AD-A178 833 INVESTIGATION OF THE TRANSVERSE-DISCHARGE COPPER-VAPOR LASER(U) NEW MEXICO UNIV ALBUQUERQUE CENTER FOR HIGH TECHNOLOGY MATERIALS J J KIM 31 MAY 86 1/1

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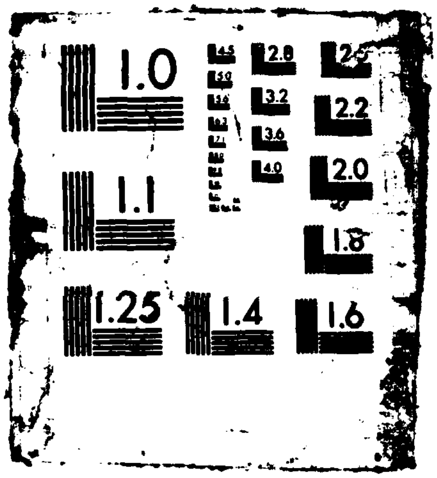
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SECURITY CLASSIFICATION OF THIS PAGE

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AD-A178 833

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A transverse-discharge copper-vapor laser has been developed using a fast flat-plate Blumlein pulse forming circuit. A specific laser energy density of 50 μJ/cm³ has been achieved. This is an order of magnitude higher than that achieved by conventional copper-vapor lasers. The high electric field to number density ratio allows operation with high temperatures of up to 1800 °C and high buffer gas pressures above atmospheric pressure. (Keywords:

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Final Technical Report

ONR Contract No. N00014-83-K-0180
(Contract Period: Feb. 1, 1983 - May 31, 1986)
(Investigation of the Transverse-Discharge Copper-Vapor Laser)

I. Summary of Work

Under the Contract, we have successfully developed a dependable testbed for transverse-discharge copper-vapor laser (TD-CVL). The TD-CVL system was constructed using a double flat-plate Blumlein pulse-forming circuit (PFC). The key feature of the system is in the design of the transverse-discharge laser cavity that can be coupled to the low inductance pulse-forming circuit and can still be operated at high temperatures of up to 1800 °C. A schematic cross-sectional view of the TD-CVL is shown in Fig. 1. A detailed description of the system is included in the published papers [1-12].

The TD-CVL system can be operated in a wide range of parameters. Extensive parametric studies were carried out to characterize the TD-CVL system within the capabilities of the equipment used in the testing. We summarize the results of the studies in the following.

The excited volume of the laser cavity was 0.6x1x20 cm^3, the active zone being approximately 20 cm long. The laser cavity was 110 cm long consisting of a 99.5% reflecting flat mirror and an 8% reflecting flat glass window of the laser which was used as the output coupler. The storage capacitance was roughly 25 nF and it was usually charged to 3-10 kV. The peaking capacitance was approximately 11 nF. A hydrogen thyratron (EG&G HY 3001) was used for triggering the switch of the Blumlein PFC. For parametric studies and due to the limitations of the power supply available, the laser was operated in a single shot made or at a low repetition rate (<10 Hz).

Oscilloscope traces of typical voltage and current pulses are shown in Fig. 2(a). The breakdown voltage in the laser cavity was in the range of 3-5 kV, indicating that there was a considerable loss of electrical energy in the discharge circuit. We did not attempt to optimize the laser operation in this work. The rise time of the discharge current pulse is approximately 8 ns and the peak current occurs in the middle of the way of the voltage breakdown as expected.

A typical green laser pulse is shown in Fig. 2(b) with the current pulse as a time reference. The laser pulse starts near the peak of the current pulse and has a full width at half maximum of 8 ns measured with a Hamamatsu biplanar phototube (R1193U). The yellow laser pulse appears approximately 10 ns behind the green laser.

The total laser energy was measured with a Molectron J3-05 joulemeter. Fig. 3 shows the total laser energy output per pulse versus temperature. The laser energy almost linearly increases from 1350 until 1650 °C. This is in striking contrast to the temperature dependence of conventional CVLs. The laser energy output of conventional CVLs peaks at 1450 °C. Also, the maximum specific laser energy density obtained in the TD-CVL is roughly 50 $\mu J/cm^3$, which is an order of magnitude higher than that achieved with conventional CVLs. Owing to the limitation of the maximum temperature allowed for the alumina tube that was used for the laser cavity, it was not prudent to increase the temperature beyond 1650 °C inside the active zone.

Fig. 4 shows the laser output versus the neon buffer gas pressure at two different temperatures, 1540 and 1630 °C, respectively. The high electric field and number density ratio (E/N) in transverse discharge allows laser operation at the buffer gas pressure above the atmospheric pressure. The capability of the TD-CVL to operate in pressures above the atmospheric pressure provides another important advantage over conventional CVLs. The high pressure of the buffer gas in the TD-CVL makes it possible to retain copper vapor for a long period of time and to operate the laser in a sealed system. This is important for practical applications.

Work is in progress to improve the present system and to construct another TD-CVL system with many improved features.

In summary, we have developed a transverse-discharge copper-vapor laser which can be operated in a steady state mode. This system generates a specific laser energy density of 50 $\mu J/cm^3$ which is an order of magnitude higher than that achieved with conventional CVLs. The TD-CVL can be also operated at high buffer gas pressures, making it possible to operate it in a self-heated steady state mode. The TD-CVL holds promise to be the next generation of CVLs.

II. Publications

1. "The Copper Vapor Laser Pumped by a Fast Transverse Electrical Discharge," Proc. Los Alamos Conference on Optics '83, SPIE Vol. 380, p. 167 (Int. Soc. Opt. Eng., Billingham, WA, 1983) (J. J. Kim and J. Elizondo).

2. "Stimulated Emission from Radiation Trapping Atoms: The Copper Vapor Laser," **Coherence and Quantum Optics** V, edited by L. Mandel and E. Wolf (Plenum, New York, 1984) p. 1217 (J. J. Kim and A. Elci).

3. "Transverse-Discharge Copper-Vapor Laser," J. Opt. Soc. Am. A1, 1242 (1984) (J. J. Kim, K. Im and A. Elci).

4. "Copper-Vapor Laser Pumped by a Fast Transverse Discharge," Conference on Lasers and Electro-Optics, 21-24 May 1985, Baltimore, MD, CLEO '85 Technical Digest, p. 162.

5. "Oscillatory Emission from the Cu-Vapor Laser," J. Opt. Soc. Am. A2, No. 13, p. P75 (1985) (J. Rai, K. Im and J. J. Kim).

6. "Transverse-Discharge Copper-Vapor Laser," IEEE J. Quantum Electron. **QE-21**, 1747 (1985) (J> J> Kim and K. Im).

7. "Transversely Excited Atmospheric-Pressure Copper-Vapor Laser," J. Appl. Phys. **59**, 3930 (1986) (K. Im, N. Sung and J. J. Kim).

8. "Self-Mode-Locking in a Transverse-Discharge Copper-Vapor Laser," Appl. Phys. Lett. 49, 131 (1986) (K. Im and J. J. Kim).

9. "TEA Copper-Vapor Laser," Conference on Lasers and Electro-Optics, 9-13 June 1986, San Francisco, CA, CLEO '86 Technical Digest, p. 162 (K. Im, J. J. Kim and N. Sung).

10. "Self-Mode-Locking in a Transverse-Discharge Copper-Vapor Laser," J. Opt. Soc. Am. 3 (No. 8 Part 2), P64 (1986).

11. "Transverse-Discharge Copper-Vapor Laser," Proc. E-O LASE '87 (Int. Soc. Opt. Eng., Billingham, WA, 1987) (in press).

12. "Stimulated Emission in Optically Pumped Atomic Copper Vapor," submitted to Optics Letters (J. J. Kim and N. Sung).

13. "Parametric Studies of the Transverse-Discharge Copper-Vapor Laser," (K. Im, J. J. Kim and N. Sung) manuscript in preparation.

III. Conference Presentations

1. "Investigation of the Transverse Discharge Copper Vapor Laser," Los Alamos Conf. on Optics '83, Santa Fe, NM, April 11-15, 1983 (J. J. Kim and J. Elizondo).

2. "Stimulated Emission from Radiation Trapping Atoms: The Copper Vapor Laser," Fifth Rochester Conf. on Coherence and Quantum Optics, Rochester, NY, June 13-15, 1983 (A. Elci and J. J. Kim).

3. "Transverse-Discharge Copper-Vapor Laser," presented at the Annual Meeting of OSA, San Diego, CA, Oct 29-Nov 2, 1984 (J. J. Kim, K. Im and A. Elci).

4. "Copper-Vapor Laser Pumped by a Fast Transverse Discharge," presented at the Conf. on Lasers and Electro-Optics, CLEO '85 Baltimore, MD, May 21-24, 1985 (J. J. Kim, K. Im and T. W. Karras), CLEO '85 Technical Digest p. 162.

5. "Oscillatory Emission from the Cu-Vapor Laser," presented at the Annual Meeting of OSA, Washington, D. C., Oct. 14-18, 1985.

6. "Self-Mode-Locking in a Transverse-Discharge Copper-Vapor Laser," presented at the XIV IQEC, June 9-13, 1986, San Francisco, CA (K. Im and J. J. Kim).

7. "TEA Copper-Vapor Laser," presented at the CLEO '86, June 9-13, 1986, San Francisco, CA (K. Im, J. J. Kim and N. Sung).

IV. Thesis Advising

Kiegon Im, "Transverse Discharge Copper Vapor Laser," PhD Thesis (University of New Mexico, 1986).

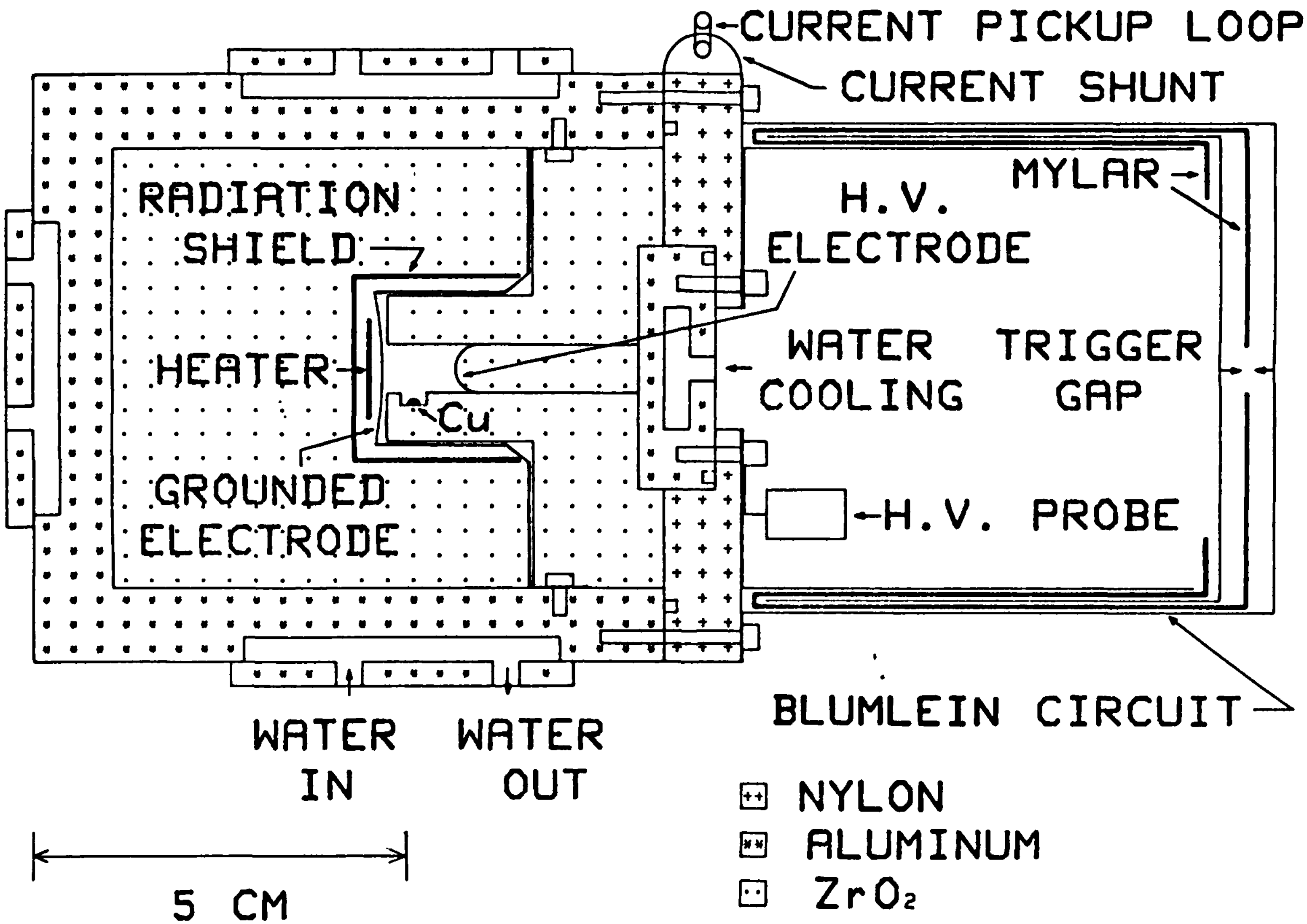

CURRENT PICKUP LOOP
CURRENT SHUNT
RADIATION SHIELD
H.V. ELECTRODE
MYLAR
HEATER
Cu
WATER COOLING
TRIGGER GAP
GROUNDED ELECTRODE
H.V. PROBE
BLUMLEIN CIRCUIT
WATER IN
WATER OUT
NYLON
ALUMINUM
ZrO2
5 CM

Fig. 1.

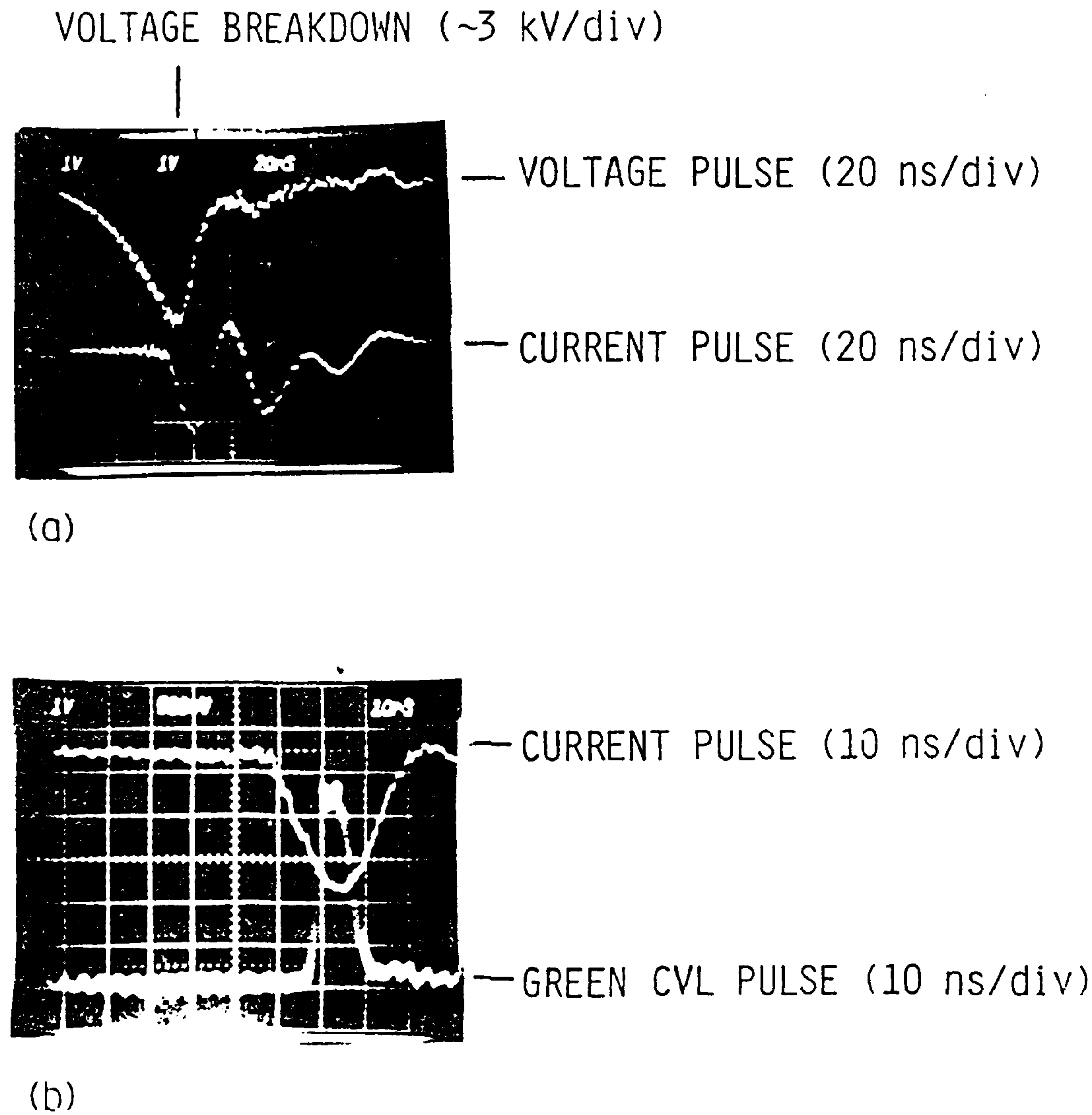
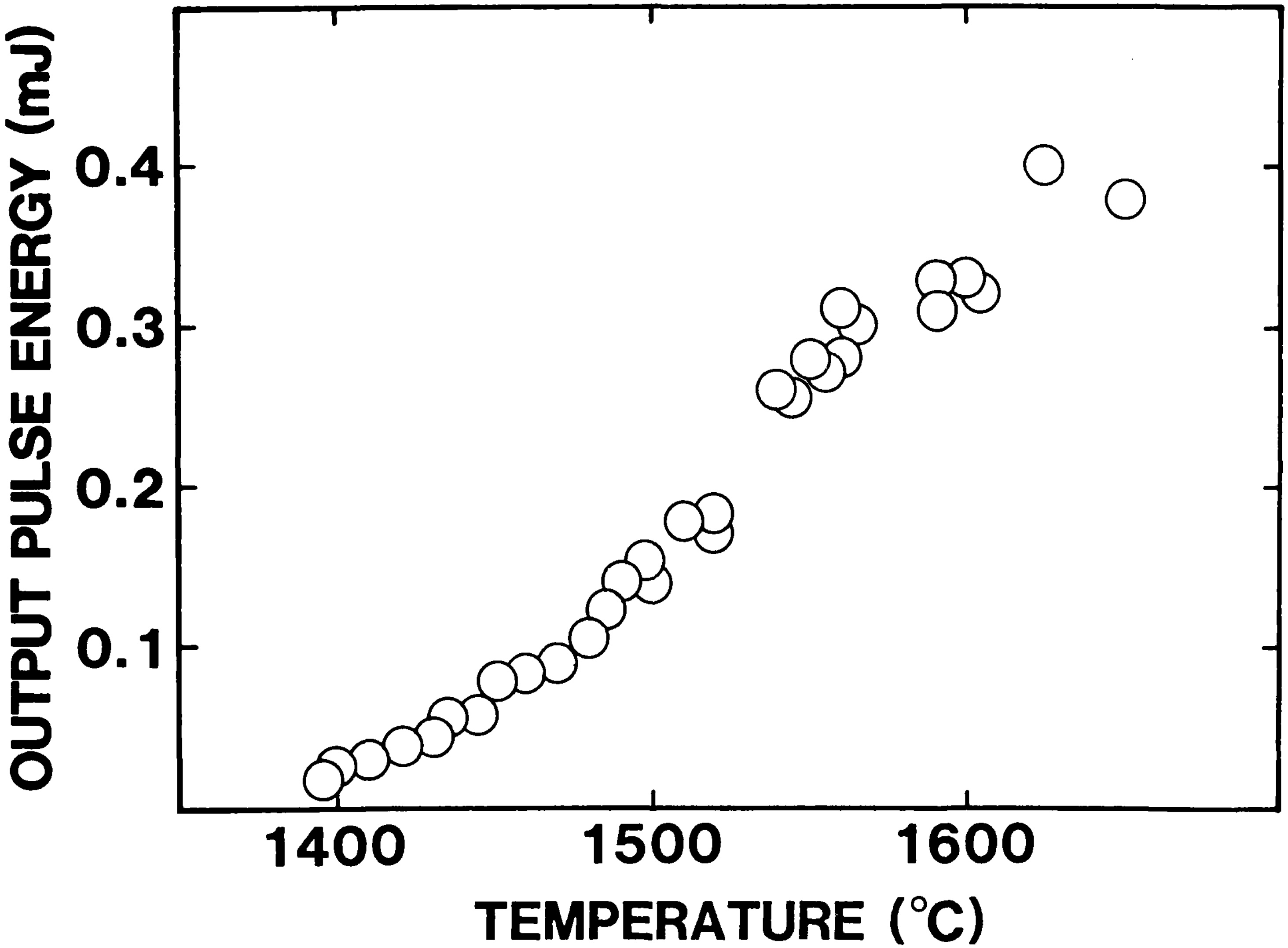

VOLTAGE BREAKDOWN (~3 kV/div)
VOLTAGE PULSE (20 ns/div)
CURRENT PULSE (20 ns/div)
(a)
CURRENT PULSE (10 ns/div)
GREEN CVL PULSE (10 ns/div)
(b)

Fig. 2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0.4
0.3
0.2
0.1
1400
1500
1600
TEMPERATURE (°C)

Fig. 3

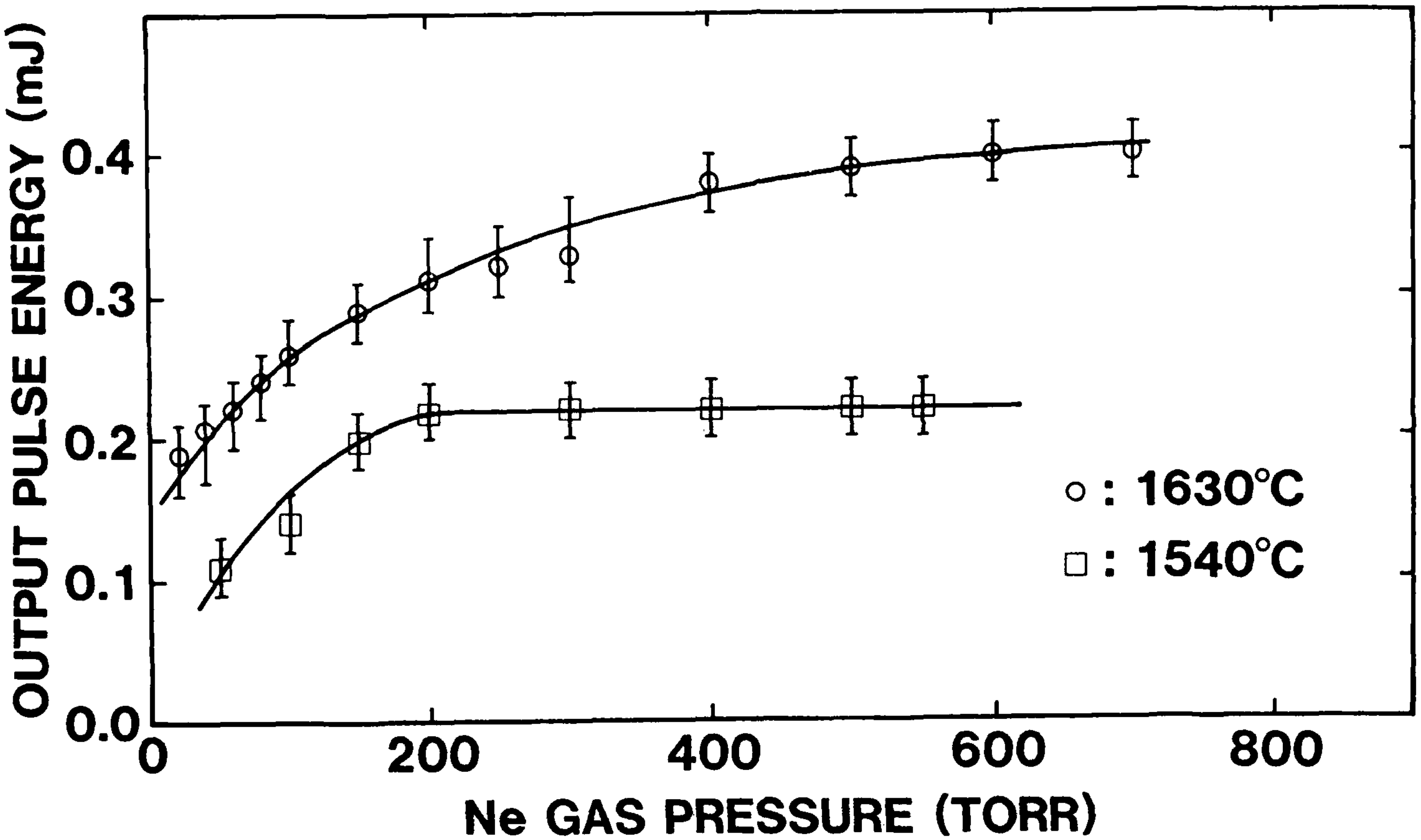
OUTPUT PULSE ENERGY (mJ)
0.0
0.1
0.2
0.3
0.4
0
200
400
600
800
Ne GAS PRESSURE (TORR)
○ : 1630°C
□ : 1540°C

Fig. 4

END

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