Compact-size electronic device for diode-laser characteristic curve tracing

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Abstract. In order to monitor the voltage-current (V-I) and optical-power–current (P-I) characteristic curves of pulsed diode lasers, we have designed, built, and tested a compact-size, low-cost electronic device with the function of both supplying periodic variable-amplitude current pulses to the diode laser and transmitting Y-X (either V-I or P-I) signals to an ordinary oscilloscope. The paper describes the features of the device and the results of its testing by characterizing two sample InGaAs/AlGaAs diode lasers. © *1996 Society of Photo-Optical Instrumentation Engineers.*

Subject terms: pulsed diode lasers; electronics for tracing characteristic curves.

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1 Introduction

In the operation of diode lasers (DLs), apart from the optimization of the internal structure of the diode itself, the emission performance is obviously controlled by the parameters of the current injection system. Also, it is often desirable to use a compact setup for monitoring the behavior of some of the most significant parameters in the operation of DL, such as the voltage-current and the optical-power–current dependences. Since the demonstration of the first DL in 1962, a large variety of DL electronics has been designed and produced,[1,2] in response to the tremendous commercial demand for such versatile sources of laser radiation. In the present paper, we report our version for a new configuration of an electronic device with the function of both injecting electric pulses into the DL and transmitting X-Y signals to any common oscilloscope, in order to trace accurate characteristic curves of the DL in pulsed operation. So, to get such curves, an expensive dedicated curve tracer is no longer necessary, since our compact-size affordable device can be successfully used instead.

Two samples of the same DL structure were studied in order to test the device we have designed. The test itself was to trace the characteristic voltage-current (V-I) and power-current (P-I) curves of these lasers. These curves are very useful. The V-I curve characterizes the internal electric behavior of DLs and the P-I curve gives information on their emission efficiency.

2 Experimental Setup and Circuit Description

The samples were strained quantum-well AlGaAs/InGaAs buried-heterostructure DLs with 100-μm active layer width and 0.7-mm cavity length, emitting at 957-nm wavelength. One of the samples presented slight structural imperfections from growth. When perfectly grown, such laser structures are able to yield 1 W and more of continuous-wave radiant power. Basically, the fabrication[3] of the sample DL consisted in forming an AlGaAs/InGaAs buried heterostructure by liquid-phase epitaxial *in situ* mesa melt etching and regrowth, on wafers grown by molecular beam epitaxy (MBE) or metal-organic chemical vapor deposition (MOCVD), a method that proved to be very effective for obtaining high-power modules emitting at near-infrared wavelengths very suitable for pumping Er^{3+}-doped fiber amplifiers and solid-state lasers. During our tests, the diodes were mounted on aluminum heat sinks, adjusted to dissipate about 5 W of thermal power.

In Fig. 1, the experimental setup is presented (the reported device being included).

The reported device consists of a pulse generator, a current buffer, a current transducer R, and the power supply (which is not represented, for the sake of simplicity). The device ensures, for all the parameters relevant for DL pulsed operation, ranges that are adequate to various applications: the pulse period T, the pulse duration Δt, and the peak current pulse $I_{\max}$ are tunable in the following ranges:

$$T=1-2.5 \text{ ms}, \quad \Delta t=10-50 \ \mu\text{s}, \quad I_{\max}=0-1.3 \text{ A}.$$

In order to obtain quasicontinuous curves on the oscilloscope display *starting from low currents*, the current

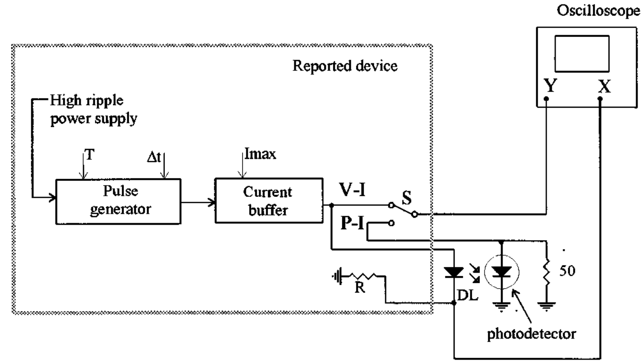


Fig. 1 General layout of the reported device and experimental setup.

pulses through the DL are amplitude modulated with 100-Hz ripple. This modulation is achieved by a high-ripple (low-filtering) power supply, which delivers voltage only to the pulse generator.

The curve to be displayed (either *V-I* or *P-I*) is selected by switch *S*.

The current transducer *R* is a resistor. Its value is low enough not to distort the curves (especially the *V-I* one).

The photodetector used for the *P-I* curves is a Romanian planar diffusion *p-n* Si photodiode (ROL 011) with 11-mm^2 active area. The 50-Ω resistor connected in parallel with the photodiode prevents its saturation at high optical powers. Passive optical attenuators were also needed: a $\times 0.1$ one for the less powerful laser, and a $\times 0.04$ one for the better-quality laser.

The oscilloscope is used in the *X-Y* regime, i.e. with two external signals applied to the two pairs of electron deflection plates, respectively, instead of the usual time-signal (*T-Y*) regime.

The electrical scheme of the reported device appears in Fig. 2; the DL and the photodiode are also represented on this scheme.

The pulse generator is built with a common 555 integrated timer,[4] resistors R_1–R_3, diodes D_1 and D_2 (any type of low-power switching diodes), and capacitors C_1–C_4. Potentiometer R_1 tunes the pulse duration Δt, and potentiometer R_3 tunes the period T of the pulses. The duty factor ($\Delta t/T$) and Δt are kept low, in order to avoid excessive heating of the DL structure. Such heating could lead to a decrease of the emitted optical power and to drift of the peak wavelength.

The high ripple of the voltage supply is achieved by the low value of the filtering capacitor C_3.

Transistor *Q* acts as the current buffer (any medium-power common type will do). The value of I_{max} is tuned by potentiometer R_6. Capacitor C_6 prevents unwanted current oscillations. Resistor R_8 limits I_{max}. The LED shows the device is active.

Capacitor C_7 creates an overvoltage on the primary winding of the power-supply transformer. The value of C_7 sets I_{max}. Therefore, I_{max} can be increased (if needed)

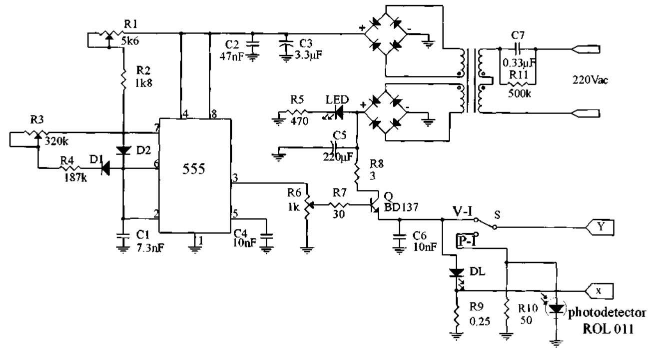


Fig. 2 Electrical scheme of the reported device.

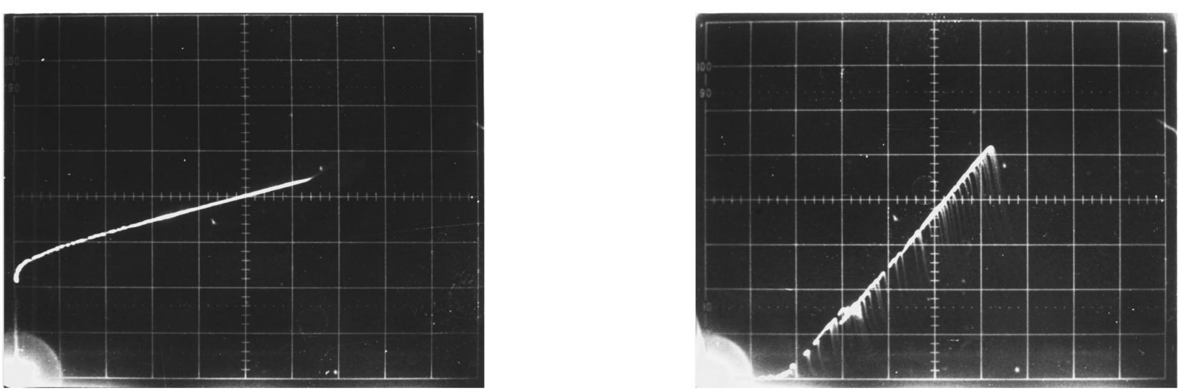
while keeping the transformer unmodified. Resistor R_{11} prevents C_7 from remaining charged with a dangerous voltage after power-off.

Because of the high ripple of the voltage supply of the 555 timer,[4] at low voltages the pulse duration may increase as a side effect. This does not affect the laser light pulses at all, as the amplitudes of longer current pulses are lower than the lasing threshold.

3 Experimental Results

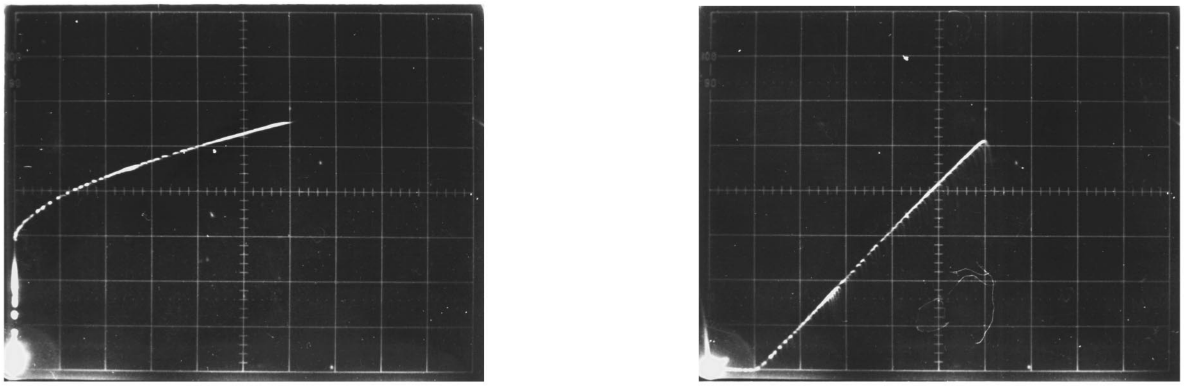
The reported device and an HM 1005 Hameg oscilloscope were used to get photographs of the *V-I* and *P-I* curves for two diode lasers (which are described in Sec. 2). In Fig. 3(a), 3(b), the photographs of the curves for the laser with growth imperfections (DL1) are presented, and in Fig. 4(a), 4(b) the corresponding curves shot for the higher-quality laser (DL2).

The peak optical emitted power of the diode lasers was measured with an Rm-3700 Laser Probe Universal Radiometer. *Only during the measurement of the peak emitted optical power,* the value of capacitor C_3 was increased



(a) (b)

Fig. 3 Photographs of the characteristic curves for DL1, as visualized on an oscilloscope in the *X-Y* regime: (a) *V-I* curve: $Y = 0.5$ V/div; (b) *P-I* curve: $Y = 26.5$ mW/div; $X = 0.2$ A/div for both (a) and (b).



(a) (b)

Fig. 4 Photographs of the characteristic curves for DL2, as visualized on an oscilloscope in the *X-Y* regime: (a) *V-I* curve: $Y=0.5$ V/div; (b) *P-I* curve: $Y=118.8$ mW/div; $X=0.2$ A/div for both (a) and (b).

enough so that the voltage supply for the pulse generator was well filtered (1000 μF instead of 3.3 μF). In that case, the current pulses were no longer amplitude modulated, but their amplitudes were all I_{max}. In fact, we have thus measured the time-averaged emitted optical power P_{av}, which corresponds to peak-power pulses (as the detector head of the radiometer—a thermopile—averages its photoresponse). According to the relationship $P_{av}=(\Delta t/T)\times P_{peak}$, since the duty factor ($\Delta t/T$) was 0.039, a peak optical power P_{peak} of approximately 138 mW resulted for DL1, and of approximately 606 mW for DL2, which reflected the DL manufacturer's specifications.

Figure 5 is a photograph of the reported device (note the pen on top of it). Behind it the optical mounts of the diode laser and photodiode can be seen.

4 Conclusion

Despite its complex capabilities, we consider that the actual configuration of the reported device ensures its compact-size realization and user-friendliness. Its scheme is simple enough, and, most important, to completely change its parameters is a very easy job. It allows one to accurately visualize important characteristic curves for diode lasers, using an ordinary oscilloscope.

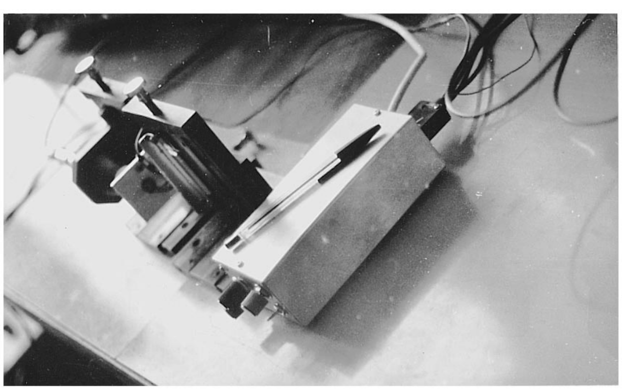


Fig. 5 Photograph of the setup used, including the reported device.

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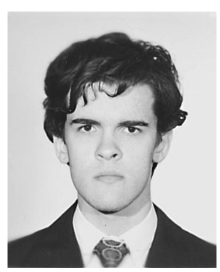

Emil Smeu graduated from the Electronics Faculty of the Politehnica University of Bucharest in 1982. He is now a scientific researcher at the Physics Department of the Politehnica University and an associate lecturer. He is an expert in laser radiometry: he designed, built, and tested the first digital laser power meter and also the first digital laser energy meter in Romania. He was also involved in the realization of a medium-speed digital waveform recorder. He is working on his Doctor's thesis in Technical Physics, on the subject of digital laser radiometry. His job at the Physics Department of PUB is to set up the Romanian National Laser Metrology Laboratory.

Biographies and photographs of other authors appear with the paper ''Fabrication, characterization, and applications of high-performance AlGaAs-based buried-heterostructure diode lasers'' in this issue.