(Electronics Letts. Vol.35, No.21, p.1847; 14th October 1999)

Broad Tunability of Grating Coupled Surface Emitting Laser with External Cavity

Jun Jiang, Oleg Smolski, Chandra Roychoudhuri
Photonics Research Center/ESE, U-192, University of Connecticut, Storrs, CT 06269, USA.
Efim Portnoi, Georgy Venus, Idris Gadjiev
Ioffe Physico-Technical Institute, 26 Polytechnicheskaia ul., St. Petersburg, 195021, Russia.
John McKillop
Laser Fare Inc., Advanced Technology Group, 70 Dean Knauss Drive, Narragansett, RI 02882, USA.

Abstract
The wavelength tuning properties of an InGaAs Grating Coupled Surface Emitting Laser (GCSEL) are presented. Wide, continuous tunable laser oscillation has been observed over a range of 115nm, between 900nm-1015nm, under pulsed current excitation. Different External Cavities have been studied to achieve the optimal performance.

Continuous, wide tunability of semiconductor lasers is very useful in light wave communications, light wave testing and measurement applications and spectrometric research and related commercial products. Semiconductor lasers generally exhibit broadband gain and can emit radiation over a wide spectrum under proper operating conditions. Single quantum well (SQW) lasers can take better advantage of the broad gain bandwidth than bulk double heterostructure lasers because of their thinner active region and larger band filling at the same current density. Tuning of the conventional cleaved-cavity SQW lasers with an external grating has been demonstrated in the range over 100 nm previously [1]-[3]. But they suffer from competition with internal FP modes unless super AR coating is deposited on one of the laser facets that emit the laser beam with a very large transverse beam divergence. Grating coupled surface emitting laser (GCSEL) possesses interesting characteristics such as higher output power, wavelength selectivity and lower divergent optical beam. Initial demonstrations of GCSEL were reported by several groups in 1975, [4]-[7] since then, different versions of GCSEL have been developed. We report here, to our knowledge, for the first time, the results of an off-resonance GCSEL in an external cavity. It has two fold advantages. First, it does not have internal feedback mechanism and hence it does not require any AR coating and consequently there is no internal FP mode competition. Second, the wide area GCSEL beam divergence is much lower and hence beam coupling optics and mounting mechanics are less stringent than for conventional FP devices.

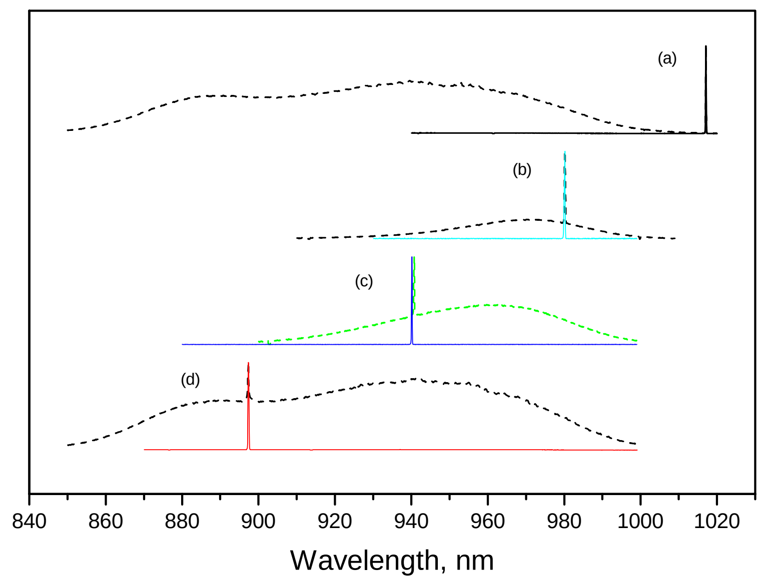

Figure 1. Demonstration of 115 nm tunability (laser power vs. wavelength) of a GCSEL device. Spectra were measured from the cleaved facet side of the GCSEL with feedback from a 100% mirror near grating. The dashed curves correspond to spectra at the lasing threshold condition (Jth) for different wavelength. The intensity of lasing line-spectra (the solid lines) are normalized to the same arbitrary fixed height and superposed on their respective threshold spectra (the dashed curves). The pumping current densities for the spectra are:
(a) Jth= 8.0 kA/cm2 (dashed) ; J = 8.6 kA/cm2 (solid). (b) Jth= 0.3 kA/cm2 ; J = 1.0 kA/cm2.
(c) Jth= 1.0 kA/cm2 ; J = 2.0 kA/cm2. (d) Jth= 7.4 kA/cm2 ; J = 8.0 kA/cm2

The device was fabricated from graded-index separate-confinement heterostructure single quantum well (GRINSCH-SQW) wafers. It consists of a 600m long amplifier section with 100m wide stripe and an 800m long off-resonance passive grating with 340nm period. With this GCSEL, it is very easy to get external cavity lasing by simply using a flat mirror as the feed back element in front of the grating. Figure 1 shows the tuning characteristics of this system, from which we can see a tunable range of 115nm. In agreement with other work [2], we see that, at sufficiently high current density, as the resonator losses reach a certain level relative to the gain at the first quantized state, lasing switches over to a higher energy transition, corresponding to the second quantized state.

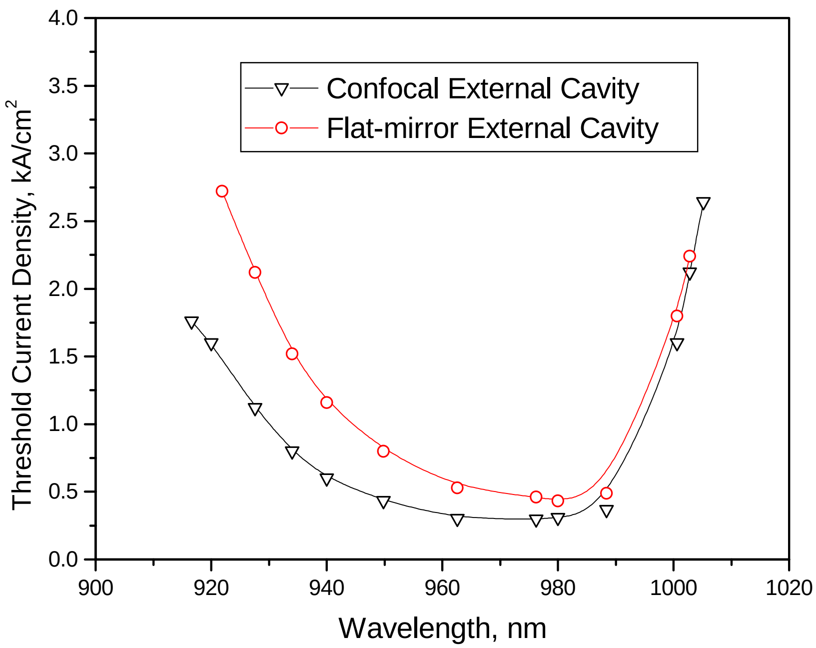

Figure 2. Comparison of the threshold current density characteristics of the flat-mirror cavity and the confocal cavity. Confocal cavity has lower loss and wider tuning ability under the same pump current.

Figure 2 shows a plot of the threshold current density as function of the tuned lasing wavelength, from which we can see a substantial increase in threshold current density on both the long and the short wavelength side. Also we see, the tuning curves are asymmetric that corresponds to the two quantized gain states of the SQW. Data from different external cavities have been compared, showing that the confocal cavity experiences lower loss and thus is able to get wider tuning range under the same pumping condition. Detailed results will be published elsewhere.

In conclusion, an 115nm wide continuous tunability was obtained using an external cavity off-resonance GCSEL gain element. Different schemes of external cavities have been studied, showing the potential to further improve the tuning characteristics.

Acknowledgment: We wish to thank the Connecticut Innovation and US Air Force Research Lab. for financial support for this research work.

Reference:

1. D.G.Mehuys, M. Mittelstein, A. Yariv: “Optimized Fabry-Perot (AlGa)As quantum-Well Lasers Tunable over 105nm ”, Electron. Lett. 1989, **25**, pp143-145
2. L.E. Eng, D.G.Mehuys, M. Mittelstein, A. Yariv: “ Broadband Tuning (170nm) of InGaAs Quantum Well lasers ”, Electron. Lett. 1990, **26**, pp1675-1677

3. Michael Mittelstein, Yasuhiko Arakawa, Anders Larsson, and Amnon Yariv: " Second quantized state lasing of a current pumped single quantum well laser ", Appl. Phys. Lett. 1986, **49**, pp1689-1691
4. Alferov Zh. I., Andreyev V. M., Gurevich S. A., Kazarinov R. F., Larionov V. R., Mizerov M. N. and Portnoi E. L. : " Semiconductor lasers with the light output through the diffraction grating on the surface of the waveguide layer, " IEEE J. Quantum Electron. 1975, **QE-11**, pp449-451
5. Burnham, R.D., Scifres, D.R. and Striefer, W. :" Single heterostructure distributed-feedback GaAs diode lasers ," IEEE J. Quantum Electron. 1975,**QE-11**, pp435-449
6. Zory, P. and Comerford, L. D. : " Grating-coupled double-heterostructure AlGaAs diode lasers, " IEEE J. Quantum Electron. 1975, **QE-11**, pp451-457
7. Reinhart, F. K., Logan, R.A. and Shank, C.V. : " GaAs-AlGaAs injection lasers with distributed feedback reflectors, " Appl. Phys. Lett. 1975, **27**, pp45-48.