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LEDS

The march of the LED

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W iliiam Payne discovers how the LED is pervading all types of applications

***Electro Optics*: June/July 2007**

From quiet beginnings, back-lighting calculators and mobile phones, LEDs are poised to become a pervasive technology, staking a claim across a whole num ber of applications including lighting, medicine, test and measurement, next-generation telecommunications, smart food and medicines labelling, and television.

LEDs could even help reshape our homes, displacing the clutter of devices and wires, like televisions, computers, hi-fi, phones, and replacing them w ith low-cost, low-power devices that merge unobtrusively into the walls when not required.

One of the biggest applications for LEDs is turning out to be lighting. While LEDs have established themselves in indicator displays, remote contro ls and backlights, it is only recently that white LEDs have begun to be used to replace conventional lighting. However, high-brightness LEDs are making rap id progress in a number of areas, including home lighting, street lighting, and the automotive sector.

Lighting up the Queen of the Night

Perhaps nothing illustrates the progress that LED lighting has made as m uch as the recent installation of the LED stage by LDDE and Philips at one of t he world's great opera houses.

The Vienna State Opera stands in a class of its own among opera houses. It is the home of Austrian opera, including not only the operas of Mozart, but also Gluck, Haydn, Beethoven, Weber, Schubert, Strauss, Schoenberg and Berg .

The company required a modern lighting solution to meet the demanding specifications of professional stage lighting. This included completely sil ent operation to avoid interrupting the performances. In addition, due to the limited stage space, the lighting fixtures had to be compact in size and mo bile to allow floor lights to sink into the stage floor, ensuring the maximum st age space for performances.

The lighting (shown above) also had to reproduce the same tones and colo urs as the original spotlights, especially for established repertoires. The Ope ra wanted the ability to alter the atmosphere and create individual moods to support each performance through the use of different lighting techniques.

Technical lighting specialist LDDE designed the SpectraLimeled fixture specifically for the Vienna State Opera House project. In order to ensure t he fixtures reproduced the individual nuances of conventional theatre spotligh ts, the SpectraLimeled incorporated warm-white Philips Luxeon LEDs, which provi de a colour rendering index (CRI) of 90, a correlated colour temperature (CCT) of 3200K, and a typical light output of 20 lumens that is up to 10 times brigh ter than standard LEDs. It is claimed as the first solid-state light source to closely match the black body illuminant spectrum across the visible colour range.

Cutting waste on the street

Few lighting applications are as wasteful as street lighting. Thousands of miles of UK roads are lit up with high-energy lighting. Recently-introduced high-pressure sodium lamps produce a better light than the old orange sodium lamps, but at the cost of greater energy inefficiency.

So street lighting is an obvious candidate for the energy efficiencies t hat LEDs can bring. But heat and electrical issues are currently barriers above 12,000 lumens. York-based firm Dialight Lumidrives has joined up with the University of Manchester's School of Electrical and Electronic Engineering to develop new approaches to overcome the 12,000 lumen barrier for LEDs. They'll also have to tackle environmental issues – like t he heat effects of having a bird nesting directly over a lamp.

LED street lighting will not only cut waste. It will pave the way for intelligent street lighting and reduce light pollution. The lifetime of the proposed LED module is in excess of 50,000 hours or 10-years if used for ro ad lighting – approximately four times longer than a conventional street light.

Going where lasers can't

One of the most important uses of lasers in medicine is in photodynamic therapy, or PDT. Toxic drugs designed to kill cancer cells are made photosensitive. In normal PDT treatments, a laser is trained on the tumour and the drugs are activated.

Lasers, however, have to be used with caution when used in especially sensitive areas, such as during neurosurgery. LEDs potentially offer a much safer alternative.

Paediatric neurosurgeons at the Medical Hospital of Wisconsin in Milwauk ee have tested LEDs to treat brain tumours during open surgery. Unlike lasers, LED light can safely illuminate through all nearby tissues, reaching parts of t he tumour that the shorter wavelengths of laser light cannot. According to Professor Harry Whelan, who led the surgical team, LEDs' ability to 'penetrate wide and deep' hold the key to its greater effectiveness.

Before embarking on surgery, the hospital had carried out experiments th at demonstrated that LEDs destroy tumours more effectively than conventional surgery. These experiments enabled the hospital to gain FDA approval to use an experimental LED probe, developed with the aid of NASA, for paediatric brain surgery.

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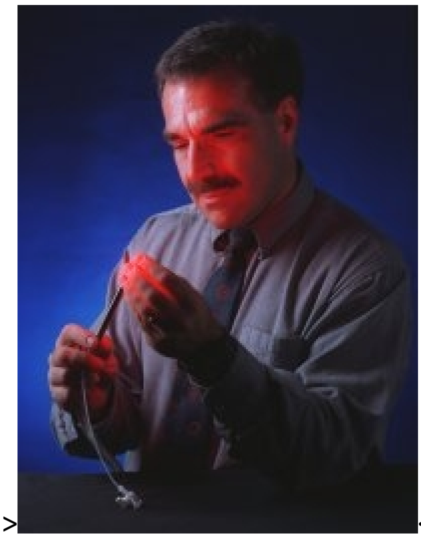

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Red light from the LED brain surgery probe shines through the fingers o f Dr Harry Whelan, a paediatric neurologist, at the Medical College of Wisconsin in Milwaukee. Whelan uses the long wavelength light from the LED probe to acti vate special drugs that kill brain tumours.

In another trial, Professor Whelan's team have used LEDs to treat eye injuries. In a series of experiments, Professor Whelan's team blinded rats by giving them high doses of methanol, or wood alcohol. This is converted by the body into formic acid, a toxic chemical that inhibits the activity of mitochondria. Within hours, the rats' energy-hungry retinal cells and optic nerves began to die, and the animals went completely blind within one to two days.

But if the rats were treated with LED light with a wavelength of 670nm f or 105 seconds at 5, 25 and 50 hours after being dosed with methanol, they recovered 95 per cent of their sight. Remarkably, the retinas of these rats looked indistinguishable from those of normal rats. 'There was some tissue regeneration, and neurons, axons and dendrites may also be reconnecting,' says Professor Whelan.

Helping Alzheimer's patients

LEDs are also being used to treat people with Alzheimer's disease. One of the side effects of the condition is to disturb sleep patterns acutely. People with Alzheimer's often wake repeatedly during the night, causi ng them to be sleep-deprived, and fall asleep continuously during the day. It also leads to night-time wandering, a major cause of Alzheimer's patients being institutionalised.

A team at Rensselaer Polytechnic Institute in New York treated Alzheimer's patients with about 20W of blue LED light for two hours before bedtime for two 10-day periods. Blue light was chosen as tests have shown it is the most effective part of the spectrum at controlling the body's circadian system, which controls sleep patterns. A control gro up were treated with red LED light.

The team discovered that blue LED light produced longer and deeper sleep during the night in the Alzheimer's patients, and more activity during the day as well.

Safer and cheaper lab measurements

LEDs are also making inroads into laboratory-based science, opening up m uch safer, cheaper and simpler-to-use alternatives to lasers.

A team in the Photophysics group at the University of Strathclyde in Glasgow, working in collaboration with Horiba Jobin Yvon IBH Ltd, has used LEDs to measure fluorescence decay of proteins.

According to the team, the fact that LEDs can be pulsed on a sub-nanosec ond timescale makes them ideal for fluorescence decay measurement.

Prior to Strathclyde's work, most development with LED-based fluorescence decay has been typically in the 450-550nm range. The shortest wavelength available with LEDs has been 370nm, too long for one the most important fluorescent samples, the amino acid fluorescence of proteins, whi ch absorbs below 300nm.

The Strathclyde team used an AlGaN-based LED, which could emit light at 280nm. The team found that adding a monochromator increased the stability a nd fine-tuning of the signal.

The team expects increasing use of protein fluorescence with LEDs. They argue that ultrafast pulses of mode-locked lasers still offer the ultimate in time resolution, but the low cost, ease of use, convenience and compactness of 280nm to 300nm nanosecond LEDs will make fluorescence techniques more widely used by protein researchers. They believe this will include not only decay kinetics, but also emission spectroscopy, microscopy, imaging and sensing u sing steady state, modulated and pulsed modes of operation.

Strathclyde's work illustrates a cheaper, safer and smaller replacement for existing fluorescence technologies. Biology and chemistry researchers at Virginia Tech have discovered that LEDs can provide rapid screening of a whole new generation of molecular drugs that bind to the DNA diseased tissues. Testing each molecule design was proving a time-consuming process, with roughly only one or two completed each day. A second year undergraduate at the institute, Aaron Prussin, has used LEDs to build an automated screening system. On a molecule successfully binding to DNA, Prussin's LED system lights up. The system now allows the institute to complete 100 tests a day. He is now planning to build an LED array that will light up with different colours depending on the DNA interaction.

Lighting up the last mile

One of the challenges for next generation broadband communications is 'the last mile'. Future entertainme nt and internet services are going to demand enormous bandwidth. With current infrastructure, that will entail a hugely expensive recabling of the last stretch from the local exchange to each subscriber home.

A team from Penn State University has shown that a system combining white LEDs coupled with power line grids can deliver extremely fast broadband direct to the home, at very little cost. It will a lso provide users with completely secure, very high-speed automatic wireless network throughout the house.

By using LED light, rather than microwave r adio, it also sidesteps the growing health concerns surrounding current home and office wireless networks. The Penn team, led by Professor Mohsen Kavehrad, use power lines to deliver broadband – an approach already used to connect backbone networks. The Penn team avoid the need for expensive terminating equipment in the home by relying on white LED lighting. Replacing conventio nal bulbs with LEDs, the broadband data, voice or video can piggyback through t he home's electrical wiring onto the light wave to reach any receiver devices around the house.

Professor Kavehrad's team has shown t hat their approach can deliver home broadband wireless of a gigabit a second, m uch faster than DSL or current fibre infrastructure. Because it doesn't penetrate walls, white LED networks will be more secure, and there are no k nown health hazards associated with white LED light.

Smart labels and 'intelligent wallpaper'

Printed electronics incorporating organic LEDs has the potential to transform labelling on food and drugs, making it far safer and more informative. Companies such as Cambridge University spin-offs CDT and Plast ic Logic, both founded by Professor Sir Richard Friend of the university's Cavendish Laboratories, concentrate on organic LEDs. Multinationals like Ep son, who have a dedicated lab at Cambridge studying this area, STMicroelectronic s, Hewlett-Packard, Agilent, PerkinElmer and Canon, are all actively investiga ting the printed electronics area.

Printed electronics is cheap: a conventionally-produced silicon device costing £30 to manufacture can be matched by an inkjet printed electronics device costing 2p. When inkjet is replaced by large-scale offset and gravure, the cost per device comes down to just fractions of a penny.

The ability to produce light, flexible, and cheap plastic devices incorporating OLED displays for just pennies, or even less, opens up a whole new field of smart labelling and ubiquitous displays.

Intelligent labelling for foods and medicines is one application. Patien ts rarely keep – or read - the leaflets that come with their medicines. Instead of relying on hard-to-read labels, or leaflets crammed with difficult-to-digest information, intelligent labels will be able to scroll through their information, enlarge it for the short sighted and even compen sate for any shaky hands.

Faced with growing concerns over obesity and the nation's diet, intelligent labelling on food will be able to much better inform customers what they're buying. In shops, intelligent labels could even play informat ion videos or adverts on their displays via a retail wireless network.

OLED-based printed electronics could even banish televisions and computer screens forever. The technology is already used to produce very large LCD displays. But printed electronics could also create intelligent wallpaper t hat could transform itself into wall-sized screens for watching television, usi ng a computer, or displaying the label instructions from packaging.

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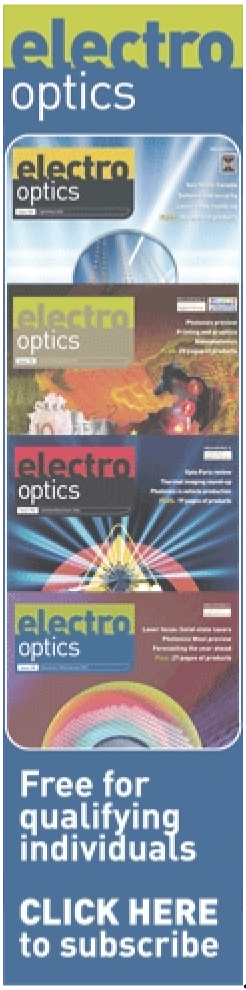

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