APPLICATION NOTE

VCSELs in the information age

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Vertical Cavity Surface Emitting Lasers (VCSELs) emerged from scientific curiosity to economic reality in 1996 when AOC introduced the world's first commercial products. The VCSEL was viewed as an enabling technology that quickly supplanted edge emitting laser technology in the data communications market [1,2]. Edge emitting lasers suffer from several inadequacies, such as poor reliability (both in the dc and ac sense), strong relaxation (turn on) oscillations, and poor coupling efficiency to optical fiber. The VCSELs produced by AOC have achieved reliability projections in excess of 10 Million hours of operation at nominal conditions while maintaining optical signal integrity during aging. In addition the physics of the VCSEL microcavity ensure well damped, extremely high frequency relaxation resonance, and they emit circularly symmetric, non astigmatic optical beams. This new laser source, coupled with the burgeoning optical communications market has triggered a phenomenal increase in the number of VCSEL shipments. To date, many millions of VCSEL based optical transceivers have been deployed. Most of the VCSELs in use today are for data communications systems operating on multimode optical fiber, and running at speeds up to 1.25GBd in applications supporting both ethernet and fibre channel.

As the internet continues to grow, so does the seemingly insatiable demand for consumer bandwidth. And the lines between data communications and telecommunications applications continue to blur. The collision of these two markets is set to happen with the adoption of the IEEE 802.3ae standard, which will proliferate ethernet into traditional SONET markets at OC192 data rates. In addition, other standards, such as Infiniband™, and Fibre Channel are emerging with 10GBd systems. VCSELs are uniquely suited for this application in a number of ways [3,4]. Because the optical beam is emitted perpendicular to the wafer surface, VCSEL arrays can be fabricated with photolithographic tolerances, making them ideal sources to mate with ribbon fiber interconnects. To date, most of the market has centered on either 4 elements operating up to 3.125GBd per channel, or 12 elements operating up to 1.25GBd per channel. The operating reach of a parallel interconnect is more than 100 meters, and is limited by the skew in the optical fiber. The use of parallel interconnects allows the user to custom design the network, using either fanout architectures or direct links, potentially eliminating the need for high-speed SERDES functionality.

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In other systems, serial data communications is more advantageous, and VCSELs have been operated at speeds in excess of 10GBd by direct modulation. Achievable link lengths are on the order of 75 meters over installed multimode optical fiber, with distances of 500 meters on 850nm optimized fiber such as Lucent's LazerSpeed™. The combination of VCSELs operating at 10GBd serial rates, and 12 element (and larger) arrays whets the appetite for 100GBd datacom systems.

While most applications to date have centered on the 850nm VCSEL operating on multimode optical fiber, researchers at numerous companies are working on VCSELs operating in the telecommunications wavelength windows of 1310 and 1550nm. Fabrication of VCSELs at these wavelengths is plagued by several technical challenges. Among these are the poor index contrast of the material system necessary to form the Bragg mirrors, the necessity to maintain single spatial and longitudinal mode operation, the need for high power (several milliwatts), and the performance over temperature. Numerous approaches are under investigation to mitigate these technical risks, but to date a viable long wavelength VCSEL has not been demonstrated. While the technical risk is high, large amounts of money and resources are being poured into the development of VCSELs suitable for telecom applications on single mode fiber and commercial products have been promised in 2002.

On the opposite end of the data communications spectrum, plastic optical fiber (POF) holds the promise of extremely low cost and high volume applications in the consumer marketplace. POF, made from PMMA, has a minimum absorption regime in the 660nm (visible) range. Current applications are served with low cost LEDs where the required bandwidth is relatively low. While the huge market potential has not yet materialized, VCSELs are expected to play a significant role at speeds of 100MBd and higher. Fabrication of VCSELs at visible wavelengths suffers from many of the same problems described earlier for telecom wavelength VCSELs [2]. The first commercial visible VCSEL products will be in the optical sensor market, and as scientist resolve technical issues, POF may fulfill its long anticipated market presence.

[1] J. A. Tatum, et. al, "Commercialization of AOC's VCSEL Technology," SPIE vol. 3946, 2000.

[2] J. K. Guenter, et. al, "Commercialization of AOC's VCSEL Technology: Further Developments," SPIE vol. 4286, 2001.

[3] J. A. Tatum et al., "VCSELs Enable High Speed Data Communications," Lightwave, March, 2000.

[4] J. A. Tatum, "VCSEL Packaging for Transceiver Design," Fiber Optic Product News, 2000.

ADVANCED OPTICAL COMPONENTS

Finisar's ADVANCED OPTICAL COMPONENTS division was formed through strategic acquisition of key optical component suppliers. The company has led the industry in high volume Vertical Cavity Surface Emitting Laser (VCSEL) and associated detector technology since 1996. VCSELs have become the primary laser source for optical data communication, and are rapidly expanding into a wide variety of sensor applications. VCSELs' superior reliability, low drive current, high coupled power, narrow and circularly symmetric beam and versatile packaging options (including arrays) are enabling solutions not possible with other optical technologies. ADVANCED OPTICAL COMPONENTS is also a key supplier of Fabrey-Perot (FP) and Distributed Feedback (DFB) Lasers, and Optical Isolators (OI) for use in single mode fiber data and telecommunications networks

LOCATION

- Allen, TX - Business unit headquarters, VCSEL wafer growth, wafer fabrication and TO package assembly.
- Fremont, CA – Wafer growth and fabrication of 1310 to 1550nm FP and DFB lasers.
- Shanghai, PRC – Optical passives assembly, including optical isolators and splitters.

SALES AND SERVICE

Finisar's ADVANCED OPTICAL COMPONENTS division serves its customers through a worldwide network of sales offices and distributors. For application assistance, current specifications, pricing or name of the nearest Authorized Distributor, contact a nearby sales office or call the number listed below.

AOC CAPABILITIES

ADVANCED OPTICAL COMPONENTS' advanced capabilities include:

- 1, 2, 4, 8, and 10Gbps serial VCSEL solutions
- 1, 2, 4, 8, and 10Gbps serial SW DETECTOR solutions
- VCSEL and detector arrays
- 1, 2, 4, 8, and 10Gbps FP and DFB solutions at 1310 and 1550nm
- 1, 2, 4, 8, and 10Gbps serial LW DETECTOR solutions
- Optical Isolators from 1260 to 1600nm range
- Laser packaging in TO46, TO56, and Optical subassemblies with SC, LC, and MU interfaces for communication networks
- VCSELs operating at 670nm, 780nm, 980nm, and 1310nm in development
- Sensor packages include surface mount, various plastics, chip on board, chipscale packages, etc.
- Custom packaging options

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