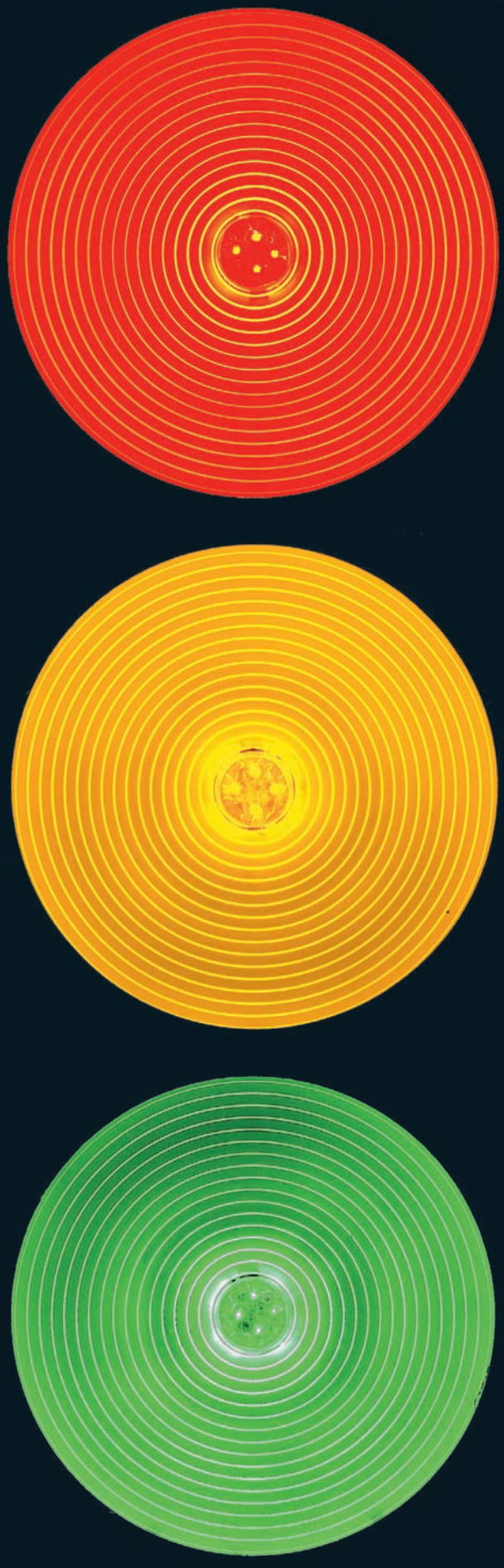

Innovative traffic light: a special lens distributes and emits the luminous effect from the LEDs

OPTICS

The LED revolution

Researchers from São Carlos develop equipment with light emitting diodes

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Published in September 2007

A new concept in traffic lights, with an innovative design, which is lighter and more compact and which, in place of traditional incandescent bulbs, use high-brightness light-emitting diodes as their source of light, the so-called LEDs, has been created by researchers at the São Carlos Research Center in Optics and Photonics (Cepof) of the University of São Paulo (USP). The new equipment is flat, is less than 2 centimeters thick and is easily installed. Other advantages lie in its low power consumption (15% less than traditional traffic lights) and in the fact that it keeps working even if there is a power cut in the region. This happens because it is attached to a set of compact batteries that keep it functioning for up to one and a half hours if there is a blackout.

Retrofit substitutes traditional traffic light lamps and reduces maintenance costs

"The technology is cheaper than conventional technology, it is economical in terms of energy consumption and has low maintenance costs", says the professor from USP's Physics Institute in São Carlos, Vanderlei Salvador Bagnato, Cepof's coordinator. The traffic light uses four LEDs and has a design that takes advantage of all the light refraction. "We have already registered a patent for the full equipment and as far as we know, no other group in Brazil or abroad is manufacturing traffic lights like ours."

Named 'blackout', in reference to the fact that it does not go out when there is a power cut, the device uses four high-brightness LEDs,(light-emitting diodes) in each light (red, yellow and green). A plastic lens with a special optical design distributes the light and emits the desired luminous effect. According to Bagnato, one of the biggest advantages of the new technology is the safety factor it will bring to road systems in cities. "It's going to reduce the probability of accidents and traffic chaos caused by small blackouts a lot, particularly in large cities, like São Paulo, where traffic flow is intense", he says. The product is in its finishing stage and the group from USP is already contacting companies that operate in the traffic signal sector to negotiate passing on the technology.

The 'blackout' traffic light is just one of the applications produced by the team led by Bagnato that is based on LED technology. The group, comprising 70 fulltime researchers and another 50 collaborators or associates, has, over the last few years, been researching and developing a series of other pieces of equipment that employ this light source, which was discovered in the 1960s (see the box on page 73). "The process for producing light in LEDs is very much more efficient that in common lamps, with up to 80% of the electricity used being converted into luminous energy. This represents an inversion in the efficiency of light production, because the rate of conversion of incandescent lamps is only 20%", explains Bagnato. "LEDs stopped being simply those small, normally red or green indicator lights on the panels of sound systems and other electronic equipment a long time ago to become an effective lighting source."

THE PROJECT

Technological innovation program of the São Carlos Optics and Photonics Research Center (Cepof)

MODALITY
Innovation and Diffusion Research Center (Cepid)

COORDINATOR
Vanderlei Salvador Bagnato – USP

INVESTMENT
R$ 200.000,00 per year (FAPESP)

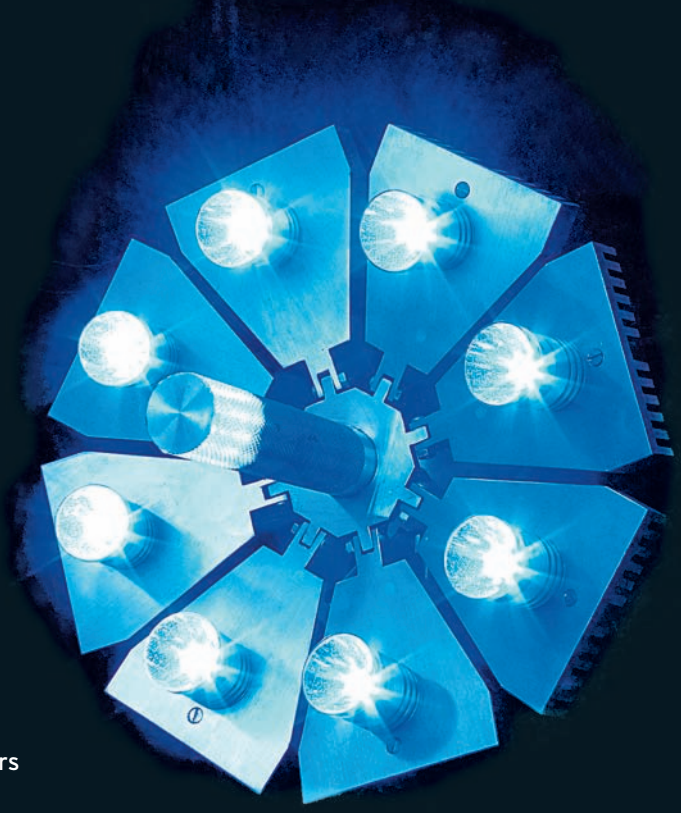
An advantageous substitution – Another application in the road signaling sector that was developed at Cepof in São Carlos, one of 11 Innovation and Diffusion Research Centers (Cepid) financed by FAPESP, is a system called 'retrofit', which uses six or seven LEDs and was created to substitute just the incandescent lamps used in traditional traffic lights. Unlike the 'blackout' traffic light, in which the LEDs are an integral part of the reflective lenses, the 'retrofit' has a shape that is similar to that an ordinary lamp and a screw socket, which allows it to easily substitute conventional lights. The technology was passed on to 'Meng Engenharia', in São Paulo and has been on sale since November 2005. "We've already sold nearly 15,000 lamps, which have been installed in traffic lights in São Paulo and Guarulhos", says Alberto Monteiro, the owner of Meng, a company that specializes in the manufacture of devices for the highway, urban and industrial signaling sector.

"The use of the LED-based lamp in traffic lights brings with it a series of advantages, because it's more economical, safer and more efficacious, in addition to lighting better. All this without mentioning the fact that the 'retrofit' has a long working life, thereby reducing the maintenance costs of the traffic light by up to 80% and the frequency with which the lamps are changed. In conventional lights the green and red lamps, which stay alight longer, are changed around four times a year and the yellow lamps, twice. Their cost varies from R$ 4 to R$ 8, totaling nearly R$ 60 annually, quite apart from the costs incurred with maintenance and exchanging the lamps. With the 'retrofit' one inspection visit a year is

enough, because each lamp lasts from between three to five years", Monteiro emphasizes. Each 'retrofit' lamp costs nearly R$ 500, which is a total of R$ 1,500.00, when divided by four years (on average), is R$ 375 per year. "With the reduction in visits to the traffic light and the maintenance costs, the installation of LEDs gives a return in around one and a half years", says Monteiro.

The lighting efficiency and durability (more than 50,000 hours, 50 times longer than conventional lamps) are two important differences that LEDs have. They also have another comparative advantage: the low environmental impact of the production process. Fluorescent lamps, always remembered as offering an alternative that is more economic than incandescent lamps, use mercury, which is a highly toxic substance. "These factors have led to the explosive growth in research over the last five years and various companies are launching more and more high-brightness LEDs and products based on them, in a great variety of combinations", points out physicist, Henrique de Carvalho, a member of the Cepof team.

Residential and urban lighting are two areas that have benefited greatly from the development of LED technology. Street lighting using light-emitting diodes and planned by Cepof is already being tested in São Paulo. In New York, there is an example in the huge screen on the NASDAQ MarketSite Tower, in Times Square, in the center of the city, which uses 18.6 million LEDs to decorate the front of the building and to give the quotations of shares traded on the North American technology stock exchange. According to the researchers from USP in São Carlos, in the residential area it is possible to substitute all lighting with LEDs, both internally and externally, without losing intensity, improving illumination quality and reducing energy consumption.



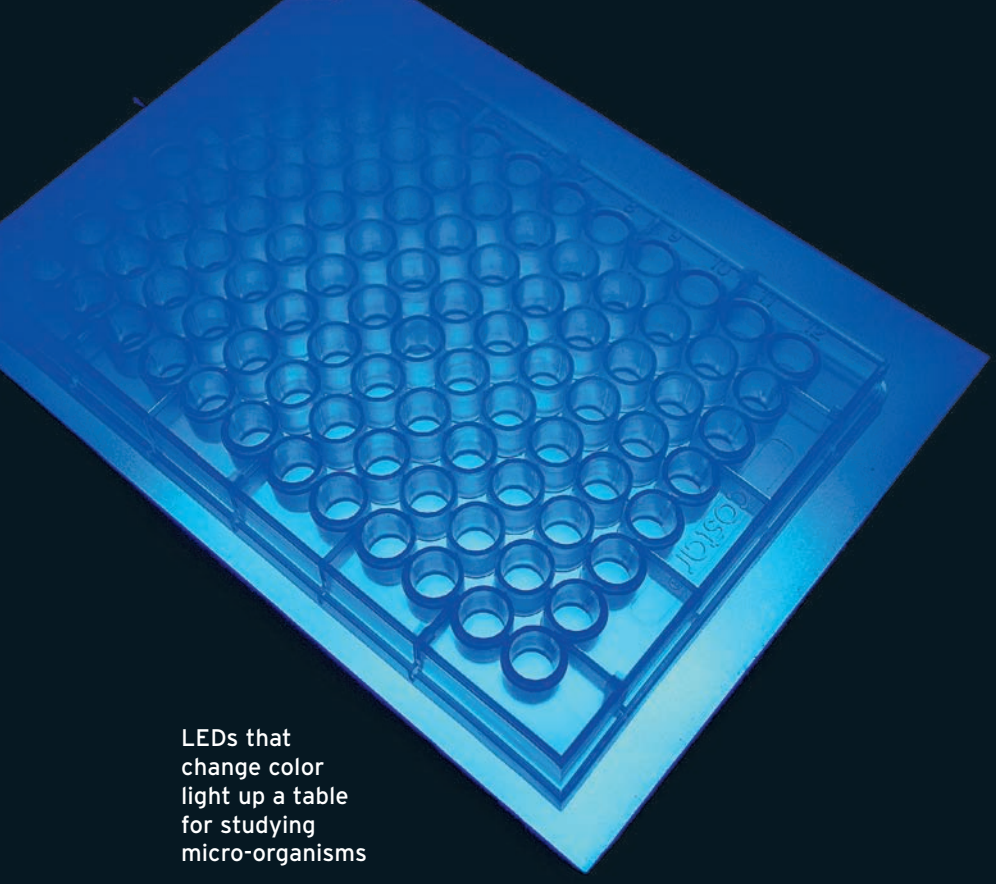
Auxiliary LEDs for lighting operating theaters

Emergency lights (those that are activated when there is a power cut) are also a promising application for LEDs. In a partnership with Cepof, Direct Light from São Carlos, which was set up by former researchers from the center, has developed two auxiliary emergency lighting models using LED technology. "The first batch of 25 units was bought by Cepof itself, which installed them in their laboratories. The second batch of 100 lamps should go on sale in September", says electrical engineer, Alexandre Oliveira, one of the seven partners of Direct Light, which was founded just one year ago.

The lamp uses just one 3 watt LED and works for one hour with 70% lighting intensity. "In addition to being more compact, our lamps use a nickel-metal hydride rechargeable battery that lasts at least twice as long as the sealed lead acid batteries used in the emergency lights found in the market", explains Oliveira. The product costs nearly R$ 90, a similar price to that of a quality emergency light made by competitors. The price is still high but the tendency is for it to fall as production increases.

Odontological reflector developed with Gnatus

The dentist's surgery - LED technology has also been used in developing various products used in the medical odontological area, such as, for example, mouth lights for dental surgeries, a segment that is also being focused on by Cepof. According to Bagnato, the de-



LEDs that change color light up a table for studying micro-organisms

vice, created by his team in a partnership with Gnatus, a manufacturer of medical odontological equipment, with its headquarters in São Carlos, allows dentists to se the colors of the teeth and gums more clearly and with greater definition. This is because the halogen lights normally used in dental lights have a yellowish tone, which makes perfect visualization difficult.

Mechanical engineer, Carlos Banhos, Engineering Manager for Gnatus, points out other differences in the apparatus, which is being launched in Brazil in September. "As the light emitted by the LED is cold, it emits no heat and avoids causing discomfort to the patient. Furthermore, the new light reflector allows for a reduction in power consumption of up to 90% when compared to traditional devices", he says. Gnatus is banking heavily on the equipment, which will be presented during the second half of the year at various international dental congresses in countries like Mexico, the United States, Italy and Russia. "We expect to sell the product, called the Gnatus LED Reflector, to customers abroad. Our products are already exported to 140 countries", Banhos says. The apparatus is between 10% and 20% more expensive than conventional devices that use halogen lamps.

Another piece of equipment that was created in Cepof's laboratories and that has already found a market is the PDT LED, an apparatus that uses light-emitting diode technology for photodynamic therapy techniques, PDT, in patients that have skin cancer, recurrent cutaneous breast cancer and other surface lesions.

Manufactured by MM Optics, another Cepof spin-off company, the PDT LED is an alternative to devices that use lasers for the same type of treatment. "With the difference that it is a quarter the price. While a laser apparatus costs nearly US$ 40k ours is R$ 20k", says mechanical engineer, Fernando Ribeiro, one of the company's partners. Since it was put on sale in the first half of last year MM Optics has already sold 20 photodynamic therapy apparatuses.

The equipment has a set of 21 LEDs with total voltage of 3 watts, at a wavelength of 630 nanometers. The light emitted reacts with the sensitizing drugs, which are applied to the patient and which concentrate in the tumor cells. The reaction kills the tumor. "The robustness of the apparatus is a result of the low maintenance that is needed, which gives our product yet another point of difference. And all this without mentioning that the LED, because it emits a less concentrated light, manages to treat a greater area of the patient's skin, while the laser is more pinpointed", explains Ribeiro. "This is the first and only device using LED technology made in Brazil for photodynamic therapy."

The equipment's success has meant that Bagnato and his team have developed a new version of the device. This is a kit with three devices for treating not only patients that have skin cancer, but also psoriasis, a disease that causes the skin to peel, human genital or anal papillomaviruses (HPV), which are visible or microscopic warts, and cancer of the mouth. This project is being carried out in partnership with, among other entities, USP's Faculty of Medicine in Ribeirão Preto, the Heart Institute (InCor), in São Paulo, the Amaral Carvalho Hospital in Jaú and the ESM-Sigma-Pharma pharmaceutical laboratory in Hortolândia.

"What's new about this project is that it offers a kit that treats various illnesses at the same time. We're getting close to the final, commercially viable design of the devices." Cepof's researchers are so excited about the kit that they have already asked for financing from the National Economic and Social Development Bank (BNDES) in order to conclude the project for creating 100 treatment centers throughout Brazil that will use the equipment", says Bagnato. According to the researcher three companies, including MM Optics and Direct Light, are already studying the possibility of producing the kit.

Colored microscopy - For the scientific area the researchers from Cepof have created two innovative, LED-based pieces of equipment. One of them is an illuminated table for photobiology studies, called the biotable. It works in a simple way: the scientist places micro-organisms on a transparent plastic slide positioned on top of the table and checks how they react to

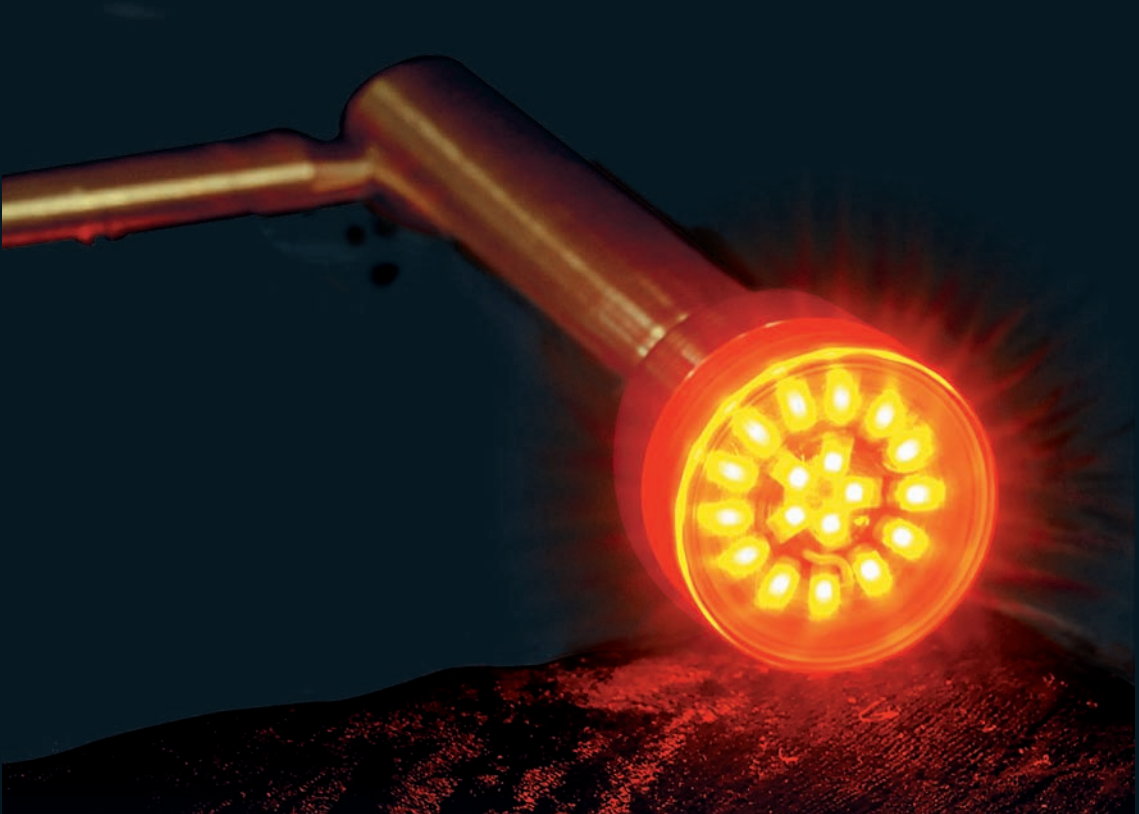
the application of different colored lights installed inside the table. The apparatus, still a prototype, is being tested by various teaching institutions, like the Odontology schools of the Paulista State University (Unesp), at its Araraquara campus, at USP in Ribeirão Preto and Bauru, and on USP's Biochemistry course in São Carlos.

The other apparatus is an optical microscope lit by LEDs. "It's our own technology, which uses three LEDs: blue, red and green. By combining light intensity, the researcher manages to highlight some of the morphological structures of the micro-organisms that are being studied. This would be impossible to do with a traditional optical microscope", explains the Cepof coordinator. The technology, known as chromatic contrast microscopy, is still in the test phase, but already has a registered patent.

"All the development done by our group reveals the enormous potential for the application of light-emitting diodes. Of the nearly 40 patents that originated within Cepof, at least 15 have already been transformed into end products and of these, half are LED-based devices", Bagnato says. "After the invention of the electric light and the laser we believe that the LED represents the third revolution in the optical field." ■

A illuminating story

The first light-emitting diode (LED) was created by North American scientist, Nick Holonyak Jr., in 1962, when he was working in a General Electric laboratory in Syracuse, in New York State. Interest in using these new devices for lighting purposes, however, only arose in the 1990s, when a group of researchers from Hewlett Packard, also in the United States, developed the first high-brightness LED. "Right after, researchers from the Japanese company, Nichia discovered the first high-brightness blue LED, which opened up the path to white-light LEDs", says physicist, Henrique de Carvalho, from Cepof in São Carlos. "Today, LEDs cover the whole electro-magnetic spectrum, from ultraviolet to infrared." The LED is a light emitter, the principle of which is different from that of incandescent or fluorescent lamps. "It's a semiconductor device that emits visible light when an electric current is passed through it, in a process known as electroluminescence, with nearly 80% of the voltage applied in it, depending on the wavelength of the emitter", says Carvalho. One of the differences with the LED is that, unlike ordinary lamps, it can produce light that changes color, intensity and distribution. In addition to LEDs, researchers in research institutes and companies are improving light-emitting diodes using organic-based substances, like compound polymers with carbon molecules instead of inorganic semiconductors made from silicon and gallium arsenide. Called organic light-emitting diodes (OLEDs), they can be produced from malleable and transparent materials. They are already being used in cell phones and MP3 players and the first prototypes for TV screens are being tested.



Apparatus substitutes the laser in photodynamic therapy for treating skin cancer