how it works

COMPLEX CHEMISTRY AND SPECIALIZED DRIVE CIRCUITRY GIVE ELECTROLUMINESCENT LAMPS THEIR COOL AND EERIE GLOW.

Electroluminescent lamps: sharp answers to flat lighting

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Designers use electroluminescent lamps as backlighting for LCDs in pagers, cell phones, watches, and control panels and as lighting sources for safety strips and highlighting. Why would you want to use a light source that is less efficient than an incandescent lamp, requires several hundred volts of drive, and has a limited lifetime?

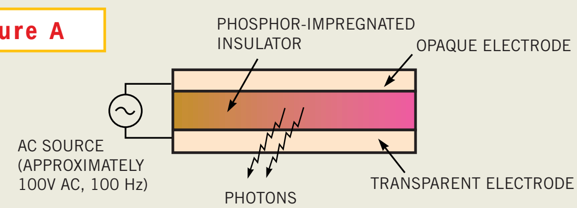
The answer is simple: An electroluminescent lamp is the most practical way to evenly illuminate a flat area, whether that area measures 1 sq cm or several square meters. Although you could use point sources of light, such as LEDs, the requisite light diffuser is mechanically complex and costly, and it still doesn't provide an evenly spread glow without annoying illumination hot spots. Illuminating an irregularly shaped area or a flexible panel with this backlight

DUST OFF THOSE PERIODIC CHARTS

Today's electroluminescent panels have a dielectric layer and a phosphor layer located between two conductive electrode layers (**Figure A**). One of these electrode layers is opaque; the other layer is transparent. The applied field alternates, and the electrons of the phosphor absorb energy as the field intensity increases. This increase in field intensity kicks these electrons from their resting valence band into a higher conduction-energy band. As the field intensity decreases, the energy states relax, and the electron falls back to the valence band, giving up the energy difference between bands as a photon. This photon exits the lamp through its transparent conductive layer.

By using different phosphors, such as zinc sulfide, calcium sulfide, or strontium sulfide, and adding elements, such as magnesium, samarium, and europium, electroluminescent-lamp vendors can modify the energy-band differences and change the resulting photon energy and illumination colors. Changing the excitation frequency also causes slight color shifts.

Figure A



The construction of an electroluminescent lamp is deceptively simple: A dielectric and phosphor layer is sandwiched between two conductive layers, one of which is transparent.

Unlike most electronic components, electroluminescent lamps don't burn out, but they do wear out. Vendors specify the time it takes for an electroluminescent display to dim as one-half of the display's initial value, and most vendors also specify an end-of-life time at which brightness is 1% of the initial value. The typical half-life of an electroluminescent lamp is 5000 to 10,000 hours, depending on phosphors, excitation voltage, and excitation frequency. Ambient humidity also decreases lamp life. For many applications, you use the electroluminescent lamp only for a few seconds, so limited lifetime is not a major problem.

Electroluminescent lamp vendors include Durel Corp (www.durel.com); Leading Edge Industries/Metromark (www.metromark.com); Luminescent Systems Inc (www.lumsys.com); Lumitek International, Inc (www.us.net/quantex); and MKS (www.quantaflex.com). Japanese-based vendors include NEC Corp (www.nec.com), Nippon Graphite, Seiko Precision (www.seiko-precision.com), and Toshiba (www.toshiba.com).

glow is even trickier. These areas are where the electroluminescent lamp shines: It gives you the illumination you need, tailored to the shape of your display or panel.

Electroluminescent lamps are based on the research of Professor G Destriau in France in 1936. Destriau found that when you suspend a zinc-sulfide phosphor powder along an insulator (he used oil on glass ceramics) and apply an ac voltage, the resulting electric field causes the phosphor to glow (see **sidebar** "Dust off those periodic charts"). By modifying the phosphor, you can change the color of the glow from blue-green to bluish, yellowish, and even dull violet. (Do not confuse electroluminescent lamps with thin-film electroluminescence (TFEL), a technology used for image formation. The underlying principles, construction, and drive-circuitry architecture for TFELs differ greatly from those parameters for electroluminescent lamps.)

The brightness, L, of the Destriau-type electroluminescent lamp increases with applied voltage, V, according to the equation:

$$L = A^{-(B/\sqrt{V})},$$

where A and B are, as they say in the textbooks, "constants to be determined." A and B depend on the phosphor mix that the electroluminescent lamp uses. You can first-order approximate the brightness as roughly proportional to the applied voltage, which typically ranges from 30 to 200V ac p-p.

But voltage is not the only factor that affects electroluminescent brightness (see **sidebar** "Who'll do the driving?"). The applied ac frequency is another factor. Again, a first-order approximation is that brightness is proportional to the frequency for a fixed applied voltage. Most electroluminescent lamps use frequencies of 50 to 400 Hz, although some lamps use frequencies as high as several kilohertz. As the frequency increases to several kilohertz, the increase in brightness tapers off.

Efficiency of electroluminescent lamps is relatively low. A good electroluminescent lamp yields about 3 to 5 lm/W of input power; a typical incandescent lamp yields output of 12 to 18 lm/W (corresponding to about 10% efficiency); a fluorescent lamp yields 50 to 80 lm/W. The LED is the champion at more than 90% efficiency. But, as with most visual and brightness subjects, these raw numbers are not the whole story. Designers most often use electroluminescent lamps in relatively low-intensity situations, when absolute output magnitude is not the primary factor. In these situations, obtaining an even glow over the entire area is more important.

Electroluminescent illumination evenly distributes and sources where you need it, rather than shining on the display from a distance. Therefore, it is not wasted or diffused by distance. (Recall that a point source's intensity falls off as the square of the distance, so the flatness of the electroluminescent-lamp illumination and its location at the display panel make the electroluminescent lamp a much better choice than simple efficiency numbers indicate.) The heat that the electroluminescent lamp generates is not usually a problem, because the power levels are relatively low and the dissipation is spread over the surface area of the lamp, unlike the point source of an LED or incandescent source. □

Reference

1. "*McGraw-Hill Encyclopedia of Science and Technology*," Eighth Edition, 1996.

WHO'LL DO THE DRIVING?

Ironically, the dominant mass-market applications for electroluminescent lamps are very-low-voltage, battery-powered applications. You start with a dc source that your drive circuitry must transform (with high efficiency) into an ac signal at approximately 100V and 100 Hz with no residual dc component.

Electrically, the electroluminescent lamp looks like a capacitive load of about 1 nF/cm^2. Fortunately, despite the high drive voltage, the nature of the load keeps current requirements fairly low, ranging from 0.03 to 1 mA/cm^2, depending on electroluminescent-lamp design, chemistry, and the level of brightness you need.

Before the development of dc/dc converter ICs, it was difficult to build an efficient and cost-effective drive circuit without the numerous discrete components that provide both the voltage step-up function and the commutation required to convert a dc supply into a commutating, 0V-symmetrical ac signal. Even a so-called complete drive IC required several external inductors or a transformer. Now, most available ICs require only a few resistors and capacitors and a single small-value inductor. You set the operating frequency via one of the resistors or capacitors, depending on the design. Some of these ICs automatically adjust the drive output as the battery output falls to maintain brightness; these ICs also detect electroluminescent-lamp aging by the associated increase in lamp capacitance and compensate by creating a higher output voltage.

If you are designing with electroluminescent lamps, there are many subtleties for you to consider regarding the interplay among the electroluminescent-lamp parameters, including interrelated factors of operating voltage, frequency, desired output brightness, required lamp life, color, and cost. There are also subtleties between the drive circuitry and the electroluminescent lamp. The application engineers at the electroluminescent-lamp vendors and at the drive-circuitry vendors are important resources for you because they have experience with both electroluminescence in general and with the unique characteristics of their products. The engineers will recommend vendors and models of inductors you will need. Their help is important, because complex factors beyond the nominal inductance value, such as the inductor's dc resistance and stray capacitance, play key roles in your ability to achieve reliable, consistent operation. Although some electroluminescent lamp vendors offer also drive circuitry ICs and assistance, you can also get electroluminescent-specific ICs along with comprehensive applications support from IC-only vendors, such as Sipex Corp (www.sipex.com) and IMP, Inc (www.impweb.com).

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