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High-Speed Frequency-Sweeping Semiconductor Laser for Remote Sensing

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1. Introduction

In the case of DIAL measurement, on and off-line frequencies must be selected to be as close as possible, and the laser beams which have on and off frequencies must be radiated nearly simultaneously. Semiconductor lasers (SLs) have several advantages such as small size and high efficiency. SLs can be tuned to a wide range of frequencies by temperature control. Moreover, a high-speed frequency tuning can be realized easily by using frequency sweeping by high-speed, high-efficiency direct modulation of a single-mode SL[1,2]. Moreover, by injection seeding of the SL beam to a Ti: Al_2O_3 laser or dye laser, high-energy laser pulses can be obtained. This paper describes the characteristics of high-speed frequency sweeping of the single-mode visible AlGaInP laser.

2. Experiment and Result

We measured the amplitude of frequency sweeping of a single-mode visible AlGaInP laser (Toshiba Corp., TOLD9215) when it was operated with sinusoidal direct modulation. The temperature of the SL was controlled with the temperature stability of 1 mK using a thermoelectric cooler. The laser spectrum was measured using a scanning Fabry-Perot interferometer (free spectral range: 7.5 GHz). Figure 1 shows the lasing spectrum of the AlGaInP laser operated with 2 MHz sinusoidal direct modulation. Figure 2 shows the maximum laser frequency shift of the AlGaInP laser against the modulation frequency. The maximum laser frequency shift increased when the modulation frequency became low, and the maximum laser frequency shift of 9.7 GHz was obtained. A larger laser frequency shift will be obtained when the SL is operated with lower modulation frequency.

Figure 3 shows the experimental setup for time-resolved measurement of frequency sweeping. The single-mode visible AlGaInP laser was operated with pulsed sinusoidal direct modulation. The drive current and image intensifier trigger waveforms are shown in Fig. 4. The variation of the interference fringe generated by a Fabry-Perot etalon was observed with a gated image intensifier and a camera. We calculated the frequency shift from the variation of the interference fringes. The results when the AlGaInP laser is operated with modulation frequency of 1 MHz and 2 MHz are shown in Fig. 5. When it was operated with 1 MHz modulation, the laser frequency varied slightly following the current variation, and a frequency shift of 8 GHz within 600 nsec was obtained.

We also measured the wavefront variation during frequency sweeping. The single-mode AlGaInP laser wavefront was not distorted during frequency sweeping even when it was operated with 2 MHz modulation. The high-speed frequency-sweeping single-mode SL can be used as a frequency control laser for remote sensing.

References

[1] T. Fujii et al., "Visible Semiconductor Laser for Application to Isotope Separation", IEEE Lasers and Electro-Optics Society 1991 Annual Meeting, San Jose, CA, November 4-7, 1991, SADL6.4.

[2] T. Fujii et al., "Characteristics of Visible Semiconductor Laser as Frequency-Tunable Laser", The 6th International Symposium on Advanced Nuclear Energy Research, Mito, Ibaraki, Japan, March 23-25, 1994, Ⅲc-P3.

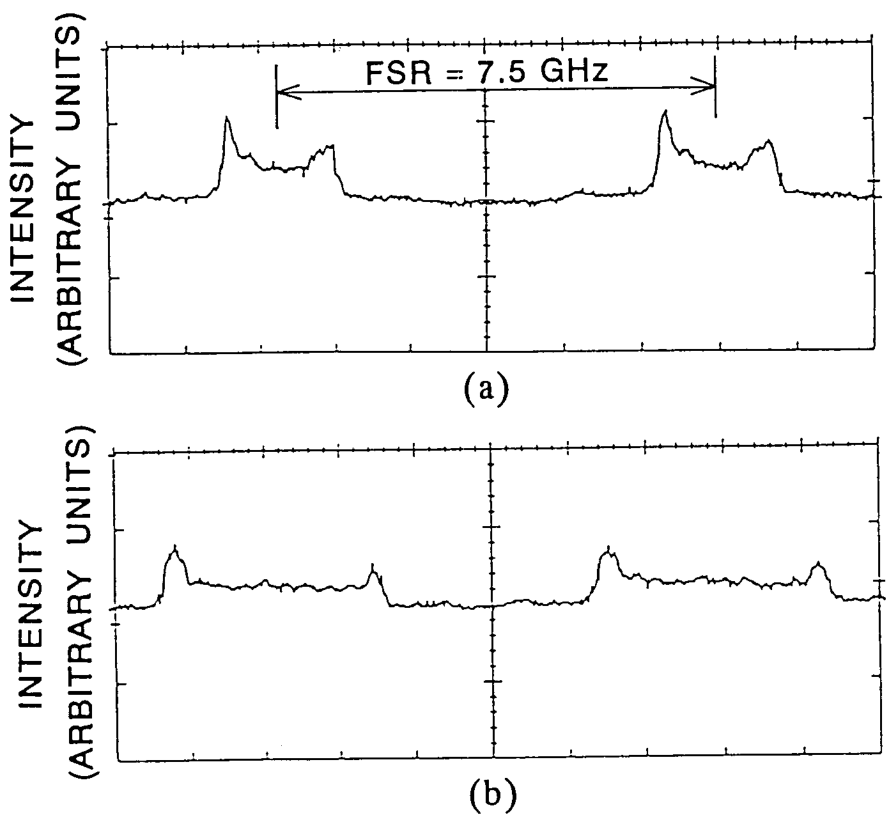

Fig. 1 Lasing spectrum of visible AlGaInP laser operated with 2 MHz sinusoidal direct modulation with modulation amplitude (peak to peak) of (a) 0.05Ith and (b) 0.1Ith. Ith: threshold current=33.2 mA and bias current=1.2Ith.

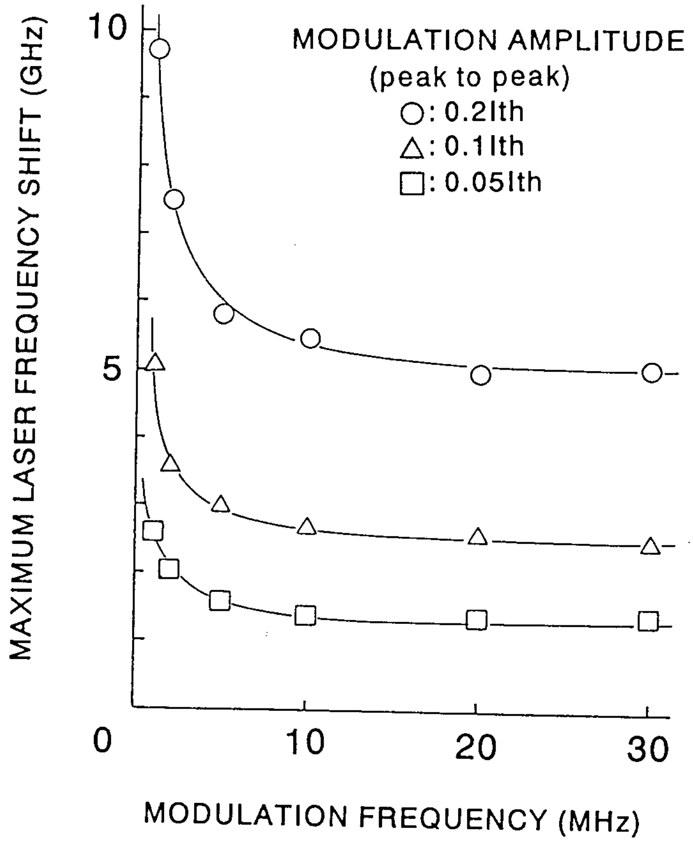

Fig. 2 Maximum laser frequency shift versus modulation frequency of visible AlGaInP laser. Ith: threshold current=33.2 mA and bias current=1.2Ith.

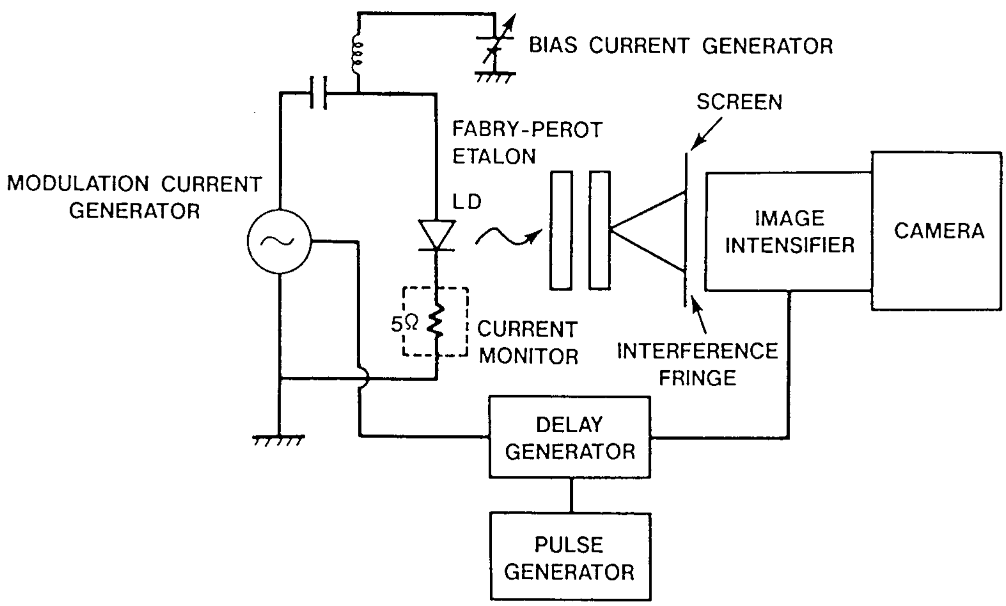

Fig. 3 Experimental setup for time-resolved measurement of frequency sweeping.

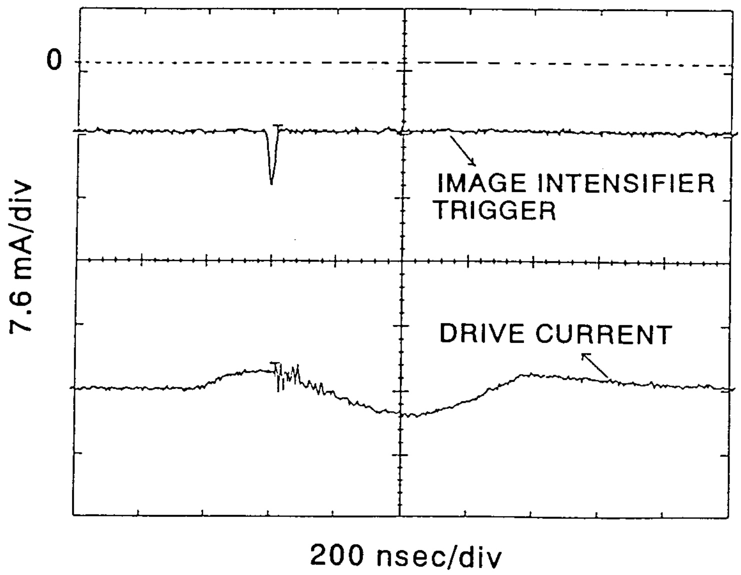

Fig. 4 Drive current waveform of visible AlGaInP laser and image intensifier trigger with 1 MHz sinusoidal direct modulation.

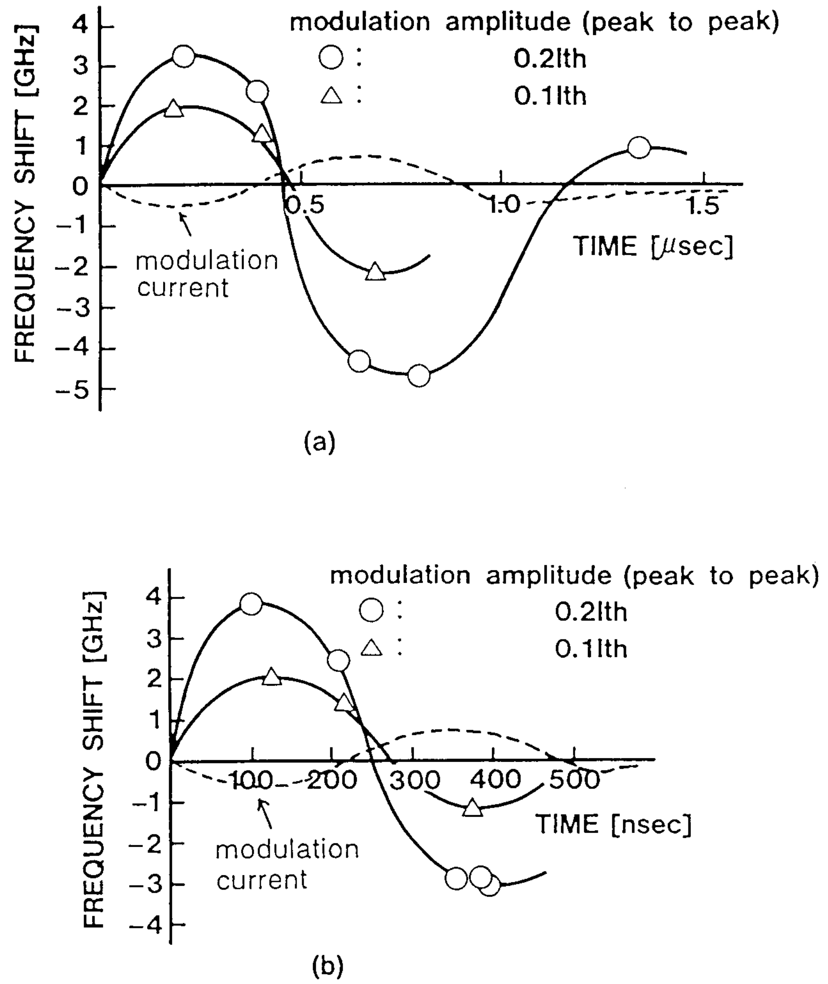

Fig. 5 Frequency shift of visible AlGaInP laser versus time when operated with (a) 1 MHz and (b) 2 MHz sinusoidal direct modulation. Ith: threshold current=33.2 mA and bias current=1.2Ith.