NATURE

100 YEARS AGO

The recent sporting experiences of Mr. Selous. **Having seen, or shot, practically every species of great game in South and South-east Africa, the indefatigable author of the volume before us has devoted several seasons in the closing decade of the century to hunting-trips in the northern hemisphere. These expeditions included three trips to Asia Minor in search of the wild goat, the Armenian sheep, and the Asiatic red deer, and two to the Rocky Mountains, where wapiti, mule-deer, white-tailed deer, prongbuck and lynx fell to the practised aim of the veteran hunter. Not that Mr. Selous is by any means merely a hunter; he is likewise an observant field-naturalist and enthusiastic egg-collector, having contributed many years ago an important paper on African antelopes to the *Proceedings* of the Zoological Society, while his recent expeditions to Asia Minor have furnished material for an ornithological paper to the *Ibis.* It is perhaps needless to add that such an experienced hunter may be depended upon not to shoot animals for the mere sake of slaying, and that after obtaining a few fine examples of the species he encountered for the first time to add to his splendid collection at Alpine Lodge, Worplesdon, and occasionally killing an individual or two for the commissariat, Mr. Selous has always been content to stay his hand.**

From *Nature* 6 December 1900.

50 YEARS AGO

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From *Nature* 9 December 1950.

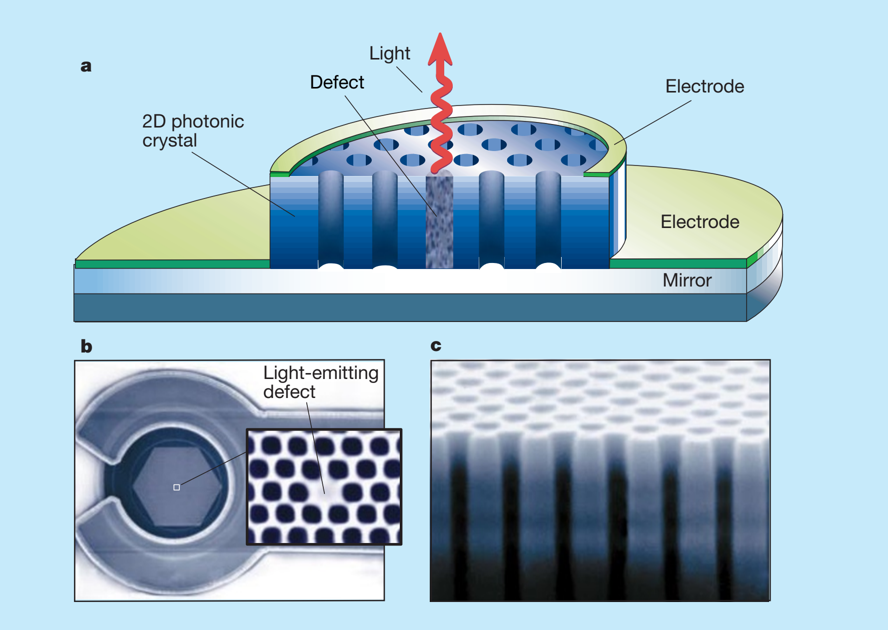

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Figure 1 **A photonic-bandgap semiconductor laser.** a, **The device built by Zhou *et al.*[4] emits light following injection of current through the electrodes. The light is emitted from an optical microcavity, created by a single defect in the centre of a two-dimensional photonic crystal.** b, **A scanning electron micrograph of the photonic-bandgap laser from above, showing a single defect approximately 0.4 μm across.** c, **Scanning electron micrograph of a cross-sectional view of the photonic crystal.**

established devices, being small, cheap and efficient at converting electric current into light at useful wavelengths. So why go to the bother of making photonic-bandgap lasers that require artificial crystal structures? Ordinary semiconductor lasers are still typically about half a millimetre long, so a photonic-bandgap laser represents a significant reduction in size. This means it can provide an extremely focused source of light, or that many more of them can be packed together in an integrated optical circuit.

In Zhou *et al.*'s device[4] the ideal (three-dimensional) photonic crystal structure has been modified to become a planar two-dimensional lattice of cylindrical holes, with one small 'defect cavity' — actually a missing hole (Fig. 1). The defect traps photons inside a cavity just 0.4 micrometres wide. The photonic crystal is placed within a mirror, ensuring that photons can escape only from the top of the cavity through the semiconductor–air interface. The efficiency of this laser (measured as power output over current input) is still quite low — a modest 0.0015 W A^{-1}. A larger laser (but still compact at 16 μm long) described by Rennon *et al.*[5] in the same issue of *Electronic Letters* achieves an efficiency of about 0.04 W A^{-1}, about 25 times better. This means that most of the electrical input in Zhou *et al.*'s device is producing heat rather than light. Both of these values are significantly inferior to those for existing semiconductor lasers, where efficiencies of 0.4 W A^{-1} are standard.

The threshold current — the level at which the laser switches on — of the photonic-bandgap laser designed by Zhou *et al.*[4] is 300 μA, much more than the threshold of 40 μA and lower seen in other semiconductor lasers[6,7]. There is still some way to go before technology delivers the full potential of the photonic-bandgap semiconductor laser. But we can expect such lasers to switch on at currents as small as 1 μA and produce a maximum of about 10 μW of light, together with a power-conversion efficiency of 50% or higher. Although such microwatt output power levels seem small compared with the several milliwatts obtained with ordinary semiconductor lasers, the corresponding number of photons per second is still large enough to give adequate performance for practical fibre-optical systems. This type of laser could eventually have a near-zero threshold.

So what are the prospects for photonic-bandgap lasers? If they reach their full potential, arrays of these devices might be used in high-speed optical connections between adjacent silicon chips in a computer — or even between different points on the same chip. In these applications, heat production is likely to be a severe problem, because the devices will be packed closely together. So small photonic-bandgap lasers (possibly just a square micrometre in size) that emit light in a range of directions and switch on at very low current levels will be an attractive choice. The power needed per device reduces with size, but efficient conversion between electrons and photons will remain an essential feature of these tiny lasers if they are to operate at room temperatures