Light-emitting diodes (LEDs) are as small as motes of dust — but they’re giants when it comes to environmental friendliness. Not only do white LEDs require only one-fifth the power used by traditional light bulbs; but they last about 50 times longer. What’s more, unlike conventional energy-saving lamps, they are mercury-free. In fact, the white LED success story has been in the making for years (Pictures of the Future, Spring 2007, p. 34).

Offering 1,000 lumens, which is brighter than a 50-watt halogen lamp, the star in the LED firmament is undoubtedly “Ostar Lighting.” With its efficiency of about 70 lumens per watt, it literally relegates incandescent bulbs (15 lm/W) to the shadows. The lamp contains six high-efficiency LED chips, each measuring one square millimeter. "With Ostar, we have created a very large illuminated area," says project leader Dr. Steffen Köhler from Osram Opto Semiconductors in Regensburg, Germany, a subsidiary of Osram, a Siemens company. In contrast to the trend toward miniaturization in the electronics industry, LEDs for general lighting should be as big as possible, so that they can supply large amounts of light.

Achieving this goal is anything but an easy matter, though. It’s important to bear in mind that LEDs are a combination of differently doped semiconductor crystals. In other words, dopant atoms have been introduced to the crystal lattices, which have to be pure and regularly structured at the atomic level. The larger the crystals are, however, the higher is the probability that impurities and irregularities will occur. And the greater the number of impurities, the less efficient the conversion of electrical energy into light. Nevertheless, Köhler is confident that even more efficient and bigger chips can be produced. “We know that 2,000 lumens is a feasible goal,” he says.

Another important factor when it comes to producing efficient LEDs involves the yellow and orange-red colorants that are applied to the original light source in layers in order to transform the LED chips’ blue light into white. Osram researcher Dr. Martin Zachau is an expert in this field. He and his team use colorant grain size to control the dispersion properties of the particles, which allows them to vary emitted light. Efficiency is optimized via chemical composition. The stability of the phosphor is increased by means of a protective coating.

LEDs still do not accurately reproduce natural colors. That’s because, unlike sunlight or light from incandescent bulbs, they produce only blue and yellow wavelengths. With this in mind, Zachau’s team has come up with a new system that will transform parts of the blue LED light not only into yellow, but also into green and red light. “As a result, the LED spectrum will be complete — like sunlight — and colors will be superbly reproduced,” Zachau explains.

To accelerate phosphor development, Dr. Ute Liepold of Siemens Corporate Technology in Munich relies on combinatorial chemistry (Pictures of the Future, Spring 2003, p. 26). To that end, Liepold uses a perforated metal sheet about the size of a postcard. The sheet holds as many as 96 crucibles containing mixtures of powders, which create new phosphors when heated in an oven. A computer-controlled manipulator is then used to weigh out the starting materials and position the pans on a sample carrier. The advantage of this method is that several hundred samples can be produced in a single day. “But organizing and evaluating all the data is quite a challenge,” says Liepold. The objective of the screenings is to test as many compositions as possible in the shortest period of time.
**Mercury-Free Lamps.** A small amount of mercury, which turns into a gas at a lamp’s operating temperature, is usually added in xenon automobile headlights. Thanks to their larger size, mercury atoms are more easily hit by electrons in the plasma of these gas-discharge lamps. Because they emit light that is close to the visible spectrum, the loss occurring during conversion into white light is very low. Mercury also serves as a chemical and thermal buffer, preventing unwanted oxidation processes and helping to dissipate heat. But mercury is also poisonous and can accumulate in the environment. An EU regulation therefore specifies that it should be avoided whenever possible in the automotive sector, which is why researchers are looking for alternatives.

Just over a year ago, Osram launched the “Xenarc Hg-free lamp,” which replaces mercury with zinc iodide, a harmless gas. “The product’s development was difficult,” says Christian Wittig, head of Marketing for Xenarc Systems. “We had to adapt the entire electronic and optical environment to the new technology.” For example, the higher currents in this xenon lamp subject the components and electronics to greater stress, so Osram had to use thicker electrodes and thicker fused quartz glass. “Production is a bit more complicated, but it’s a step forward for the environment,” says Wittig. Automakers including Audi, Ford, and Toyota already use the new lamps.

**Glowing Prospects.** Osram compact fluorescent lamps still use mercury, but less than three milligrams per lamp. “It’s nearly impossible to dispense such a small amount of this material in drop form,” says Dr. Ralf Criens, an Osram environmental expert. “So the mercury is fixed with iron powder, which lets us put the right amount into each lamp.” Long service life is particularly critical for environmental reasons. Ultimately, longer service life means fewer replaced lamps — and less mercury. That’s why Osram researchers developed the very long-lasting compact fluorescent Dulux EL LongLife lamp, which can burn for 15,000 hours.

“Service life is a key factor when working on concepts for new lamps, as is the need to think in terms of systems,” says Criens. He foresees perennial favorites like white LEDs, which provide up to 90,000 hours of light, dispensing with the need for a base — a development that is expected to soon usher in new kinds of floor lamps, table lamps, and other applications using LEDs as fixed components at competitive prices. As a result, many customers could soon be glowing with pleasure at the sight of their bright, environmentally-friendly and long-lasting lamps.

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Catching Contaminants

Some Siemens products that contain electronic components are scrupulously analyzed in a special laboratory for traces of toxic substances such as lead or cadmium. The lab, which has expertise in chemistry and physics, not only helps to clear up mysterious product failures, but has also defined international test standards for environmental toxins.

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