SAN098-0517C

SAND--98-0517C

Composite Resonator Vertical Cavity Laser Diode

CONF-980529--

Kent D. Choquette, H. Q. Hou, W. W. Chow,
K. M. Geib, and B. E. Hammons

Center for Compound Semiconductor Science & Technology

Sandia National Laboratories

Albuquerque, NM 87185

(505) 844-7287 voice

(505) 844-8985 FAX

kdchoqu@sandia.gov

RECEIVED

MAR 09 1998

OSTI

Abstract

We report the first composite resonator vertical cavity laser diode consisting of two optical cavities and three monolithic distributed Bragg reflectors. Cavity coupling effects and two techniques for external modulation of the laser are described.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

MASTER

19980420 079

Composite Resonator Vertical Cavity Laser Diode

Kent D. Choquette, H. Q. Hou, W. W. Chow,
K. M. Geib, and B. E. Hammons

Center for Compound Semiconductor Science & Technology
Sandia National Laboratories
Albuquerque, NM 87185

The use of two coupled laser cavities has been employed in edge emitting semiconductor lasers [1] for mode suppression and frequency stabilization. The incorporation of coupled resonators within a vertical cavity laser opens up new possibilities due to the unique ability to tailor the interaction between the cavities. Composite resonators can be utilized to control spectral and temporal properties within the laser; previous studies of coupled cavity vertical cavity lasers have employed photopumped structures [2],[3]. We report the first electrically injected coupled resonator vertical-cavity laser (CRVCL) diode and demonstrate some of the novel characteristics arising from the cavity coupling, including methods for external modulation of the laser.

Fig. 1 depicts the CRVCL which consists of a lower $1\text{-}\lambda$ thick active resonator containing 3 InGaAs quantum wells and a passive upper resonator composed of $1\text{-}\lambda$ thick GaAs. In the bottom active cavity we employ selective oxidation of AlGaAs to form buried oxide layers for efficient electrical and optical confinement [4]. Separate electrical contacts to each cavity provide independent current injection into the two resonators. The coupling between the resonators is controlled by the transmission of the shared middle distributed Bragg reflector. Fig. 2(a) is a plot of the cavity resonances as a function of mirror periods in the middle distributed Bragg reflector (DBR). As the DBR reflectivity decreases, the resonance splitting and thus cavity coupling increases. The resonances shift in opposite directions in Fig. 2(a) which may be important for frequency tuning applications. In Fig. 2(b) we show the measured reflectance

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

of a CRVCL with a 11.5 period middle DBR: the two cavity resonances are 14 nm apart in Fig. 2(b), in agreement with our calculations in Fig. 2(a).

In Fig. 3 we show the cw light output from a large aperture ($20 \times 20 \mu\text{m}$) CRVCL with injection current into the lower active cavity. A single lasing emission at 997 nm corresponding to the longer resonance in Fig. 2(b) is observed. Lasing emission from only the eigenmode of the lower active cavity is apparent, since the upper passive cavity eigenmode is not adequately pumped even with current injection into the passive resonator (although increased spontaneous emission is observed). For increasing current applied to the top passive cavity, the lasing output decreases in Fig. 3, while the spontaneous emission continues to increase below threshold. Injection current into the passive cavity changes its optical path length which modifies the composite cavity wavefunction, leading to decreased overlap with the quantum wells in the active cavity. Thus the behavior in Fig. 3 conclusively demonstrates that a coupled resonator effect is responsible for the reduction of light output above lasing threshold. Moreover, by slightly reverse biasing the top cavity, the lasing is completely extinguished, due to cavity enhanced absorption in the top cavity. Using this effect, 50 MHz large signal modulation of the CRVCL (apparatus limited) has been achieved. Note with the bottom cavity maintained above threshold and employing coupled cavity effects for modulation, chirp-free high speed modulation should be possible and is under investigation. This work was supported by the U. S. DOE under contract No. DE-AC04-94AL85000.

References

- [1] W. T. Tsang, N. A. Olsson, and R. A. Logan, Appl. Phys. Lett. **42**, 650 (1983).
- [2] R. P. Stanley, R. Houdre, U. Oesterle, M. Ilegems, and C. Weisbuch, Appl. Phys. Lett. **65**, 2093 (1994).
- [3] P. Michler, M. Hilpert, and G. Reiner, Appl. Phys. Lett. **70**, 2073 (1997).
- [4] K. D. Choquette, R. P. Schneider, Jr., K. L. Lear, and K. M. Geib, Electron. Lett. **30**, 2043 (1994).

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-AC04-94AL85000.

Figure Captions

Figure 1. Top view and sketch of coupled resonator vertical cavity laser (CRVCL).

Figure 2. (a) Cavity resonances resulting from CRVCL with varying mirror periods (reflectivity) in the middle mirror between the cavities. (b) Measured reflectivity of CRVCL with 11.5 periods in the middle mirror showing two resonances (denoted by arrows).

Figure 3. Light output versus injection current into the bottom active cavity for various values of constant current injected into the top (passive) cavity.

Figure 1
CLEO98
Choquette
Composite Resonator VCL

Figure 2
CLEO98
Choquette
Composite Resonator VCL

Figure 3
CLEO98
Choquette
Composite Resonator VCL

M98004115

Report Number (14) SAND--98--0517C

CONF-980529--

Publ. Date (11) 199805

Sponsor Code (18) DOE/CR, XF

UC Category (19) UC-900, DOE/ER

DOE