SAND--97-0902C SAND97-0902C

CONF-970510--6

ACCEPTED CLEO '97

Multiple Wavelength Vertical-Cavity Surface-Emitting Laser Arrays using Surface-Controlled MOCVD Growth Rate Enhancement and Reduction

G. G. Ortiz+, C. P. Hains, S. Luong and Julian Cheng

University of New Mexico
Center for High Technology Materials
Albuquerque, NM 87131

H. Q. Hou and G. A. Vawter

Sandia National Laboratories
Albuquerque, NM 87185

AUTHOR CONTACT INFO:
University of New Mexico
Center for High Technology Materials
EECE Building, Room 125
Albuquerque, NM 87131
vox: (505) 277-1623
fax: (505) 277-7245
e-mail: gortiz@chtm.eece.unm.edu

ABSTRACT

Multi-wavelength VCSEL arrays are achieved by the surface-controlled enhancement and depletion of the MOCVD epitaxial growth rate, with a repeatable, periodic wavelength span of > 30 nm (3.5%) over distances of < 5 mm.

+ NASA Fellow on leave from the Jet Propulsion Laboratory, Pasadena, CA.

DISCLAIMER

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Multiple Wavelength Vertical-Cavity Surface-Emitting Laser Arrays using Surface-Controlled MOCVD Growth Rate Enhancement and Reduction

G. G. Ortiz, C. P. Hains, S. Luong and Julian Cheng

University of New Mexico
EECE Building, Room 125
Center for High Technology Materials
Albuquerque, NM 87131

H. Q. Hou and G. A. Vawter

Sandia National Laboratories
Albuquerque, NM 87185

Multiple-wavelength VCSEL and photodetector arrays are useful for wavelength-multiplexed fiberoptic networks, and for optical crosstalk isolation in parallel, free-space interconnects. Multiple wavelength VCSEL arrays have been obtained by varying the growth rate using thermal gradients caused by a backside-patterned substrate [1], by growth enhancement on a patterned substrate [2], and by varying the cavity length through anodic oxidation and selective etching of the wafer [3]. We show here for the first time both the enhancement and the reduction of the growth rate of the entire VCSEL structure on a topographically patterned substrate, and demonstrate the controlled variation of the lasing wavelengths of a VCSEL array over an extended spectral range.

It is known that the growth rate of Al(GaAs) on an etched surface differs from that on a planar substrate [4]. The rate increases with a narrowing ridge width and decreases with narrowing of the width of the etched channel. The growth rate is also strongly dependent on both the depth and the spatial duty-factor of the etched pattern. By taking advantage of the concentration gradients produced by the local accumulation and depletion of the reactant species near ridges and channels, respectively, we are able to vary the growth rate of a VCSEL epilayer structure in a controllable manner, and fabricate multiple-wavelength VCSEL arrays with a wide range of lasing wavelengths.

The patterned GaAs substrate contains arrays of chemically-etched channels and ridges, with a constant period (p = 250 μm) but a varying width (w) and spatial duty-factor (1-w/p). An 850-nm-VCSEL epilayer structure was grown on this patterned substrate by MOCVD on a rotating substrate. The growth variations in the ridges and channels were investigated by the spatially-resolved optical pumping (Ti:sapphire laser at 790 nm) of both the ridge (enhancement regime) and channel (depletion regime) regions. Figure 1 plots the emission wavelength as a function of the spatial duty factor, showing that the cavity mode can be controllably varied over a wide wavelength range (>30 nm).

Top-surface-emitting, proton-implant-confined VCSELs were fabricated in both the ridge and channel regions simultaneously. The devices have uniform threshold currents (~ 5 mA) and voltages (~ 4 V). The lasing wavelength of each VCSEL was measured by keeping the power dissipation constant. The peak output powers were typically ~ 0.5 mW.

The lasing spectrum of several 12 μm diameter devices corresponding to different spatial duty factors are shown in fig. 2, and the lasing wavelengths for all devices are plotted in fig. 1. Due to limitations in the mask design, we were unable to fabricate devices in the narrower ridges and channels, and therefore only a reduced wavelength span of ~20 nm was demonstrated (fig. 1). The narrower regions are expected to lase, as shown by the optical pumping experiments and by the high quality of the material that is grown on these ridges (fig. 3). Although wavelength grading was previously demonstrated using only the enhancement regime [3], our data shows that a greater wavelength range can be achieved by also utilizing the depletion regime.

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-ACO4-94AL85000.

[1] L. E. Eng, K. Bacher, W. Yuen, M Larson, G. Ding, J.S. Harris, Jr. and C.J. Chang-Hasnain, Electronics Letters 31 (7), 562-563 (1995).

[2] F. Koyama, T. Mukaihara, Y. Hayashi, N. Ohnoki, N. Hatori, and K. Iga, IEEE PTL 7 (1), 10-12 (1995).

[3] T. Wipiejewski, M. G. Peters, E. R. Hegblom, and L. A. Coldren, IEEE PTL 7 (7), 727-729 (1995).

[4] L. Buydens, P. Demeester, M. Van Ackere, A. Ackaert and P. Van Daele, Journal of Electronic Materials, 19 (4), 317-321 (1990).

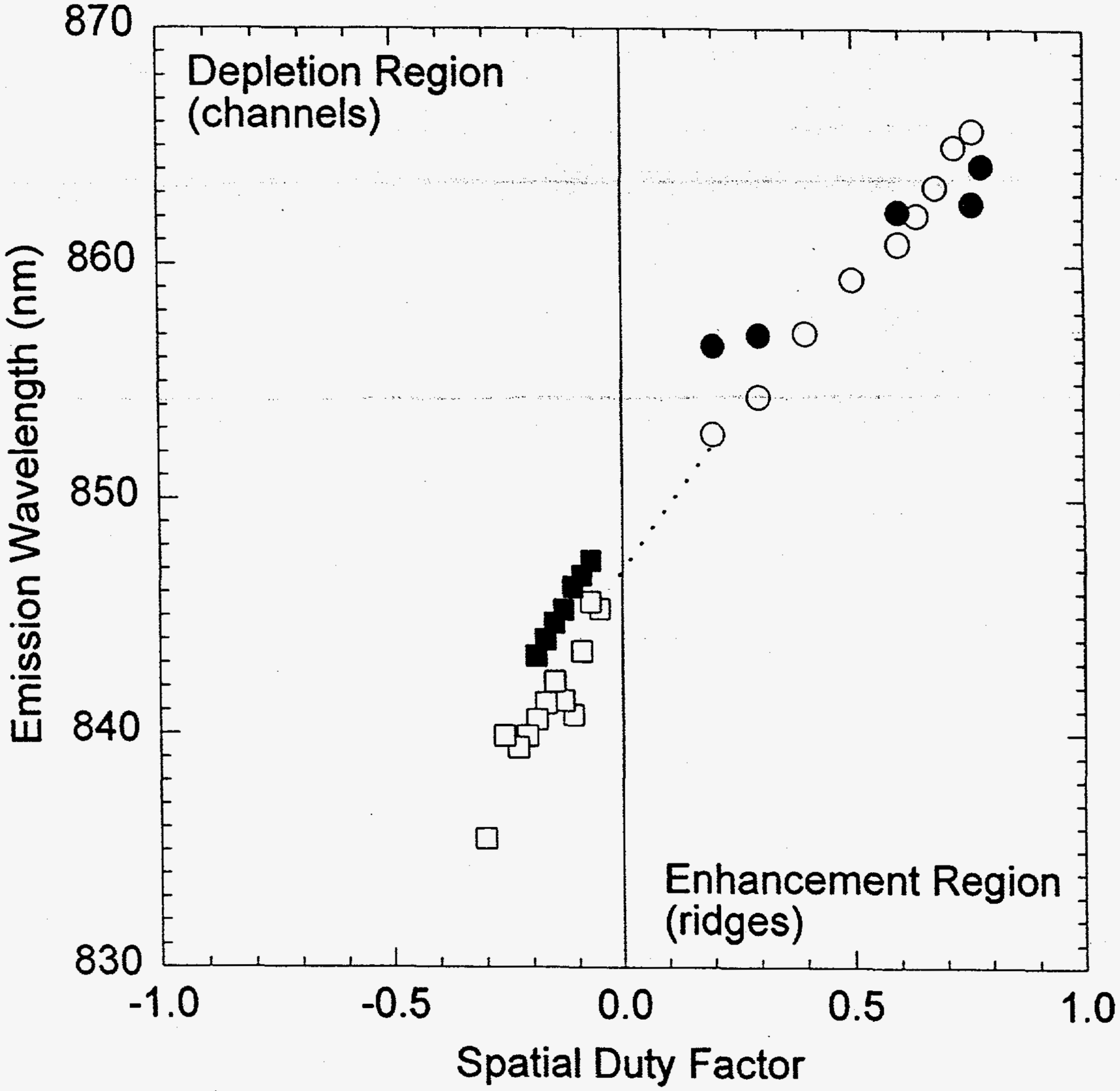
FIGURE CAPTIONS:

Figure 1. Emission wavelength vs. spatial duty factor demonstrates both regions of growth activity. Filled symbols are VCSEL lasing wavelength, while the open symbols represent the cavity resonant photoluminescence.

Figure 2. Lasing spectra of the wavelength-chirped VCSELs processed simultaneously in both the enhanced growth rate regime and the reduced growth rate regime.

Figure 3. SEM of the epitaxial growth of the 850 nm VCSEL over a very narrow etched ridge on a GaAs surface shows good quality of growth.

Figure 1



870
860
850
840
830
Emission Wavelength (nm)
Depletion Region
(channels)
Enhancement Region
(ridges)
-1.0
-0.5
0.0
0.5
1.0
Spatial Duty Factor

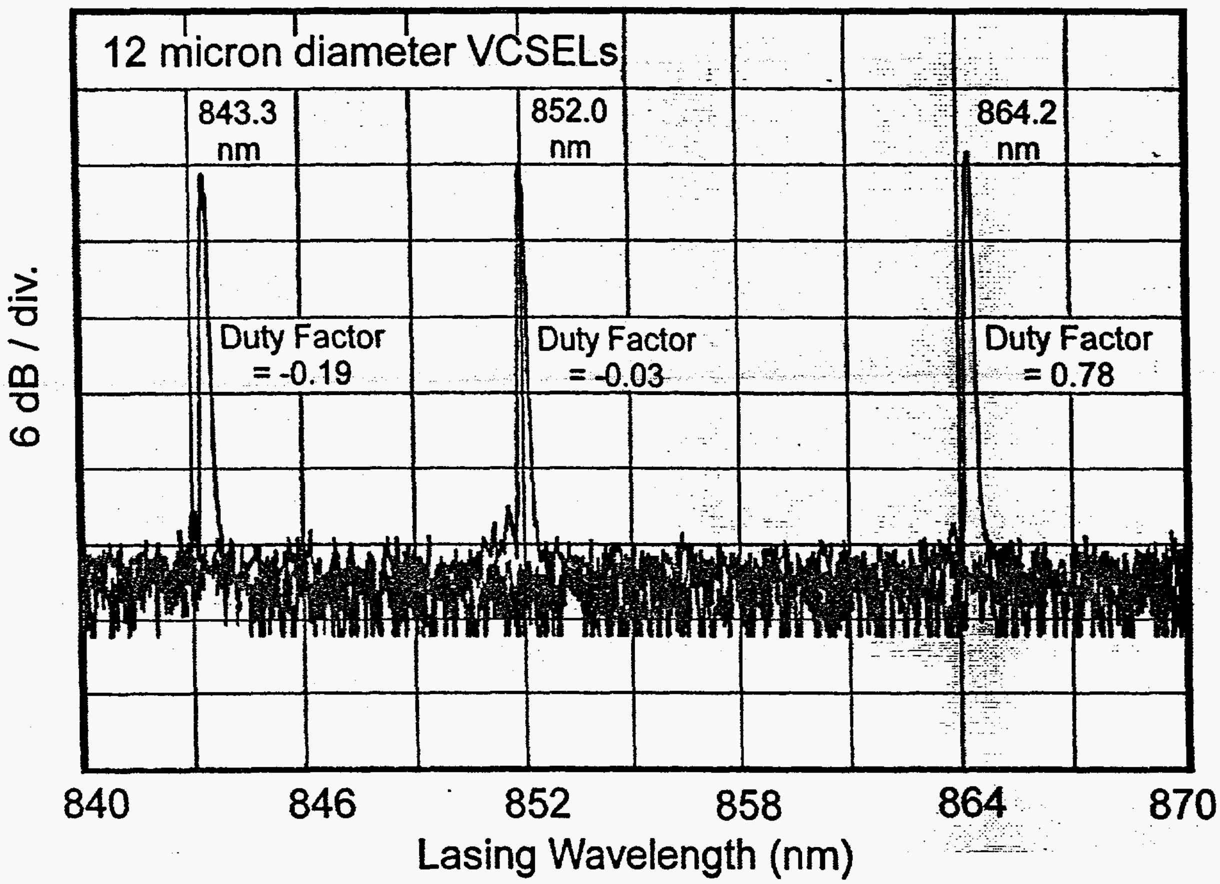


Figure 2. The lasing spectra of several VCSELs in a wavelength-chirped array with a uniform spatial period but different spatial duty factors.

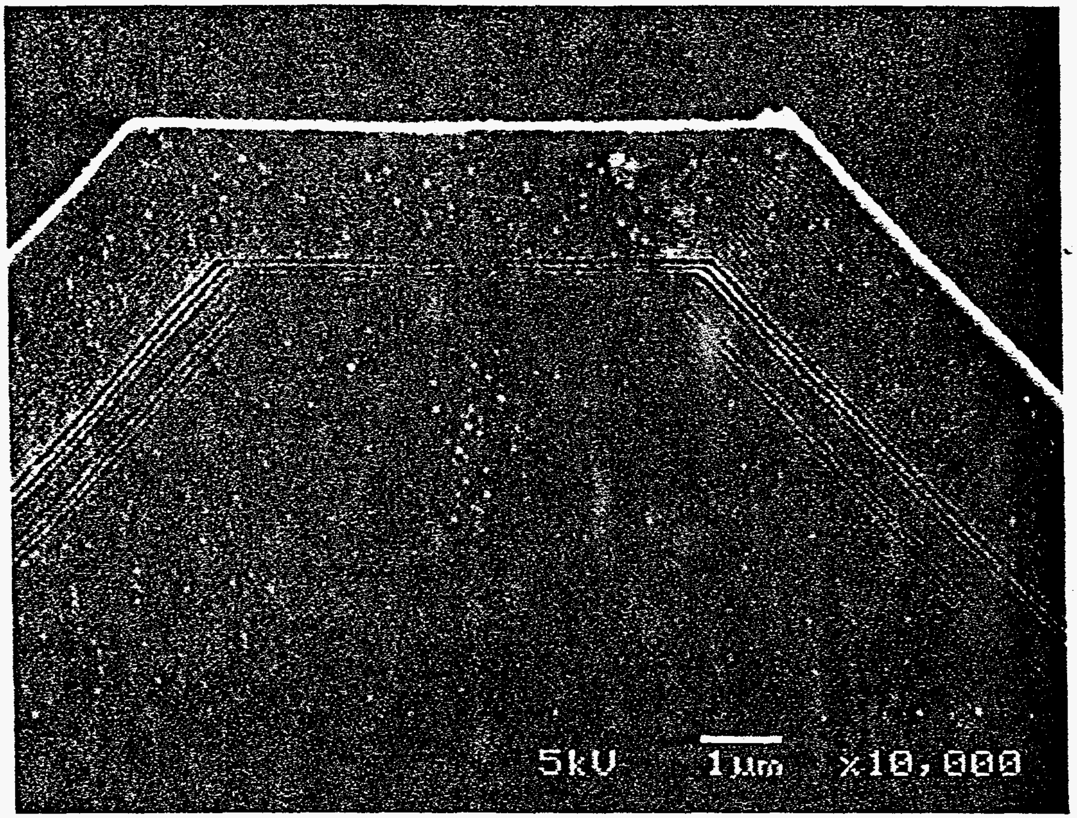


Figure 3. The epitaxial growth of a 850 nm VCSEL structure over a very narrow etched mesa on a GaAs surface.