VCSEL`s frequency stabilization using an external cavity setup

– Countermeasures against atmospheric temperature variations –

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1. Introduction

Semiconductor lasers boast significant advantages over their competition; lower cost, greater efficiency and durability. However, because their spectra are not stable or pure as the other lasers, we need to encounter them in using it for next-generation optical communications- and measurement-applications. So, the only obstacles to their use in these areas appear to be the susceptibility of their oscillation frequencies to fluctuations in input voltage and ambient temperature; issues that have confronted researchers from the start. The experiments now underway in our facility involve the stabilization of a temperature-controlled semiconductor laser's oscillation frequency, through the management of its driving current.

External cavity diode lasers (ECDLs) appear to have the greatest potential, as laser light-sources for advanced optical measurement systems. While they normally require an active external cavity-control device, we replaced this element with a second external cavity; a technique that boasts the added advantage of having a narrower oscillation-linewidth than would be achievable, using a single optical feedback.

VCSEL is now commercially available, and the ECDL systems using them are expected to improve their frequency stability, we have replaced a Fabry-Perot type laser diode with a VCSEL, and examined its oscillation-frequency stability. Therefore we expect that the VCSELs with our double optical feedback system have good oscillation frequency stability.

2. Experiment

We introduced the vertical cavity surface emitting laser (VCSEL) as the laser diode in our external cavity system. The VCSEL has low threshold current, single-longitudinal-mode operation, a circular output beam, wafer-scale integration and less mode hopping characteristics by the temperature change than the other semiconductor lasers.

The output of semiconductor lasers VCSEL1 and VCSEL2 is divided by a beam splitter (BS1), as shown in Fig. 1. The resulting beams are further divided by BS2, and fed back to the semiconductor lasers from mirror of Littrow arrangements. These oscillation widths will be characteristically narrower than would be nothing. In constructing our ECDL systems, we mount two systems on a 230mm×230mm, iron/nickel alloy, super-invar "breadboard", to eliminate the influence of atmospheric temperature on resonator-length.

The ECDL semiconductor laser systems are temperature controlled within 1/100K or 1/1000K variation. We measured a beat signal output between two ECDL systems from APD and evaluated the relative frequency stability of two ECDL systems, by calculating the Square root of the Alan variance.

3. Result and Examination

Because Low Frequency Fluctuations (LFF) were considered to be problems in the single optical feedback ECDL system, we upgraded to one based on dual optical feedback. The resulting improvements in the ECDL systems' oscillation-frequency stability are shown in (Fig. 2), but stability can be maintained, only when temperatures are precisely controlled.

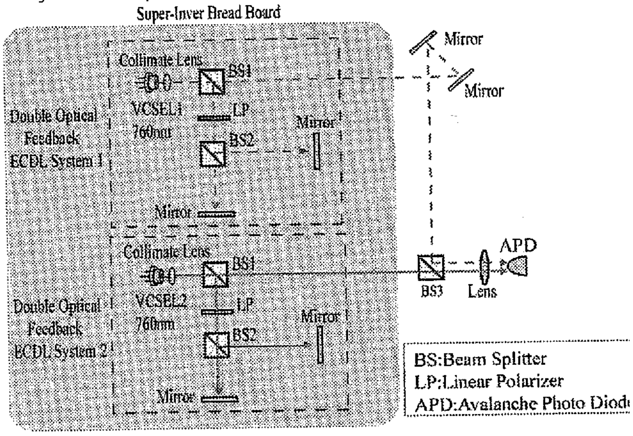

Fig.1 Optical Setup

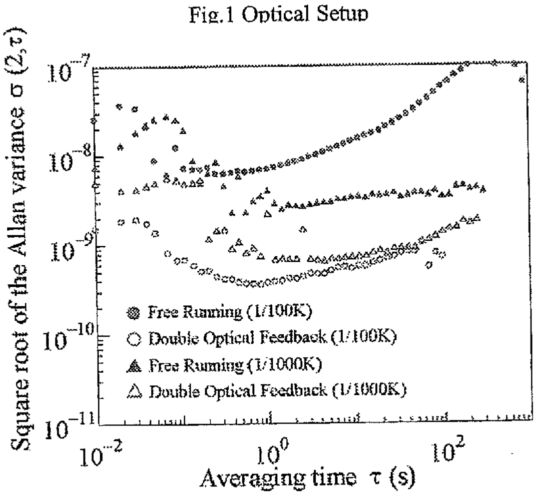

Fig.2 Stabilities of oscillation frequency