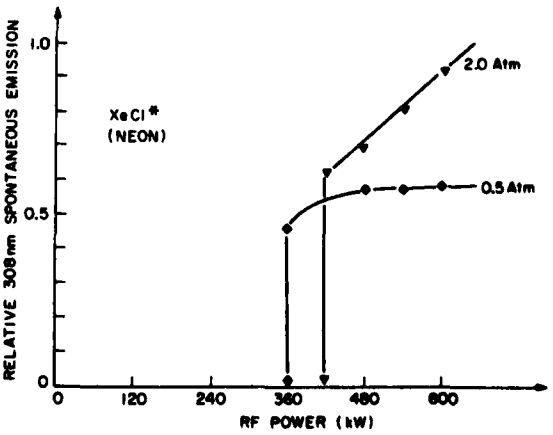

FIG. 4. Intensity of 308-nm spontaneous emission as a function of microwave power and total pressure.

lasers. Such a system may be useful for generating well-controlled mode-locked pulses for a high-power amplifier chain. In addition, the microwave pumping scheme lends itself to applications where long gas lifetimes and hands-off operation are required because of the all metal and quartz construction and the absence of eletrodes with their sputtering problems.

We would like to acknowledge the technical assistance of B. Yoshizumi; R. N. gratefully acknowledges the support of the Canadian National Science and Engineering Research Council. This research was supported by the Air Force Office of Scientific Research and the Army Research Office under Contract No. F49620-80-C-0023.

[1] R. C. Sze, IEEE J. Quantum Electron. QE-15, 1338 (1979).
[2] M. Rokni, J. A. Mangano, J. H. Jacob, and J. C. Hsia IEEE J. Quantum Electron. QE-14, 464 (1978).
[3] W. L. Nighan, IEEE J. Quantum. Electron. QE-14, 714 (1978).
[4] A. V. Eletskii, Sov. Phys. Usp. 21, 502 (1978).
[5] J. I. Levatter and S. C. Lin, J. Appl. Phys. 51, 210 (1980).
[6] S. C. Lin and J. I. Levatter, Appl. Phys. Lett. 34, 505 (1979).
[7] H. J. Riblet and T. S. Eaad, Proc. IRE 36, 61 (1948).
[8] L. F. Champagne, L. J. Palumbo, and T. G. Finn, Appl. Phys. Lett. 34, 315 (1979).

Accession For
NTIS CRA&I ☑
DTIC TAB ☐
Unannounced ☐
Justification
By
Distribution/
Availability Codes
Dist | Avail and/or Special
A

END

DATE
FILMED

7-81

DTIC