Submitted to IEEE Journal of
Quantum Electronics

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B. Fan, B. Leskovar, C. C. Lo,
G. A. Morton and T. K. Gustafson

April 23, 1974

Prepared for the U. S. Atomic Energy Commission
under Contract W-7405-ENG-48

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A High-Repetition-Rate Nd:Glass Laser Mode-Locked by a Saturable Absorber

B. Fan, B. Leskovar, C. C. Lo,
G. A. Morton and T. K. Gustafson

ABSTRACT

A passively Q-switched and mode-locked Nd:glass laser with an electrooptic shutter which generates a single 6-picosecond pulse at a rate of five per second is reported.

B. Fan is with the Department of Electrical Engineering and Computer Sciences and Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720.

B. Leskovar, C. C. Lo and G. A. Morton are with the Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720.

T. K. Gustafson is with the Department of Electrical Engineering and Computer Sciences, University of California, Berkeley, California 94720.

A passively mode-locked Nd:glass laser [1] has been designed and constructed which can be operated at a repetition rate of five pulse trains per second. The presently reported rate is limited by the capability of the flashlamp power supply rather than the laser itself. Indications are that much higher rates can be achieved with a more powerful power supply [2].

The Nd:glass rod was a Brewster-angled Owens-Illinois clad rod 7.30cm long and 6.35mm in diameter. The active core of the rod had a diameter of 3.18mm. The rod was pumped by two linear xenon flashlamps in a dual-elliptical cavity. Both the rod and the lamps were cooled by room-temperature water at a flow rate of 10 liters/min. No provision was made to stabilize the temperature of the coolant.

The resonant cavity was designed for efficient generation of the TEM_{00}-mode radiation, taking account of the thermal lensing effect of the laser rod [3]. It consisted of two concave dielectric mirrors separated by about 95cm. The radii of the curvature of the mirrors were both 10m. The reflectivity of the output mirror was about 80%.

The saturable absorber for mode-locking was Eastman A9740 diluted with 1,2-dichloroethane. Provision was made to circulate the saturable absorber through a cell in a laminar flow, as was essential for mode-locking at high repetition rates. The cell consisted of a fused quartz

window in contact with the output mirror with a path length of 0.5mm. The intracavity cell window was wedged with ∿30 arc minutes to avoid any etalon effect.

A typical mode-locked pulse train had about 50 ultrashort pulses with a total energy 25mJ in a single TEM_{00} mode. An oscillogram of a mode-locked pulse train is shown in Fig. 1a. The detection system had a total rise time of one nanosecond. The pulse duration, averaged over the whole pulse train, based on two-photon fluorescence (TPF) experiments [4], was 6ps. Approximately 10,000 pulse trains were generated before degradation of the saturable absorber interrupted mode-locking. By properly adjusting the optical density of the saturable absorber and pumping level [5], more than ninety per cent of these pulse trains were free from statistical satellite pulses. The amplitude variation of the train envelopes was about 20%, much of this being attributed to fluctuations in optical pumping.

Single picosecond pulses were selected from the trains of mode-locked pulses with an electrooptic shutter [6] consisting of a KD*P Pockels cell between a pair of crossed Glan polarizers. Synchronization of the shutter with the laser pulse was obtained by a laser-triggered spark gap pressurized with a 1:1 mixture of argon and nitrogen at ∿15 atmospheres. The sparkgap was terminated in a 50-ohm resistive load five meters beyond the Pockels cell. The 5%-reflection from the resistive load returned too late to degrade the original 6ns rectangular pulse across the Pockels cell. A typical

oscillogram of a single picosecond pulse, selected from a mode-locked pulse train, is reproduced in Fig. 1b.

In conclusion, it is demonstrated that a passively mode-locked Nd:glass laser of conventional design is capable of high repetition rate operation. Such high power lasers are of interest for picosecond spectroscopy and investigation of various fast processes. The capability of utilizing such high repetition rate lasers in sampling techniques is also a desirable feature.

This work was performed as part of the program of the Electronics Research and Development Group of the Lawrence Berkeley Laboratory, Berkeley, and was supported by the U. S. Atomic Energy Commission, Contract No. W-7405-eng-48.

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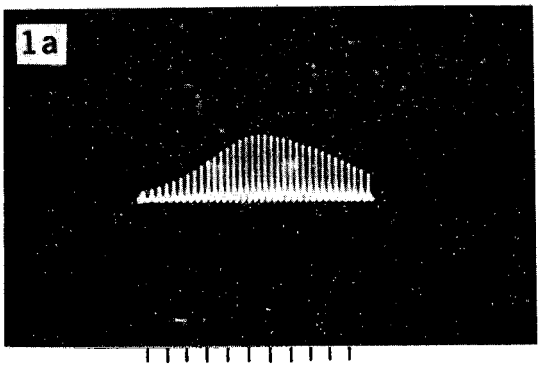

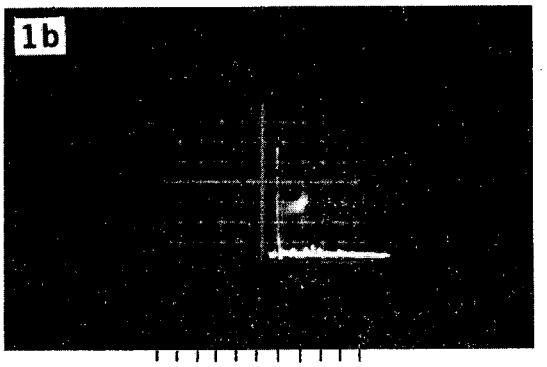

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Figure Captions

Fig. 1. Oscillograms of pulses from a mode-locked Nd:glass laser operated at three pulse trains per second: (a) a single train of mode-locked pulses, (b) a single selected picosecond pulse.

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