Working at the Speed of Light –
Making and Breaking things with Photonics

When Ted Maiman invented the laser in 1960, his breakthrough accomplishment changed the world. We are all familiar with the “lasers” used by fictional heroes such as James Bond, Luke Skywalker and Captain James T. Kirk. What is less well known is the level of complex science and engineering that has been mastered and refined over the last 40 years to produce the laser systems of today. Whether they are simple semiconductor lasers for DVD players or giant systems for laser fusion, they are now essential tools for medics, scientists, engineers, construction workers, and disc jockeys alike.

One would think that the story is pretty much over, that laser systems can only get cheaper and more widely spread, after all what else can be accomplished? We know how to make coherent photons in large numbers; of every conceivable colour; or so tightly squeezed together that they are the shortest pulses in the universe. So what next?

There have been a number of laser developments in recent years that are quite staggering in their simplicity, that are so powerful in their operation that engineers and scientist have to rethink the laser future. One such that will change the optical landscape forever is the fibre laser, born out of the optical telecoms revolution. It challenges currently held views on how to make things, how to repair things, and how to destroy things. It has the potential to change every industry and discipline it encounters.

The combination of small size, maintenance-free operation, thermal and electrical efficiency combined with outstanding (diffraction- limited) beam quality have made the fibre laser a huge success and an attractive alternative to traditional lasers. In fact, in many processes the fibre laser is the enabling technology.

Unique among high power lasers, the fibre laser is monolithic, the light being entirely confined to the fibre core. This gives immunity to thermal distortion of the beam, almost instant start-up, very high beam stability and protection from the environment. Maintenance is minimal, since no realignment or cleaning of components is necessary.

Fibre lasers have very high gain (30dB) because of their extended length. Thus amplifiers are the preferred configuration, rather than oscillators, as used in most conventional lasers. This simple concept borrowed from optical telecoms gives far greater design freedom and leads to an extraordinary range of performance in the c.w., pulse or single frequency regimes.

For example, for defence applications multiple amplifiers fed from a single seed source can be coherently beam combined provided they are polarized and have narrow linewidth. This provides a means of scaling fibre lasers from the current diffraction-limited record of 2.5kW to perhaps beyond 100kW. By stacking kW fibre lasers in beam-combined arrays having near-perfect beam quality, an immensely powerful beam could be produced which is stearable over a wide arc by phase controlling the outputs from each laser.

The MOPA configuration offers further advantages for pulsed lasers, as required in many processing applications. Under the operator’s control and using a low-power diode laser seed, the output pulse from a multi-stage pulsed MOPA laser can be carefully shaped to optimize peak power and processing parameters. In fact, there is little need to use the traditional and often fragile Q-switching or mode-locking techniques, when better control can be obtained through amplification to the kW regime.

This year's Mountbatten Lecture will present the story of the fibre laser, from lab conception to industrial and military applications with a tantalising glimpse into the manufacturing industries of the future.