Full beam ahead

Plain sailing as long wavelength vcsels move into production. By **Louise Joselyn**.

Just occasionally, the right technology, with the right performance becomes available at the right price and in time to meet real needs. The long wavelength vertical cavity surface emitting laser (vcsel) is such a technology.

The vcsel itself is not new: devices have been around since 1989. Short wavelength devices (850nm) are widely used in consumer devices, spectroscopy and analytical instrumentation. High power vcsels are also used for range finders and for lighting.

More than five years ago, long wavelength vcsels were heralded as a great new technology for optical telecommunications, offering high bandwidth performance, with lower power consumption and higher power output than edge emitting semiconductor lasers. But nothing happened.

For a combination of reasons, long wavelength vcsels faded from view: the technology looked 'nice to have', but not a 'must have' and some technical and production issues needed attention.

But that has all changed. Exponential growth in internet traffic and lans, increasingly competitive markets and the overriding trend towards low power operation and energy saving schemes, have created huge problems for telecommunication service providers. The shift from 1 to 4 to 10Gbits/s Ethernet has highlighted the inherent disadvantages of edge emitting lasers.

An x10 increase in speed implies a far greater increase in power consumption, which not only adds to the oem's burden of removing excessive heat from high tech systems, but is also diametrically opposed to the customers' desire for lower power operation. Costs of current solutions at 10Gbit/s have also escalated. Worse, bandwidth demand continues to increase, with 40Gbit/s clearly visible on the horizon and 100Gbit/s anticipated within a few years.

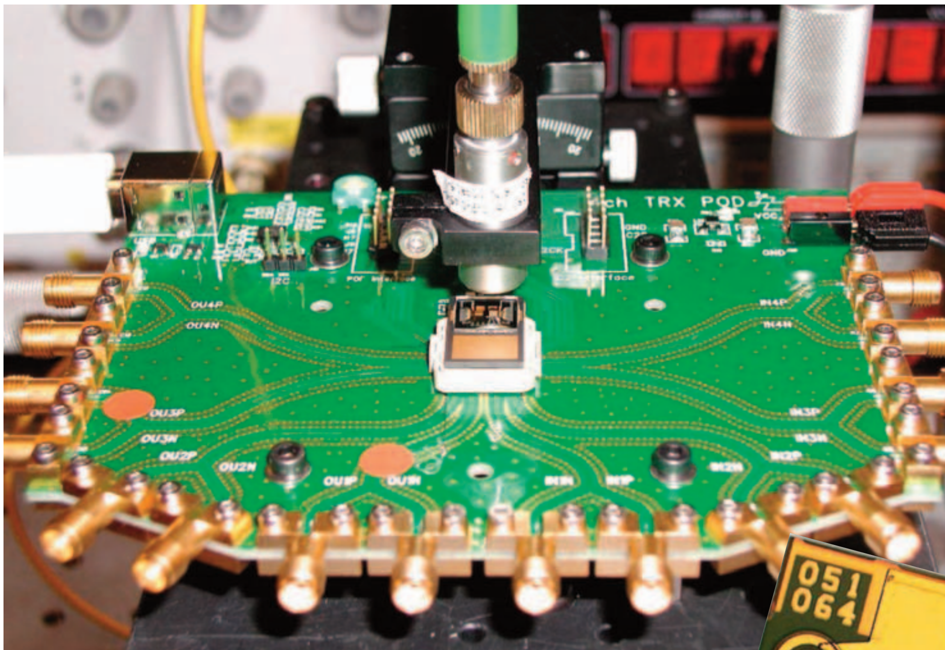
Meanwhile, the long wavelength vcsel arena has transformed. While some of the big names of five years ago have been acquired or closed, a few dedicated believers in Europe embarked on an ambitious three year collaborative project which has just completed with encouraging results and enthusiastic partners. Led by CEA-Leti, the MOSEL project included design and processing specialists from research labs, academia and industrial partners.

Alight Technologies' team has refined its photonic bandgap technology to ensure stable operation

According to CEA-Leti project manager Philippe Gilet: "The critical challenge with this technology was to achieve the necessary output power of better than 1mW at high temperature operation. This meant an output power of better than 2 to 3mW at room temperature." The researchers had to find the optimal method of opening the active area of the device's surface enough to achieve the power output, but without it becoming multimode. "Only single mode operation will give the required reach (typically 10km) at a 10Gbit/s bandwidth," Gilet explained.

In fact, the project demonstrated error free 10GBase-LR operation up to 100°C, with a single mode power of more than 1mW up to 100°C and 10Gbit/s modulation and transmission over 10km of single mode fibre. A bit error rate of less than 10^{-11} was achieved up to 100°C, with a power penalty of less than 1dB.

Industrial partners Alight Technologies and BeamExpress believe they have made net gains



by participating in the project. Both are set to launch products into a market itching to exploit long wavelength vcsel technology. "I was a little concerned at first," Gilet admitted, "with two potentially competitive industrial partners. But they worked and communicated well with each other and the other partners. It was perfect 'co-opetition'. The project ran very smoothly."

"We are still in communication with the partners, sharing results and measurements," said Dan Birkedal, Alight's cto and founder. "When you want to sell coffee to a predominantly tea drinking market, then it is a good idea to work with other coffee sellers first to convert and grow the coffee market!"

BeamExpress found the MOSEL project invaluable, according to ceo Jean-Claude Charlier. "The project's aims were perfectly aligned with industry needs. It gave us the technology boost we needed and, importantly, now we have the timing right."

The companies have each developed slightly different solutions, resulting in products with different characteristics aimed at different, although overlapping, applications. Both companies are in discussions with potential customers and in the critical phase of shifting from sampling to production. Birkedal: "When you are looking to convince customers to switch to a completely new technology, they want to see there are multiple players."

The Mosel project allowed Alight to refine its proprietary Photonic BandGap technology, originally acquired from Infineon. Photonic crystal structuring of the long wavelength GaInNAs/GaAs vcsels ensures stable single mode operation over the entire operation range. The company expects to be delivering sample devices for 10Gbit/s Ethernet optical systems by the second half of this year. It is working with specialist foundry Philips ULM Photonics, itself a high volume manufacturer of 850nm vcsels for consumer applications.

"We are looking at server to server communications, as well as big installations," said Birkedal, "and the market for 10km reach systems is looking pretty good." The critical factor, says Birkedal, is the low power operation, which can be from five to 10 times less than the conventional edge emitting lasers.

Whereas early high bandwidth optical fibre technology was specifed primarily for high capacity links (such as intercontinental and intercity), today the demand is for low cost, intelligent and scalable solutions. Applications range from metropolitan and local area networks down to access networks such as fibre to the home (FTTH). Birkedal remarked that FTTH applications will require much higher power technology than the MOSEL project has currently achieved, but that this is an attractive market.

BeamExpress continues to work closely with research partner EPFL. Their approach is a proprietary InPGaAs localised wafer fusion technology, incorporating patterned tunnel junctions and other intracavity structuring elements for efficient carrier and photon confinements. Charlier explained this structure will enable the development of single mode operation vcsels over the extended 1200 to 1600nm wavelength range, for bandwidths beyond 10Gbit/s. The technology is also expected to yield tunable vcsels for bandwidth on demand applications, as well as devices for multiple wavelength solutions.

Prototypes and early product samples became available last year, and selective sampling is now underway with a mix of customers. "This includes early adopters, major players and some smaller firms," confirmed Charlier. Although the device structure technology is developed by and licenced from EPFL, manufacturing will be via a European foundry.

Charlier sees the major markets for BeamExpress in 40Gbit/s systems, which may combine four 10Gbit/s lasers or multiple wavelength devices, and FTTH. "It is the high output power performance combined with low power operation and low cost that is catching the market interest," Charlier added.

Meanwhile, the researchers have also been looking ahead. "We are moving vcsel technology forward, using sub wavelength grating mirrors and nanotechnology," Gilet explained. First results show sub milliamp threshold currents, a linearly polarised emission and single mode maximum output power at 980nm of more than 4mW at 70°C. The high power output is key to match the emerging needs of the silicon photonics market, which requires light sources emitting in the 1200nm to 1600nm range. And the long awaited promise of optical interconnects on semiconductors and boards may be as close as two or three years, Gilet hinted.

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