Continuous Wave Operation of 1.3 μm Vertical Cavity InGaAsN Quantum Well Lasers

A. J. Fischer, J. F. Klem, K.D. Choquette, O. Blum, A. A. Allerman,
I. J. Fritz, S. R. Kurtz, W. G. Breiland, R. Sieg, and K. M. Geib
Sandia National Laboratories, Albuquerque, NM 87185-0603

J. W. Scott, R. L. Naone
Cielo Communications, Inc., Broomfield, CO 80021

Abstract

We report selectively-oxidized vertical-cavity lasers emitting at 1294 nm using InGaAsN/GaAs quantum wells with continuous wave operation observed at temperatures as high as 55 C.

DISCLAIMER

DISCLAIMER

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

Continuous Wave Operation of 1.3 μm Vertical Cavity InGaAsN Quantum Well Lasers

A. J. Fischer, J. F. Klem, K.D. Choquette, O. Blum, A.A. Allerman, I.J. Fritz, S.R. Kurtz, W.G. Breiland, R. Sieg, and K.M. Geib
Sandia National Laboratories, Albuquerque, NM 87185-0603
Phone: (505)844-6543 Fax: (505)844-8985

J. W. Scott, R. L. Naone
Cielo Communications, Inc., Broomfield, CO 80021

Vertical-cavity lasers emitting at 1.3 μm are extremely attractive for high bandwidth fiber communications where it is advantageous to operate at the dispersion minimum of silica optical fiber. To date, VCSELs based on pseudomorphic GaAs materials have achieved lasing emission only slightly longer than 1.2 μm [1-3]. We report the first 1.3 μm selectively oxidized VCSELs using InGaAsN quantum wells which operate continuous wave at and above room temperature.

Shown in Fig. 1 is a sketch of the top emitting VCSEL structure. The VCSELs are grown on GaAs substrates using molecular beam epitaxy with active *in situ* optical reflectance feedback control. Both top and bottom mirrors are n-type to reduce free carrier absorption while a tunnel junction was placed at a node of the optical field to provide hole injection into the active region. The top and bottom n-type distributed Bragg reflector mirrors contain 28 and 33 periods, respectively. The optical cavity contains two 6 nm thick nominally $In_{0.34}Ga_{0.66}As_{0.99}N_{0.01}$ quantum wells with GaAs barriers designed for emission at nominally 1.3 μm. The InGaAsN quantum wells are grown using an RF plasma source.

Fig. 2 shows the light versus current curves plotted at temperatures from 10 C to 55 C for a VCSEL with 4x4 μm^2 oxide aperture. VCSELs with apertures varying from 2x2 up to 12x12 μm^2 operated with threshold currents varying from 1.5 to 10 mA. The inset of Fig. 2 shows the single transverse mode lasing spectrum at 20 C with emission at 1294 nm and a 28 dB side mode

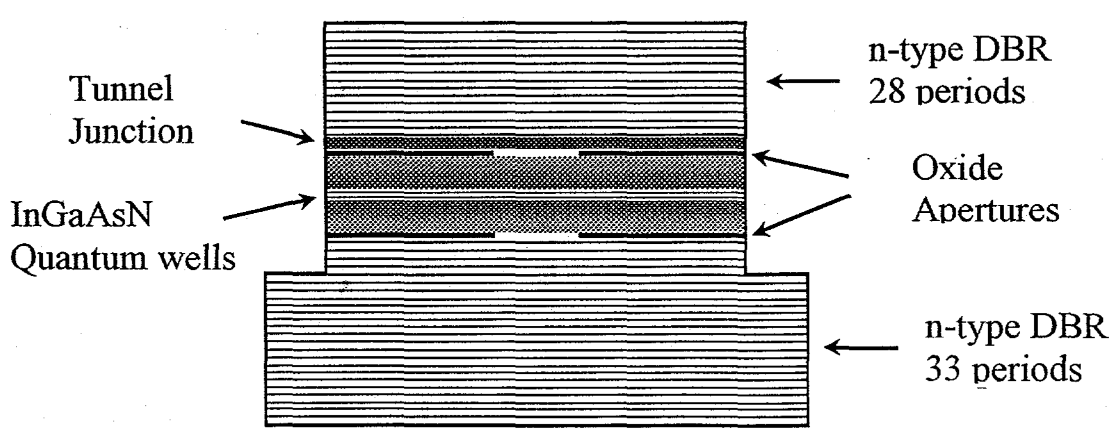

Figure 1: Sketch of 1.3 μm VCSEL structure showing top and bottom n-type mirrors with selectively oxidized apertures and a tunnel junction in the top output coupler.

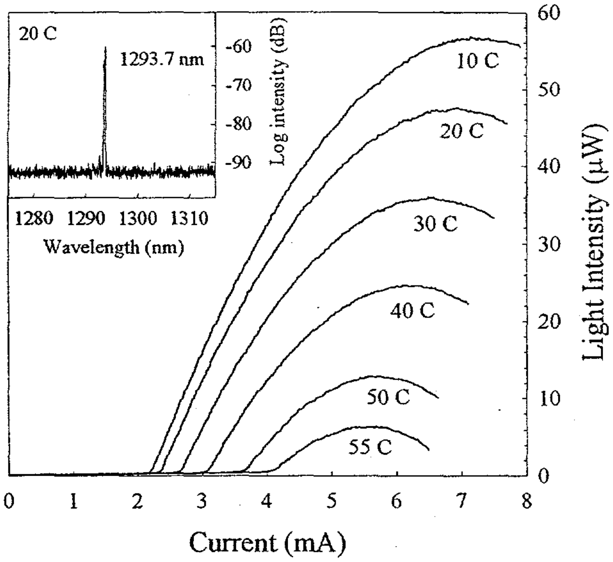

Figure 2: Temperature dependent light vs. current curves for a device with a 4x4 μm oxide aperture.

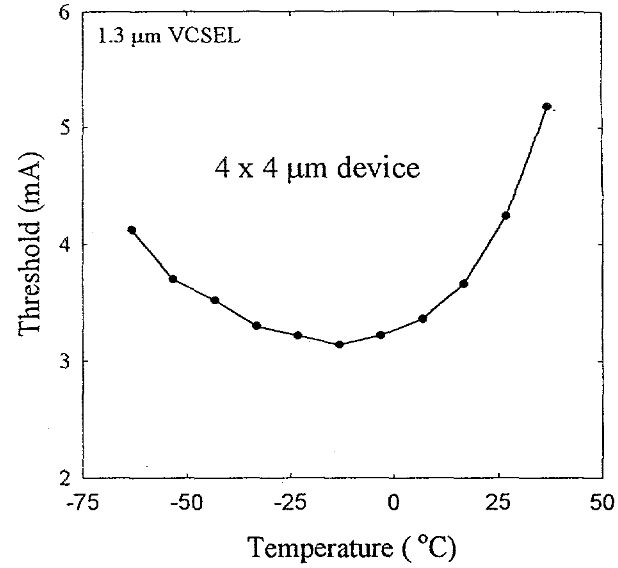

Figure 3: Threshold current vs. temperature for a device with a 4x4 μm oxide aperture.

suppression ratio. Note that the threshold current decreases as the temperature is reduced below room temperature. Figure 3 shows the threshold current as a function of temperature over a much wider temperature range. The optimum alignment between the gain peak and the cavity resonance occurs 40 degrees below room temperature. Thus, at room temperature, the gain peak is actually at a wavelength *longer* than the lasing wavelength of 1294 nm. The submilliwatt maximum output in Fig. 2 is the combined result of the spectral misalignment between the cavity resonance and the laser gain and the high reflectivity of the output coupler.

In summary, motivated by demands of emerging VCSEL network applications, continuous wave operation of 1.3 μm VCSELs grown on GaAs substrates has been achieved up to 55 °C. These VCSELs employ the mature AlGaAs/GaAs distributed Bragg reflector mirror technology, including selective oxidation for efficient cavity designs.. Moreover, by incorporating a tunnel junction near the optical cavity, both mirrors are doped n-type, which provides the benefits of low optical loss as demonstrated in other VCSEL materials and wavelengths. With further improvements in the mirror, cavity, and quantum well design, we expect appropriate long wavelength performance can be achieved to sustain the next generation of VCSEL applications.

Sandia National Laboratories is a multiprogram laboratory operated by Sandia Corporation for the United States Department of Energy under contract No. DE-AC04-94AL85

[1] M. Yamada, T. Anan, K. Kurihara, K. Nishi, K. Tokutome, A. Kamei, and S. Sugou, Electron. Lett. **36**, 637 (2000).

[2] M. C. Larson, M. Kondow, T. Kitatani, K. Nakahara, K. Tamura, H. Inoue, and K. Uomi, IEEE Photon. Tech. Lett. **10**, 188 (1998).

[3] C. W. Coldren, M. C. Larson, S. G. Spruytte, and J. S. Harris, Electron. Lett. **36**, 951 (2000).