ENLIGHTENING THE WORLD

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ABSTRACT

The great success of optical fibres in telecommunications has generated numerous applications in a number of related fields, such as sensing, biophotonics and high-power lasers. The topic remains extraordinarily buoyant and new materials, structure and applications emerge unabated. The talk will review recent developments and explore future possibilities.

TELECOMMUNICATIONS

Following in the footsteps of Marconi and the revolution of wireless, the internet is perhaps the most important and life-changing invention of the 20th century. It too required the invention of a new global communication medium capable of carrying vast quantities of information across trans-oceanic distances, reliably, cheaply and efficiently. This turned out to be the unpredictable, unlikely and extraordinary role of optical fibres made from the two most common elements of the earth's crust, silicon and oxygen (silica).

In recognition of the huge impact of his invention, Charles Kao was awarded the Nobel Prize for Physics in 2009, while Charles Townes, who provided the laser, was similarly honoured in 1964.

As with all new and disruptive concepts, the optical internet has proven a rich source of innovation, from the optical amplifier that compensates for losses in long spans of fibre, through new forms of digital communications appropriate to light as a carrier, to new materials and lasers. Perhaps even to quantum technologies for the future.

But is the innovation over? The demand for capacity continues unabated, fuelled by demand for faster connections and a new age of creativity at home – You Tube, Twitter, Facebook – as well as an insatiable demand for high quality videos. You Tube alone consumes more bandwidth today than the entire internet in year 2000 and projections show that a capacity crunch looms in both the internet optical backbone and the wireless final drop in the next decade or so. Yet we are still on the first hardware iteration of the optical infrastructure, so is there an internet 2.0?

FIBRE LASERS

Incredibly, the same fibres that carry tiny internet signals when doped with rare-earths can generate more than 10 kilowatts of power, sufficient to cut through inch-thick steel. But is that where it ends?

For the first time, we have in the optical fibre a low-cost gain medium that can be produced in lengths of hundreds of kilometres. By analogy with the internet, this leads to the radical concept of fibre laser circuits consisting of thousands of lasing strands combined together into a single, controllable beam of immense power.

The exquisite control of the laser offered by the fibre environment makes coherent beam combination a possibility for very large numbers of fibre amplifiers fed from a common seed laser, perhaps to power levels in the megawatt regime. Coherent combination in a phased-array configuration rather like a radar antenna with active phase control of the individual beams allows control of the spatial beam profile, as well as a degree of beam steering. In the ICAN project we are currently investigating the possibility of using coherently-combined femtosecond fibre sources to drive Wakefield accelerators for particle colliders in an initiative led by G. Mourou and T. Tajima. The high average powers required makes the high efficiency of fibres a necessity. Although many thousands, perhaps millions, of fibre channels will have to be combined, the manufacturability, scalability and reliability of active fibre technology makes this a realistic proposition over the next few decades.

Whether by beam combination or the intrinsic control and flexibility of an individual laser, high-power fibre sources are truly revolutionary in the performance they offer and the applications they enable in science and industry.