BRIGHTER lasers for tomorrow's technologies

Scientists and engineers across Europe have joined forces in a unique collaborative effort to develop a new generation of high-brightness lasers that will transform the fields of healthcare, communications and entertainment. The €16.25m (€9.7m of European Commission funding) project called WWW.BRIGHTER.EU, which runs until September 2009, has brought 22 of Europe's top research teams together from industry, internationally-recognised research laboratories and leading academic institutions to achieve the next quantum leap in this multi-billion Euro field – by making lasers smaller, brighter, more efficient - and cheaper!

The project name stands for 'World Wide Welfare: High-Brightness Semiconductor Lasers for Generic Use', brings together partners from a total of ten European countries and is funded by the European Commission's Information Society Technologies Programme. The WWW.BRIGHTER.EU collaboration builds upon the successful WWW.BRIGHT.EU project, which was completed in 2006. Poland is represented by the team from the Institute of High Pressure Physics UNIPRESS from Warsaw.

The main challenges addressed by the Consortium are to develop low-cost, high-brightness light sources for an extended range of colours (wavelengths) and to couple more light power into smaller diameter optical fibres. These improvements will, on the one hand, allow the replacement of existing cumbersome and expensive laser sources, and on the other hand facilitate the emergence of new applications. Success for the Brighter EU scientists will present opportunities for society that are simply not available today, including improved cancer treatments, new medical diagnosis techniques and state-of-the-art communications and display systems for entertainment.

Project coordinator, Michel Krakowski of Alcatel-Thales III-V Lab in France, said: "There are huge markets for laser diode technology. There are a lot of applications that currently are not possible to address without high-powered diode lasers, either because of cost, colour or portability. The goal of this project is to develop new lasers with increased power and brightness. It's about how tightly we can focus the beam."

The Polish partner UNIPRESS specializes in high pressure methods applied to material technology and to devices. UNIPRESS has developed high-pressure growth of dislocation-free GaN monocrystals and demonstrated high-power laser structures grown on these monocrystals. The team participating in the project uses high pressure methods for two purposes: (i) to tune the emission wavelength of the lasers developed by the consortium, (ii) to characterize the lasers under pressure which reveals their properties difficult to access by other methods. The pressure/temperature tuning yields the widest achievable wavelength range and allows one to reach emission wavelengths not available for laser diodes. For example, the team recently demonstrated the tuning of a high-power red laser developed by OSRAM (645 nm wavelength) to a yellow-greenish colour at 575 nm. Several medical applications exist in this wavelength range and so far the shortest commercially available wavelength for laser diodes is 630 nm.

The unique pooling of resources in WWW.BRIGHTER.EU is stimulating new lines of research and, through the participation of major industry (who are contributing €6.5m of their own funding to the project), promises to deliver the benefits of improved technology to the European public first and much more quickly than would otherwise have been possible. This critical mass of expertise is also allowing the BRIGHTER consortium to remove barriers between disciplines and develop laser technologies for important new applications.

As well as the technological developments, the project contributes to the structuring of the European Research Area. Professor Eric Larkins of the University of Nottingham said “The project is actively encouraging the increased mobility of young scientists between industry and academia to provide exciting career development opportunities. We are also developing new tutorials for training in cutting-edge technologies. These are also available through the project website to students and researchers outside the consortium.” Interested readers can find more information on the BRIGHTER project website at www.ist-brighter.eu, where they can also ask to be put on the mailing list to receive the biannual e-newsletter.

According to the Photonics21 European Technology Platform, “the photonics world market in 2005 amounted to more than €225 billion … and the total photonics world market is expected to triple within the next 10 years.” They also state that “the revenue of the European photonics industry grew by 12% to €49 billion in 2006 ... photonics production is now equivalent to that of microelectronics in Europe and is expected to exceed it soon.”

Viviane Reding, the European Commissioner for Information Society and Media, said: "Photonics is driving innovation in Europe and has a strong competitive potential in areas such as communication, entertainment, healthcare and life sciences. By developing new light sources with high brightness, the BRIGHTER project is making an important contribution to the development of photonics in Europe."

Medical applications are extremely important for European society, but the market is still fragmented and poorly connected to technology developers. One example is the minimally-invasive procedure known as photodynamic therapy or PDT. The PDT technique uses photosensitive drugs to precisely target tumours within the body – the chemotherapy-like drugs administered to the patient preferentially attach themselves to malignant tissue, causing no harm to the surrounding healthy tissue, and are only activated when illuminated by a specific colour of laser light (e.g. red). Ultimately, the winner is the patient, who will benefit from better treatment with fewer side-effects and an improved quality of life.

Blue and red lasers are being developed in the BRIGHTER project for PDT applications in medicine. The blue lasers are used for fluorescence spectroscopy imaging of fluorescent markers used to locate malignant tissue. The red lasers are then used to activate the cancer drug (photosensitizer) which, like the fluorescent marker, accumulates in the tumour. In the medical field, however, technological success is no guarantee for clinical or commercial success. Thus, to ensure the clinical success, the BRIGHTER project is addressing all areas in the development chain from device and module development to systems integration and even includes clinical testing.

In the first year of the project, improved red lasers have already been demonstrated and are ready for incorporation into a PDT delivery system. A high-brightness blue laser source has been demonstrated by the frequency-doubling of a high-power infrared laser. (Frequency-doubling is an advanced technique that uses a special nonlinear optical crystal to convert the colour of the laser output.) The new blue laser has been incorporated into a fluorescence imaging system for looking at malignant tissue at the Lund Laser Centre and the first clinical tests have already begun.

Projection display systems are a relatively new application of laser diodes with several challenges that still need to be overcome before such systems become portable and affordable for everyday use. A laser display requires red, green and blue lasers to be integrated into a single module. Red and blue lasers are being developed within the project for the medical market, so that the main challenges remaining are the realisation of a high-brightness green laser diode and the development of a full system prototype. The green laser diode is a particular challenge as no semiconductor material exists that can be used to directly produce green laser light. In BRIGHTER, the frequency-doubling principle, successfully demonstrated in the realisation of the blue medical laser, is now being extended to produce this all important green laser from a high-brightness infrared device.

In the communications world, near infrared lasers play a key role in helping to send digital information down many hundreds of kilometres of optical fibre. The growth of the internet and the reduction in long distance costs are largely due to advances in erbium-doped fibre amplifiers or

EDFAs, which are pumped by high-power laser diodes. According to the Photonics21 Strategic Research Agenda, data rates to the home are expected to continue to increase a hundred-fold during the next decade. This will require a further increase in the capacity of the telecommunications networks. In order to increase the network capacity, new systems such as Raman amplifiers and their associated pump lasers must be developed to serve new optical bands in the telecommunications spectrum.

In the project, high-power near infrared lasers are being developed to pump both EDFA and Raman amplifiers. These lasers are also being developed for optical wireless communication systems, which allow high-speed data links between, for example, buildings on a campus or a city centre without the need for buried fibres. This technology will also have an important role in re-establishing temporary communications in disaster areas. Over the last year, researchers in BRIGHTER have produced near-infrared devices with improved power and brightness for these communications applications. The infrared lasers that have been realised have also been shown capable of the high-speed operation necessary for optical wireless systems and also for the green display lasers.