Electro-optically Q-switched RF excited partial Z-folded CO_2 waveguide laser

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An electro-optically Q-switched partial Z-folded RF CO_2 waveguide laser with an intracavity CdTe modulator has been designed and characterized. The partial Z-fold channel is 3×460 mm in length. In this paper we study the laser output power as a function of gas pressure for partial Z-fold channel without Q-switched crystal inside the cavity. The maximum laser output power is about 21 W. For Q-switch operation, the peak power is 730 W and the pulse width is 150 ns.

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Electro-optically Q-switched laser technology has been applied to some fields of study, such as a laser radar, high-resolution laser spectroscopy, and metrology[1−4]. In order to improve the laser output power, we design an electro-optically Q-switched RF excited partial Z-folded CO_2 waveguide laser. The maximum CW laser output power is about 21 W without Q-switched crystal inside cavity. The peak power of Q-switched laser is 730W and the pulse width is 150 ns.

Our design is shown in Fig. 1. The laser is designed around a metal ceramic sandwich waveguide, which has a 2.25×2.25 mm^2 cross-section. The waveguide channel excited by the RF source is partial Z-fold structure and placed within a water-cooled stainless vacuum housing which incorporate a RF feed through to enable power to be transmitted to the gas medium. The partial Z-fold channel is 3×460 mm in length.

For reducing coupling losses for the EH_{11} mode and easy to insert a modulator crystal and other optical elements into the resonator, we designed equivalent Case III waveguide resonator for partial Z-fold channel. Three total reflectors are at the elbow parts of Z-fold. A flat ZnSe window is placed 5mm away from the front of the partial Z-fold waveguide. A ZnSe lens and a output mirror, which are closed as soon as possible, are equivalent to concave mirrors as Case III waveguide resonator for partial Z-fold channel. The three total reflectors, and ZnSe window are attached to the vacuum housing with mounts sealed by "O" ring, which permitted angular adjustments along the two orthogonal axes.

In this new structure, the laser head is fed by a power (0 − 300 W) and frequency (80 MHz) controllable RF transmitter and it is matched to 50 Ω by a network based on a tunable strip line. Ten parallel inductors are placed across the electrodes to form a resonant transmission line at 80 MHz. The network was chosen in order to minimize the power losses due to stray resistances and to avoid in the meantime voltage differences on the longitudinal direction of the waveguide[5]. In this way we can assume with confidence that the RF power, measured at the RF source by a bird through line directional power meter, is completely delivered to the discharge.

At the condition of RF input power 300 W, RF frequency 80 MHz and the ratio of unoptimized gas mixture $CO_2 : N_2 : He = 1 : 1 : 3$. The partial Z-fold channel can uniformly discharge simultaneously and the 10p(18) laser output is achieved from this channel. Laser power was measured with a LP-3C power meter. The laser power as a function of the gas pressure is shown in Fig. 2. The maximum output power is 21 W at the gas pressure is 8 kPa.

In order to get Q-switch operation, we insert Q-switch into the cavity. The schematic diagram of the Q-switched laser is shown in Fig. 3. The Q-switch includes CdTe crystal, Brewster window and $\lambda/4$ phase plate. The $\lambda/4$ voltage of the CdTe crystal at 10.5710 μm is 2.3 kV. The pulse repetition rate can be tuned from 1 Hz to 10 kHz. At a pulse repetition rate of 10 kHz, the Q-switched laser pulse is detected by a photovoltaic of a HgCdTe detector and the laser waveform is monitored on TDS3032 digital storage oscilloscope. At the condition of RF input power

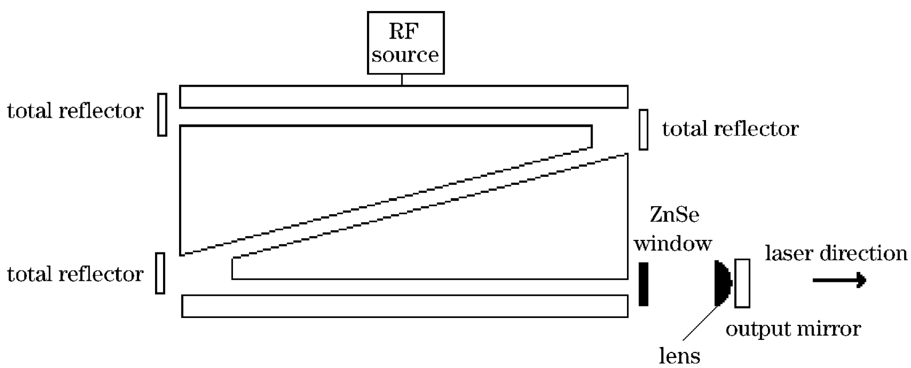

Fig. 1. Structure of partial Z-folded waveguide Q-switching CO_2 laser with common electrodes.

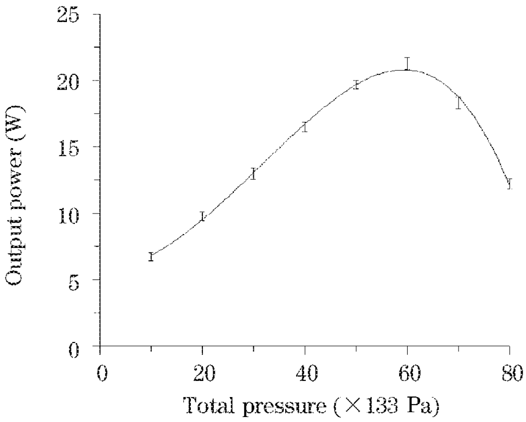

Fig. 2. Laser output power as a function of gas pressure.

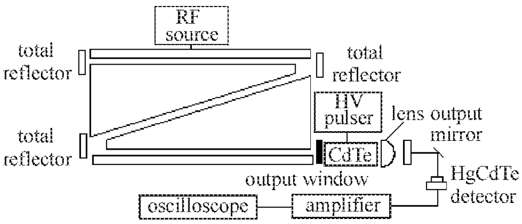

Fig. 3. Schematic diagram of the Q-switched CO_2 waveguide laser.

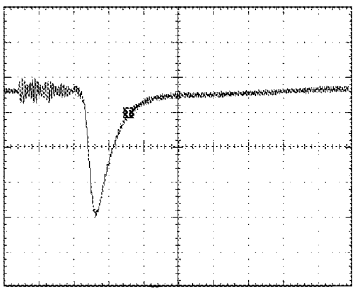

Fig. 4. Electro-optically Q-switched laser pulse waveform at a repetition frequency of 10 kHz (200 ns/div).

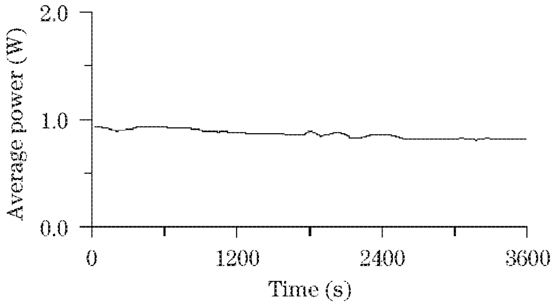

Fig. 5. Variation of the output power in long term.

300 W, gas pressure 8 kPa, the electro-optically Q-switched pulse laser waveform from the partial Z-folded channel is shown in Fig. 4 with 730-W peak power and 150-ns pulse width. The tail phenomenon is obvious. The pulse setup time is about 270 ns, and the pulse is stable in long-term observation on the oscilloscope. We also measured variation of average output power in long term for Q-switched laser output at the pulse repetition rate of 10 kHz (see Fig. 5). It can be seen from the figure that the variation of average output power is less than $\pm 7\%$ during one hour period.

In conclusion, the objective of this study was to explore method of obtaining high peak power from an electro-optical Q-switching partial Z-folded laser. The main advantages of the laser are a compact structure, small size and lower cost. These advantages can well satisfy the requirements of laser radar and other scientific study.

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