LED bulbs

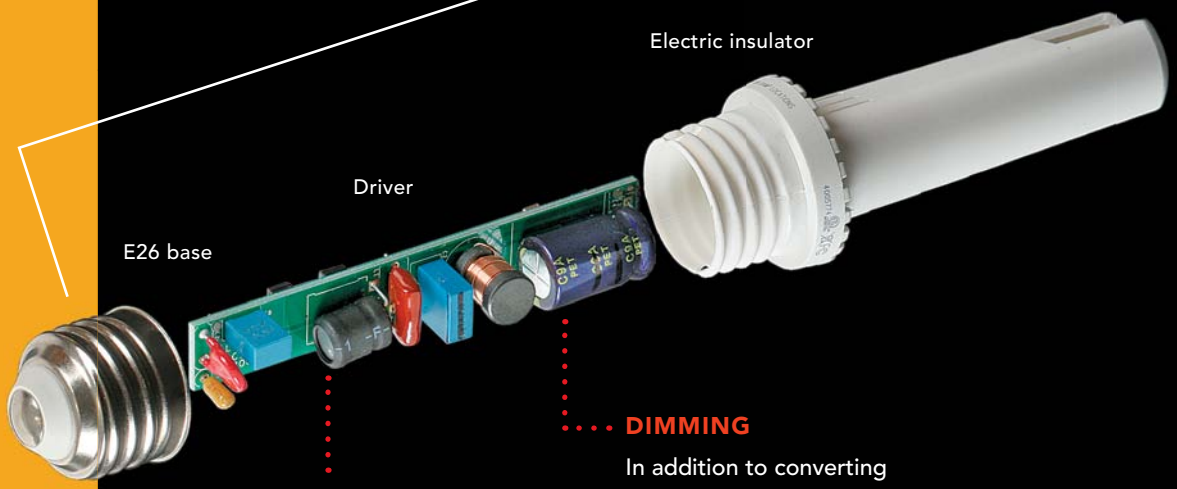
BY DEBRA JUDGE SILBER

For half a century, light-emitting diodes (LEDs) have offered the potential for highly energy-efficient home lighting. But there's been a catch: Light produced by LEDs is very unlike the light produced by the incandescent bulbs we've been using for more than 100 years. To win over consumers, LED manufacturers had to find ways to make their bulbs exhibit the same qualities as the older technology. Now available in the familiar shape of an A-lamp and designed to cast a wide beam of warm, incandescentlike light, LEDs have gained new acceptance from consumers. Recently, LEDs crossed the final frontier—cost—with the introduction of affordable and widely available screw-in replacement bulbs from reputable manufacturers. Here's how they work.

Debra Judge Silber is managing editor. Photos by Rodney Diaz.

BACK TO THE FUTURE

To gain acceptance as the lightbulb of the future, LEDs have undergone design tweaks so they more closely mimic the light of the past. Specific challenges—and how they were met—are outlined below.



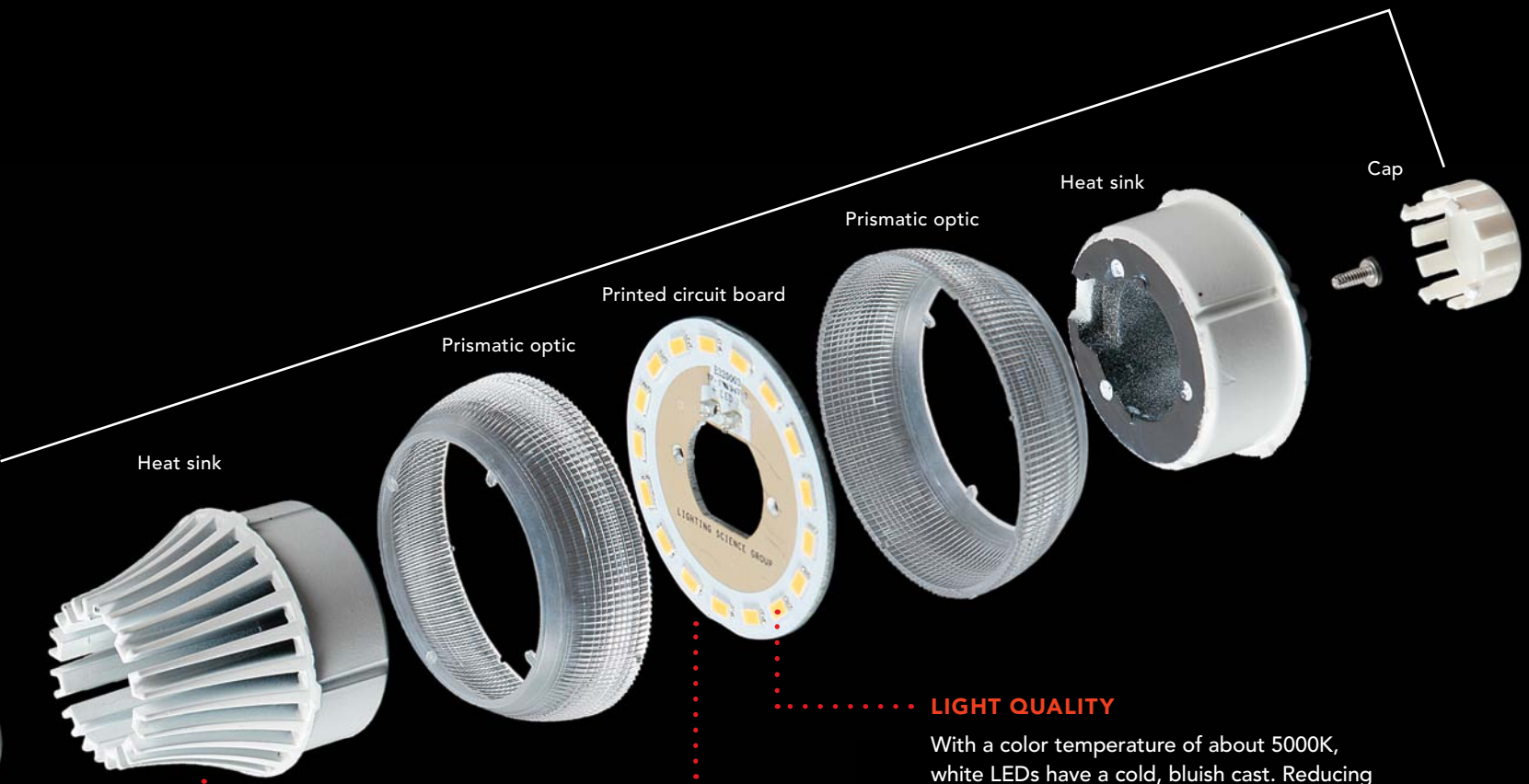
ELECTRONIC COMPATIBILITY

Because LED chips operate on low-voltage DC current instead of household 110v AC current, LED bulbs require built-in drivers to convert and step down the current, to filter out electromagnetic interference, and to ensure dimmer compatibility. Driver performance is critical to light quality and bulb life. Electric current enters the driver through a traditional screw base, allowing replacement LEDs to fit any fixture designed for A19 incandescent bulbs.

DIMMING

In addition to converting line voltage, LED drivers have had to be designed to work with standard incandescent dimmers. Unlike incandescents, which produce a warmer light when dimmed, the color temperature of LEDs remains consistent when dimmed. Some manufacturers have combined LEDs of different color temperatures in one dimmable fixture in order to replicate the candlelightlike effect of dimmed incandescent bulbs.

Sources: General Electric; Cree; Lighting Science; Group Corporation



HEAT SENSITIVITY

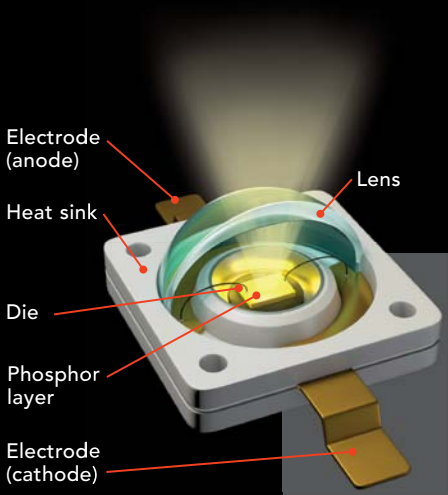
Although LEDs produce less heat than incandescents, they are more sensitive to it. For this reason, all LEDs include some type of heat sink, a conductive material to draw heat away from the chip. Some also incorporate fins to promote cooling through convection. Improved efficiency in new LEDs, however, has allowed manufacturers to do away with finned designs.

LIGHT DIRECTION

Light from an LED projects in one direction, unlike the omnidirectional glow that comes from an incandescent filament. To get around this, LED bulb manufacturers arrange diodes in various ways (photos right) to produce the multidirectional light consumers want. Light distribution is also enhanced with the use of reflectors inside the bulb, coatings or surface textures on the optic (bulb cover), and the design of the LED component itself.

LIGHT QUALITY

With a color temperature of about 5000K, white LEDs have a cold, bluish cast. Reducing that temperature to the 2700K of incandescent light is done with the application of yellow phosphors to the optic or to the LEDs themselves. High-quality phosphors add to the cost of bulbs with the most pleasing color temperature and the best color rendering.



LEDs consist of two types of semiconductor material. Light is created when electric current causes negatively charged electrons in one material to fill positively charged electron "holes" in the other. When this occurs, the electrons release energy in the form of photons of visible light. Depending on the semiconducting material, these photons may be red, green, or blue. White light is created when colors are combined or when a blue diode (typically silicon carbide paired with synthetic sapphire or gallium nitride) is coated with a yellow phosphor that converts the light to white.

Drawing: John Hartman