# Fabrication of Low Threshold Voltage Microlasers

A. Scherer, J.L. Jewell,[+] M. Walther,
J.P. Harbison and L.T. Florez

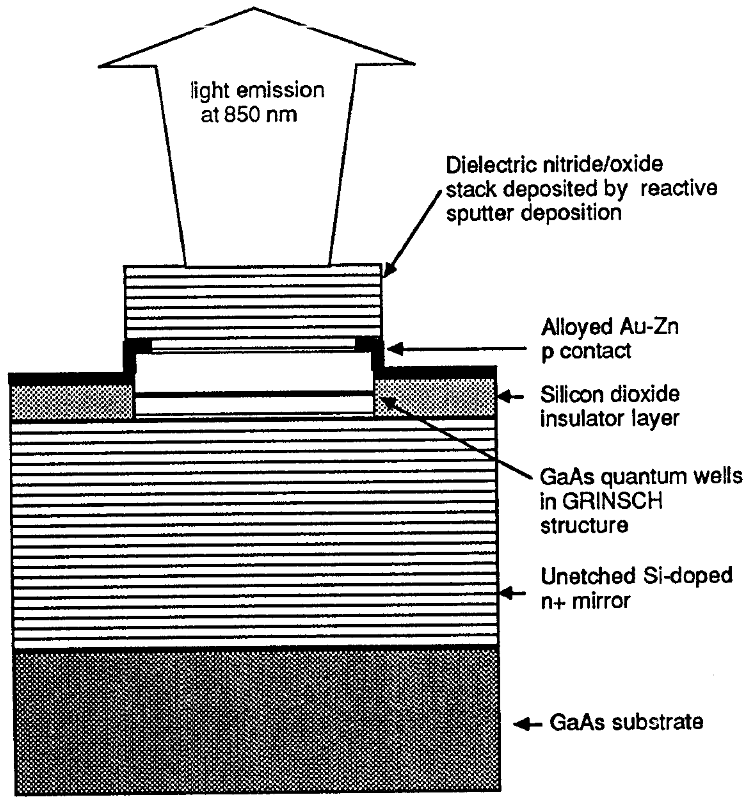
*Bellcore, (908) 758-3367*
*331 Newman Springs Rd., Red Bank, New Jersey 07701*
*[+]Photonic Research Inc., (303) 465-6491*
*100 Technology Drive, Broomfield, Colorado 80021*

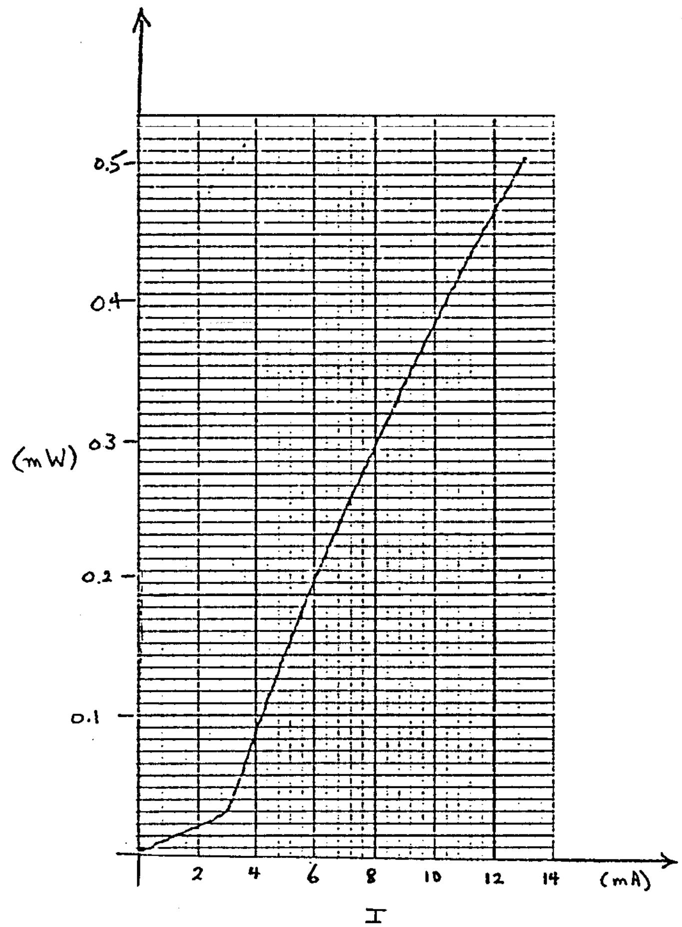
We have reduced the voltage required for threshold in vertical cavity surface emitting lasers (VCSELs) to 1.7 V. Molecular beam epitaxy (MBE) was used to grow 30 pairs of n-doped $Al_{0.15}GaAs/AlAs$ bottom mirrors and the active p-n junction with a 1 μm p-doped top contact. 12 pairs of alternating $SiO_2/Si_3N_4$ layers formed a high-reflectivity mirror which was used to complete the laser cavity. We have evaluated these reactive sputter-deposited mirrors by using finesse measurements in resonator structures, and obtain reflectivities of above 98% in 9.5 pairs. Individual laser elements were defined by ion etching through the p-n junction, followed by planarization with $SiO_2$ to define the current path. Then, Au-Zn p-contacts were deposited and alloyed for lateral current injection. Finally, another ion milling step was used to isolate individual contacts. Lasers with widths ranging from 7.5 μm to 25 μm were fabricated and measured.

In these lasers, 850 nm light is generated by three 10 nm GaAs quantum wells and is emitted through an annular p-contact. The p-resistance is reduced by heavily Beryllium-doping the top of the cavity. This configuration reduces the series resistance to below 70 ohms for 12 μm laser elements. The threshold currents and voltages of 12 μm diameter lasers were measured to be 3 mA and 1.7V, respectively. We also determined peak output powers of from 12 μm devices, and obtain 1 mW when lasers are pulsed at 1% duty cycle with 20 mA. We can also operate these lasers by cw pumping. However, the threshold current increases to approximately 5 mA. We also find that the emission wavelength of our lasers can be deliberately shifted (from 850 to 855 nm) by altering the thickness of the dielectric output mirrors.

We show that the combination of high-reflectivity dielectric mirror layers with accurate MBE growth can be used to significantly reduce the power requirements of individual laser elements. We expect that this advance will allow us to integrate large numbers of VCSEL devices into complex arrays without the heat-dissipation problems found in more conventional VCSEL designs [1]. Finally, the relatively shallow depth of the active area from the semiconductor surface allows us to greatly simplify the VCSEL fabrication process.

[1] J.L. Jewell, J.P. Harbison, A. Scherer, Y.H. Lee, L.T. Florez, "Vertical cavity surface emitting lasers: Design, growth, fabrication, characterization, IEEE Journal of Quantum Electronics, 27, (1991), p1332.




Schematic of our vertical cavity surface emitting laser structure and characteristic L-I curve of a 12 μm diameter microlaser.