The need for pragmatism

Larry Coldren from the University of California at Santa Barbara, USA, speaks to **Nadya Anscombe** about recent progress in the performance of semiconductor light sources.

What do you believe are the most interesting areas of research and development in semiconductor sources?
The semiconductor sources sector is too large to mention every innovation, but the areas which I believe are important are silicon laser research, green laser development, advances in VCSEL [vertical-cavity surface-emitting laser] performance and the race to develop photonic integrated circuits based on both InP and Si.

There is interesting basic research going on in these and other topics all over the world and there is no doubt that basic research is important. However, researchers also need to think about developing products that people want to buy, at least at some point in time. In some cases, people are trying to be the first to achieve something without thinking about whether the resulting device will actually have useful performance characteristics. For example, what is the point of developing a pure silicon laser if the device will never have the power efficiency required to work in real applications. Rather than battle on with the pure science problems, it is sometimes better to work on solutions that actually may result in components with reasonable metrics, which might be implemented by industry to address real problems.

What is your take on the silicon laser debate?
I do admire the work of those groups around the world that are trying to get silicon to lase — often requiring excellent materials science and good physics. However, in my opinion, the idea of a purely silicon laser with competitive characteristics is unrealistic. On the other hand, there may be some sensor applications where this does not matter so much. Given what we want from lasers today, I cannot see a purely silicon laser ever being able to catch up with the performance characteristics of other alternatives that may even be compatible with CMOS integration to an acceptable degree.

The only silicon-based laser system that is actually working well is the one developed by my colleague, John Bowers, with Intel. This uses InP gain regions wafer-bonded onto silicon waveguides. Although this is not a pure silicon laser, it does have attractive power and efficiency metrics, as well as being compatible with CMOS integration.

Larry Coldren says that developments in long-wavelength VCSELs and tunable InP lasers have been important within the semiconductor laser field.

Regarding InP-based PICs, what are the key issues and advances related to the light sources?
InP-based photonic integrated circuits [PICs] have been investigated for about two decades, but only recently are they finding their way into products. As in the case of electronic integrated circuits, the driving force has always been to reduce size, weight, cost and power dissipation, while perhaps also increasing performance. Until recently, PICs did not have the performance of discrete implementations, and the cost has still not come down because of insufficient market volume. A large driver for these InP-PICs is the transmitters and receivers for wavelength division multiplexed fibre-optic communication systems, but future sensor applications may be the true 'killer applications'. The laser sources within these InP-PICs are usually tunable, either single, very widely tunable lasers, or arrays of narrowly tunable lasers. Current research continues to produce more exotic and more stable tunable configurations. Integration with more exotic 'advanced modulation format' modulators is a current trend to try to squeeze more bits into a limited spectrum as well as enable longer fibre links.

What other developments in semiconductor sources have caught your attention?
Everyone seems to want to develop a green laser at the moment. These would be very desirable for projection displays and plastic optical fibre networks, because plastic optical fibre has a low-loss window in the green spectrum. The mainstream of research is to develop green emission from the InGaN/GaN material system that has been very successful in providing blue lasers and LEDs. However, progress has been very slow; fundamental materials issues exist and it might take a few years to solve these. Using nonlinear optics, near-infrared light can be efficiently doubled to create green emission, as has been well known for many years. Several companies now manufacture such products, although they tend to be quite a bit more expensive and bulky than a simple diode. Efforts are underway to miniaturize the relatively complex cavity structure of the nonlinear doubling approach to get the size and cost down. Even companies such as Corning, who normally focus their work in other areas, have announced a small effort in this direction.

In the area of VCSELs, there are significant advances in two notable directions: long-wavelength VCSELs, and high-speed, high-efficiency VCSELs. For the shorter wavelengths, new records in efficiency and speed have been reported in the past year. Direct modulation rates of up to 40 Gbits s^{-1} have been demonstrated with GaAs-based devices.

There has also been considerable progress in long-wavelength VCSELs, based on InP. Data rates up to 10 Gbits s^{-1} with reasonable output powers have been reported at 1,550 nm. However, in this case, significantly higher data rates are unlikely owing to inherent materials issues, such as a lower differential gain and smaller index contrast that results in larger modal volume. Applications in data communications and sensors are targeted. Although some have proposed their use in long-haul fibre communications, I have always been doubtful of their viability for such applications: output power and linewidth are problematic issues. Wavelengths even longer than 1,550 nm have been demonstrated, and these may be most useful in spectroscopy or the medical industry.

INTERVIEW BY NADYA ANSCOMBE

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