VERTICAL CAVITY SURFACE EMITTING LASERS: TOWARD APPLICATIONS

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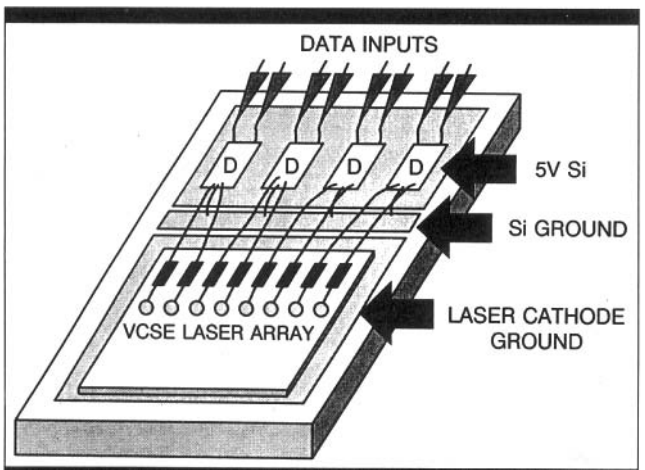
Recent developments in vertical cavity surface emitting (VCSE) laser device research have made possible for the first time, high yield, one or two dimensional arrays of almost arbitrary size and geometry.[1] This has generated intense interest in application of these devices to optical interconnects, optical data storage, optical scanners, and optical signal processing and computing. To realize the use of VCSE laser arrays in such applications, it is necessary to establish ways of optically or electronically controlling them and to investigate technologies for incorporating them as components in larger electronics systems. This article focuses on recent progress in addressing and integration of MBE-grown[2] VCSE laser arrays toward applications to optical interconnect or signal processing systems.

At the simplest level, control of an array of devices requires that a means of addressing be incorporated into the array. There are three basic choices, each having distinct advantages and disadvantages: independent electrical addressing, matrix-addressing, or optical addressing. We have fabricated independently addressable arrays[3] up to array sizes of 16 × 16 with high yield and uniformity. For larger array sizes, matrix-addressing offers inherent advantages over independent addressing, providing connections to an N × N array using only 2N bond pads. To date, the largest electronically addressed array is our 32 × 32 matrix-addressable array occupying a wafer area of only ~3.5×3.5 mm.[4]

To achieve optical addressing, we have monolithically integrated a phototransistor with a VCSE laser. The device is vertically integrated, providing a compact two-terminal device with gain.[5] Arrays of these monolithically integrated devices are well-suited to multi-stage interconnect or signal processing systems.



TOP SHOWS A SCHEMATIC OF A HYBRID VERTICAL CAVITY SURFACE EMITTING LASER ARRAY/SI CMOS MODULE. "D" INDICATES THE CMOS DRIVERS.

Crucial to widespread use of VCSE laser arrays is compatibility with prevalent circuit technologies and a simple, reliable cost effective way of making electrical contact between them and arbitrary circuits, substrates, or packages. Integration with advanced circuit technologies also provides for merging of sophisticated logic with the laser array, and is highly desirable for interconnect/signal processing applications. As a first step toward integration, we have mounted Si CMOS drivers with VCSE lasers in a hybrid package[6] (shown schematically in the figure). Excellent uniformity across the array allows the lasers to share a common pre-bias, so that the only external electrical connections to the hybrid are ground, 5V, and the data inputs to the lasers. In the hybrid package, we achieve >622 Mbit/s operation of reach laser/driver combination at $<10^{-9}$ bit error rate.

In the future, it will be desirable to place or epitaxially grow the VCSE laser array directly on the substrate or circuit of choice. We have recently demonstrated that solder bump bonding is a viable technique for this purpose: a 2 × 8 array of VCSE lasers was flip-chip bonded to a high speed package, yielding >5 Gbit/s operation for each of the 16 lasers.[7] Recent progress in the area of vertical cavity surface emitting lasers has been remarkable and exciting; however, continuing work on VCSEL device, array, control, and integration issues, as well as system-level design associated with applications, is needed before these devices enter commercial markets.

REFERENCES

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