

## 8 × 6 Wavelength-Tunable Vertical Cavity Surface-Emitting Arrays

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We report a novel individually addressable, individually wavelength tunable 8 × 6 vertical cavity surface-emitting laser (VCSEL) array. A two-dimensional array of individually wavelength-tunable VCSELs is very attractive for free-space optical interconnect in massively parallel computers [1-2]. VCSEL's have large mode spacing due to the very short cavity and are particularly suitable for continuous wavelength tuning. In addition, the low threshold currents, low beam divergence angles, and their ability to form two-dimensional arrays make them attractive for free-space optical interconnect applications. A two-dimensional array of fixed-tuned multiple wavelength VCSEL array [3] and a three-terminal VCSEL with continuous wavelength tuning [4] have been reported. In the latter, a continuous tuning range of 2.2 nm is obtained, however, it involves more complicated processing steps. In this paper, we demonstrate a continuously tunable, individually addressable 8 × 6 VCSEL array using integrated heaters. VCSEL's with a mesa size of 12 μm × 12 μm exhibit a threshold current of 4.2 mA, output power of 1.2 mW (cw, room temperature), and continuous tuning range of 10 nm are obtained.

Because VCSEL's are localized in areas, wavelength tuning with integrated heaters is very effective. Integrated heaters were used in edge-emitting distributed feedback and Bragg reflector lasers to achieve large wavelength tuning range [5]. The photograph of the 8 × 6 tunable VCSEL array is shown in Fig. 1(a). The VCSEL consists of a pair of AlGaAs/GaAs DBR mirrors and InGaAs strained multiple quantum well active regions. An 8 μm × 8 μm window is open on the 12 μm × 12 μm mesa for top emission of light. The emission wavelength is 948 nm at room temperature under cw condition. Uniform threshold currents (~ 4.2 mA) and output power (~ 1.2 mW) are obtained. A thin-film wire heater, consisting of 80 nm of AuBe and 100 nm of Au, is integrated around the VCSEL. The total length and width of the heater is 140 μm and 8 μm, respectively, and has a resistance of 35 Ohm. The wavelength is tuned by applying current through the heater, as shown in Fig. 1(b). The lasing wavelength versus the tuning current is shown in Fig. 2. The wavelength shifts continuously from 948 nm to 959 nm as the tuning current varies from 0 to 174 mA under constant optical power. The threshold current of the VCSEL increases moderately from 4.2 mA to 6.9 mA at 130 mA heater current. The wavelengths of the two dimensional array can be randomly programmed, as illustrated in Fig. 3. The thermal cross talk and the tuning speed will be presented in the conference.

### References:

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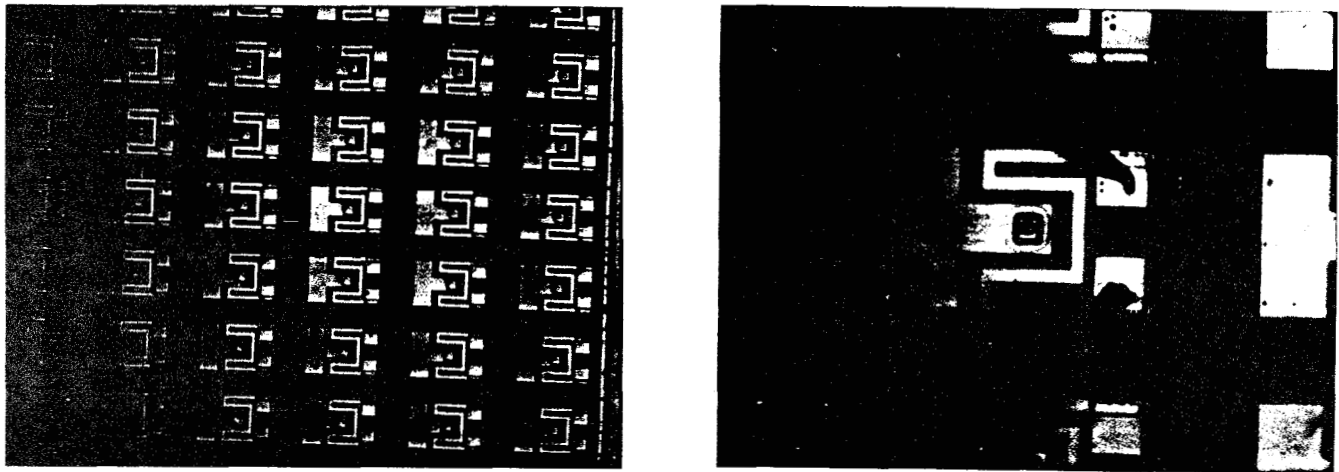


Fig. 1. (a) The photograph of the 8 X 6 wavelength-tunable VCSEL array. (b) The VCSEL with integrated heater.

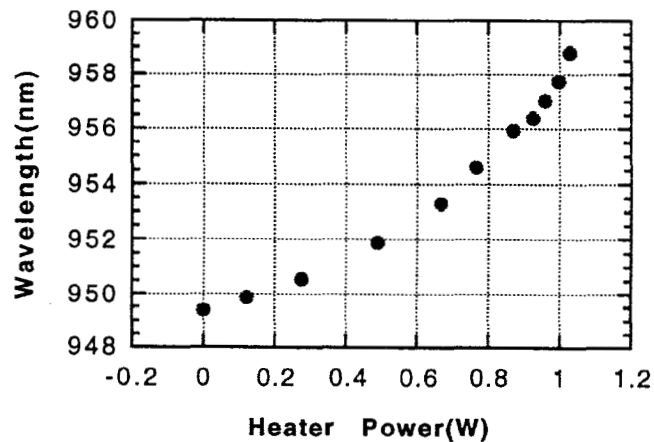


Fig. 2. The lasing wavelength of the tunable VCSEL versus the heater power.

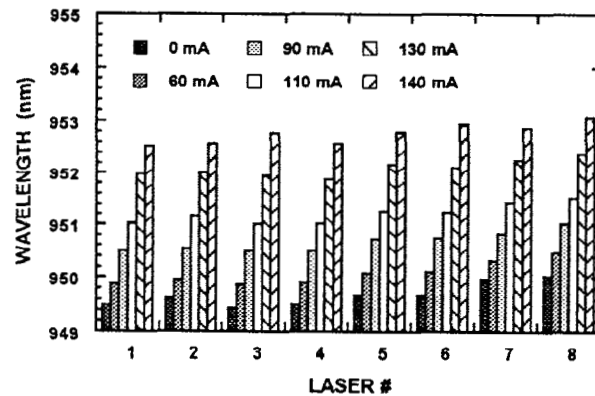


Fig. 3. The lasing wavelengths of the VCSELs along a row of the two-dimensional array under various heater currents. The VCSEL current is fixed at 7 mA.