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FINE TUNING OF AN INJECTION-LOCKED TEA CO_2 LASER BY MEANS OF INTRACAVITY ACTIVE FREQUENCY SHIFT

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INTRODUCTION

We have developed a new technique for shifting the frequency of TEA and high-pressure CO_2 lasers,[1] primarily for the purpose of isotope separation, but it can also be applied to remote sensing of atmosphere. This technique utilizes an acousto-optic (AO) frequency shifter inside the cavity, where the frequency shift starts from one of lasing lines in a cw CO_2 master laser to a desired value by controlling the gate pulsewidth of the Pockels cell. Tuning characteristics and the maximum frequency shift obtained with a TEA CO_2 laser are investigated and discussed together with a possibility of further shifting the frequency.

EXPERIMENTAL APPARATUS

Figure 1 shows the experimental arrangement. The system was mainly composed of an injection-locked TEA CO_2 laser with a cw CO_2 master oscillator. The output beam of the master oscillator was injected into the TEA laser cavity through a ZnSe rear reflector with a transmission of 5 %. In addition to the main cavity which include the rear reflector and a 50-% ZnSe output coupler, a subcavity was constructed by the common rear reflector and a total reflector. The length of both cavities was 2.2 m. When operated with only the main cavity, the system generated the single-longitudinal output as is obtained in conventional injection-locked TEA CO_2 lasers. The AO shifter was installed between the thin-film polarizer and the total reflector in the subcavity.

The laser beam growing up from the injection seed, which was linearly polarized inside the main cavity, was switched to the subcavity via the thin-film polarizer by a Pockels cell. In the subcavity the laser frequency shifted every passage through the AO shifter which was powered by a RF generator at a frequency of 40 MHz. After the frequency was shifted to a desired value, the beam was switched back to the main cavity and a fully-grown pulsed output with the shifted frequency was extracted through the output coupler. Dependence of the total frequency shift on the gate pulsewidth of the Pockels cell was calculated to be 5.4 GHz/μs from the round-trip time of 14.7 ns and the round-trip frequency shift of 80 MHz.

The experiment was carried out at the most intense line, 10P(20), since no dispersive

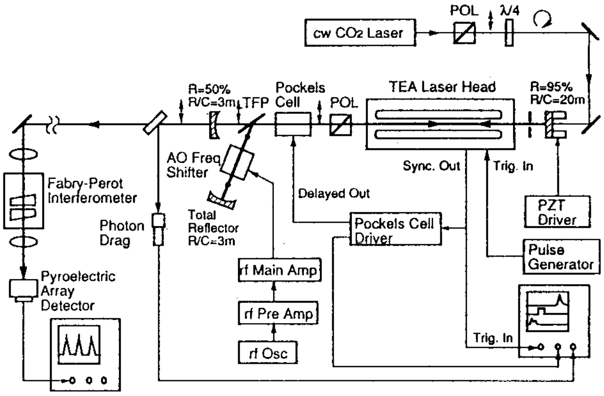

Fig. 1 Experimental apparatus.

element for the coarse tuning was employed. Timing between the CO_2 laser and the Pockels cell was adjusted by a Pockels cell driver which was triggered by a synchronized monitor signal of the discharge current. After a given delay time, it applied a quasi-square gate pulse to the Pockels cell. The pulsewidth was variable from 40 ns to longer than 1 ms. The gate pulse was set so as to start before the laser intensity reached the saturation regime.

RESULTS AND DISCUSSION

Figure 2 shows typical time histories of discharge current, gate pulse, and laser output pulses. When the laser was operated without a gate pulse, the laser output pulse appeared at 1.4 μs after the discharge current started. With a gate pulse of 100 ns duration for shifting the frequency inside the subcavity, it was observed about 200 ns earlier than that without the gate pulse since the loss in the subcavity was lower than in the main cavity. The beat pulse appeared in the frequency-shifted output corresponded to the cavity mode spacing of 68 MHz. This was caused by mismatching between the main cavity frequency and the shifted laser frequency, which had been recognized as two-mode oscillations in usual injection-locked lasers.[2,3] The amount of frequency shift was measured by using a Fabry-Perot interferometer and a pyroelectric-array detector. The frequency shift corresponded to the gate pulsewidth of 100 ns was measured to be 300 MHz.

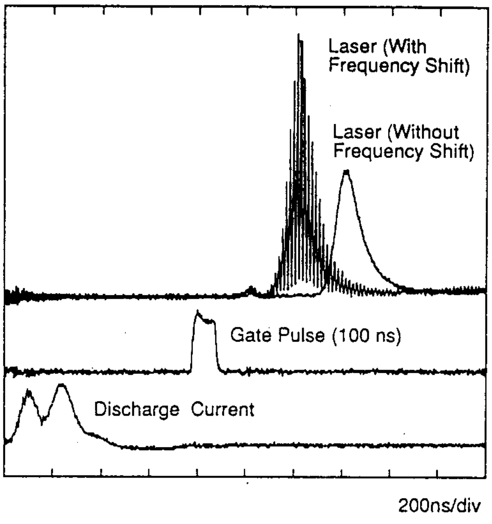

Fig. 2 Typical time histories of discharge current, gate pulse, and laser output pulses with and without the frequency shift.

Figure 3 shows the measured frequency shift as a function of the gate pulsewidth. Within the resolution, the slope of 5.3 GHz/μs agreed well with the estimated value mentioned above. The maximum frequency shift obtained was 1.37 GHz at a gate pulsewidth of 300 ns. When the gate pulsewidth was longer than 300 ns, an unshifted output pulse came to appear in competition with a frequency-shifted pulse. For further shifting the frequency, the rise and fall times of the Pockels cell should be shortened together with improving the extinction ratio of the Pockels cell as high as possible.

SUMMARY

The intracavity active frequency shift was successfully demonstrated in a TEA CO_2 laser. The frequency shift was a function of the gate pulsewidth of the Pockels cell, which resulted in continuous frequency shift starting from the frequency at one of the discrete lines seeded from the master laser. In this experiment the frequency at the 10P(20) line was shifted in the mirror-mirror cavity, however, the use of low-dispersive grating for coarse tuning can enable us to select other wavelength region. This method is most appropriate to the high-pressure CO_2 laser combined with a multi-isotope master laser[4] for fine tuning over a wide range of the spectrum.

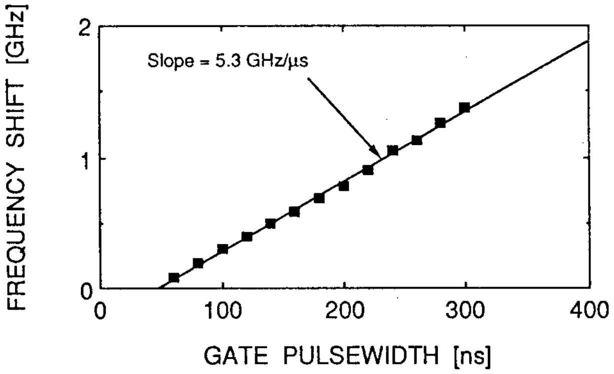

Fig. 3 Frequency shift as a function of the gate pulsewidth.

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