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Enlightened Words

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Gallium nitride LEDs light the dome of the Jefferson Memorial in Washington DC. Photo credit John Williams, ONR.

If you come to Washington, DC to see the cherry blossoms this spring, take a walk around the Tidal Basin at dusk. Go inside the Jefferson Memorial and look up—you'll see a ring of bluish-white light illuminating the lettering carved in the stone walls: "I have sworn upon the altar of God eternal hostility against every form of tyranny over the mind of man."

For almost 60 years after the memorial's 1943 dedication, these words remained in the shadows. Now, however, you can read them quite clearly, thanks to a ring of tiny gallium nitride light-emitting diodes (LEDs) that circle the dome, just out of sight. Hundreds of tiny, energy-efficient blue LEDs provide the soft glow. Light tubes, each encasing several LEDs, are coated with a phosphor material that converts the blue light to bluish-white light. Max Yoder of the Office of Naval Research's Electronics group notes that 6500 Kelvin lamps that approximate sunlight are on the market, but they are not as efficient as the bluish lamps.

The story of how this stately monument came to be outfitted with a very modern type of lighting goes back to the 1970s. Back then, Office of Naval Research (ONR) was the only defense organization funding wide bandgap semiconductor research, according to Yoder. The largest recipient of that funding was North Carolina State University. Eventually, four graduate students and a postdoc went into business for themselves, founding Cree Research. The fledgling company focused on silicon carbide products such as microwave power amplifiers and moissanite gemstones. They also carried over some of their NCSU work on wide bandgap semiconductors (including gallium nitride) for lighting applications.

In 1992, Japan got into the LED lighting game, spurring competition from U. S. companies. A Japanese company, Nichia, came out with the first high-brightness blue gallium nitride LED. Red and green LEDs already existed, and adding blue LED completed the set of primary colors. This opened the way for color LED displays of the kind now common on cell phones and laptop computers.

Currently, LED lights are being promoted as "string lamps" for decorative purposes and for marking stair railings and pathways. Philips

Electronics' wide bandgap semiconductor blue and green LEDs will replace some of the incandescent bulbs in the large ball that drops in Times Square in New York City to usher in the beginning of the year 2007. (The red LEDs use a more conventional technology.)

LED lights are much more energy efficient than incandescent bulbs. With LED lights, more of the input electricity is converted to light, and less to heat, providing potentially significant savings in air conditioning costs for large office buildings with many hundreds of light fixtures. According to a U. S.Department of Energy estimate, by 2025, solid-state lighting (e.g., LEDs) could use as little as half the energy currently required for illumination. Yoder estimated that if you changed all the traffic lights in the U.S. to LEDs, the annual energy savings would approximately equal the entire annual electrical production of Saudi Arabia or Switzerland.

Currently, the best LEDs have a light emitting efficiency approaching 50%, about 10 times that of a conventional incandescent bulb, and about 3 times that of a new fluorescent tube. The brightest LED bulbs produce about 1 watt, and they last at least 5 years. At present, cost is an obstacle to adapting LED lighting on a large scale. One vendor charges $40 for an 18-bulb LED light that fits a standard AC bulb socket and produces about the same amount of light as a 15-watt incandescent bulb. (The device includes an AC-to-DC converter, which LEDs require.) The vendor claims a lifetime of 10 years, however, making this worth consideration for hard-to-reach light sockets. Production capacity for illumination-quality LEDs is still small, according to Yoder, so costs could come down considerably if a large-scale market develops.

LEDs are also useful for locations that are subject to vibrations or frequent changes in temperature that would shorten the lifetime of an incandescent filament bulb. The Navy has shown some interest in LED illumination for shipboard lighting. It is typical, Yoder said, to lose a large number of incandescent bulbs because of vibrations every time a large gun is fired, or if a torpedo or mine hits the ship. "You need emergency lighting that won't go out during a panic situation," he noted.