LUXIM'S LIGHT EMITTING PLASMA

It's a discharge lamp, but not as we know it.

Text: Andy Ciddor

Although we're constantly being bombarded with the message that the solid-state light emitting diode is the greatest advance in lighting since our sun's photosphere kicked into action about 4.5 billion years ago, there are still innovations aplenty being wrought in many other types of sources.

Of particular interest is the Light Emitting Plasma (LEP) source from the LUXIM Corporation in the USA's Silicon Valley. While the name 'plasma' is being bandied about to draw attention to the fact that this isn't a solid state source, it's likely to cause some confusion because virtually every electric lamp that doesn't produce its light from a glowing filament involves the production of plasma.

GETTING IN A STATE

Plasma is the most active state of matter. The solid form is the least energetic and as a rule, the most stable state of matter, but if you add sufficient energy to a solid it will usually melt into the liquid state. If you keep adding energy to the liquid form of a material, it generally vaporises into the much more energetic gaseous state. When you add even more energy to the gaseous form of a material, it loses its grip on some of its electrons and becomes conductive plasma. The usual method for creating plasma is to put a pair of electrodes into container of a gas then pass a spark between them to energise the gas.

The metal-halide discharge lamps we use every day contain an inert gas, small amounts of mercury and the halide salts of metals. The inert gas is arced into conduction and driven into its plasma form by a high-energy pulse being passed between a pair of tungsten electrodes. This in turn heats the mercury and metal halide salts until they become bright, light-emitting plasma.

The requirement for electrodes in a lamp brings with it a range of problems. The high energy start pulses cause some vaporisation of the electrode material. This can lead to blackening of the transparent envelope of the lamp, which reduces its light output. Also, as the electrodes erode from vaporisation, the gap between them increases, necessitating a progressively higher energy pulse to bridge the gap and start plasma production. In addition, the electrodes also act as heatsinks, carrying away some of the energy from the lamp that might otherwise have been used to keep the plasma hot and glowing. Add to this the problems associated with getting electrical power through the envelope material and into the electrodes while not letting the high pressure gasses escape, and you have another set of places for degradation of lamp performance and eventual failure.

LOOK MUM, NO WIRES

If you could create the plasma without needing electrodes, you immediately increase both the operational life and the efficiency of the process. The idea of electrode-less plasma production has been around since demonstrations of the principle by Nikolai Tesla in the late nineteenth century.

A modern, high output electrode-less lamp was developed in the early 1990s by Fusion Lighting in the US. This now-abandoned technology used a cavity magnetron, similar to those found in domestic microwave ovens, to create plasma from powdered sulphur contained in a golf ball-sized quartz glass envelope. While being very energy efficient – approximately 100lm/W (lumens per watt) – the sulphur lamp had serious drawbacks. It was only available in very high output versions starting at about 150,000 lumens, which, while great for searchlights, doesn't have a lot of applications for general commercial, industrial or domestic lighting. The sulphur lamp's other big problem was that the magnetron operated at 2.45GHz – bang in the middle of the wireless spectrum used by everything from cordless phones and AV extenders to wi-fi Ethernet – and it took a lot of work to stop all that radio frequency (RF) energy from leaking out into the environment.

LUXIM's development of the technology it's released as LEP is a progression from the sulphur lamp, in that it too uses RF energy to produce the plasma in its source, although in this case at 440MHz. LUXIM's lamp consists of a tic-tac-sized quartz glass envelope filled with an inert gas together with small amounts of mercury and a mix of metal halide salts. The envelope is partially embedded in a puck of ceramic materials that contains the RF emitters, waveguides and feedback sensors to produce and control the excitation of the plasma. Unlike the sulphur lamp, the RF emissions from the LEP are relatively easily manageable in the design of the reflector and fixture design process.

SMARTER THAN YOUR AVERAGE LAMP

A critical component of the LEP lamp is the electronics system that generates the RF energy and monitors the status of the lamp as it goes through start up and re-strike sequences, and maintains the stability of the plasma column during continuous operation. The early versions of the control electronics contained some 200 discrete components, but LUXIM has very recently upgraded to an IBM-designed, hybrid ASIC (application specific integrated circuit) that incorporates all signal conditioning, digital processing, RF and high voltage circuitry required to drive the lamp's systems. As a bonus, this control system allows the lamp to be very rapidly and smoothly dimmed between 20% and 100% of light output, with little shift in colour temperature between 100% and 50%. The system also sports a serial data link that enables it to communicate with the outside world about everything from its health and operational status, to DMX and DALI control messages and the current leaders of the footy tipping competition. It can also be controlled by a 1 to 10V analogue control signal for compatibility with older control equipment. The reduction in the size of the electronics brought

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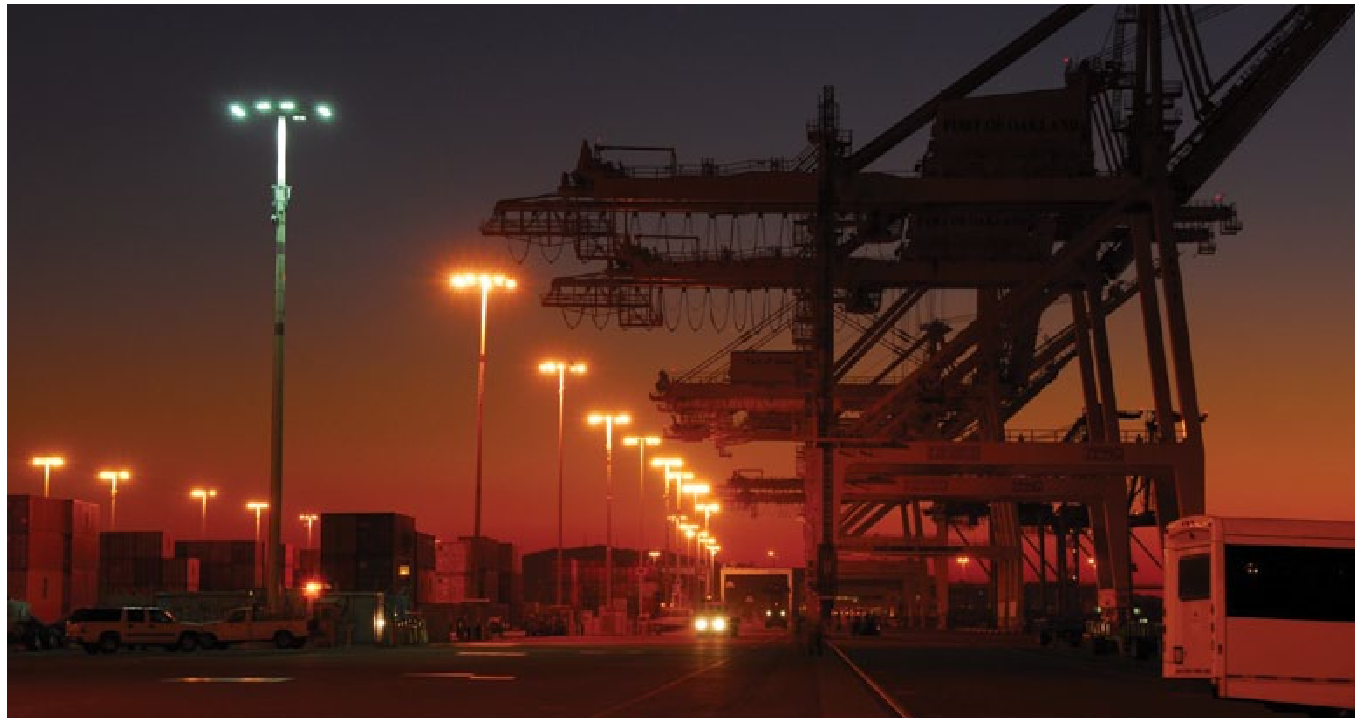
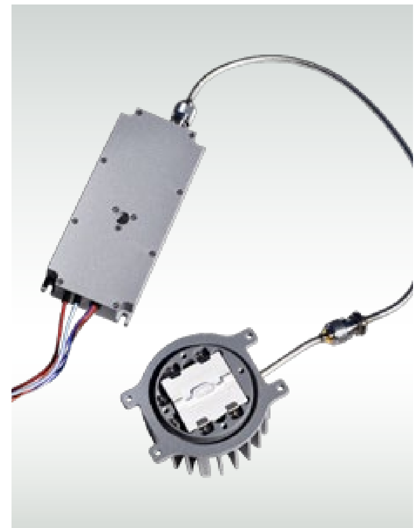
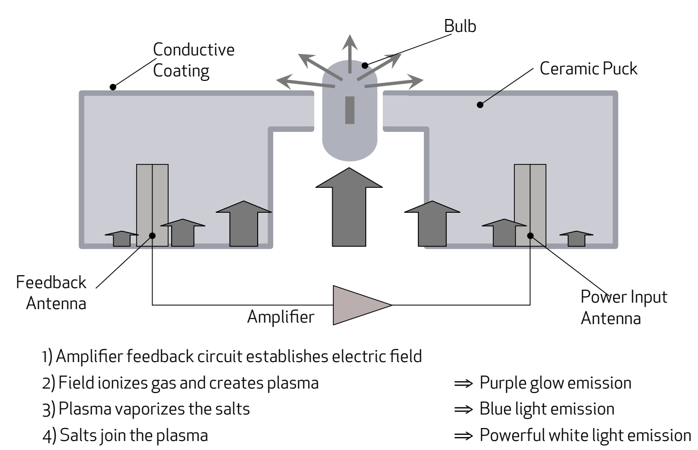
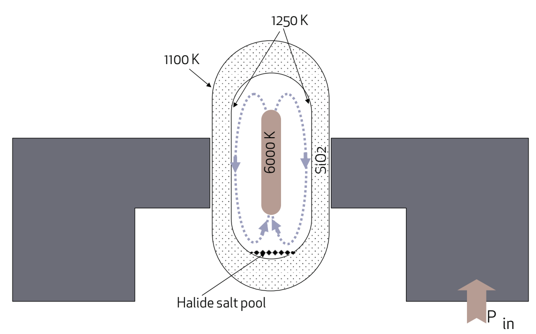




Top: Test LEP high-mast fixtures at the Port of Oakland, California really stands out from the high-pressure sodium crowd.
Above left: LEP quartz-glass capsule.
Above: Hive Lighting's Killer Plasma 4-light Maxi based around the ENT-31-02 LEP source. 1.08kW of LEP beats 2.5kW of HMI and remains flicker-free to 225 million fps.

Above right: RF-shielded LEP electronics module connected to a heatsinked lamp module via a heavily RF-screened cable assembly.
Below left: How an LEP lamp works.
Below right: The thermodynamics of an LEP capsule during operation.





> the electrode-less design… allows lamp life to extend to tens of thousands of hours

about by the move to the ASIC means that the new higher-powered lamps coming into production can fit in the same footprint as the original lamps.

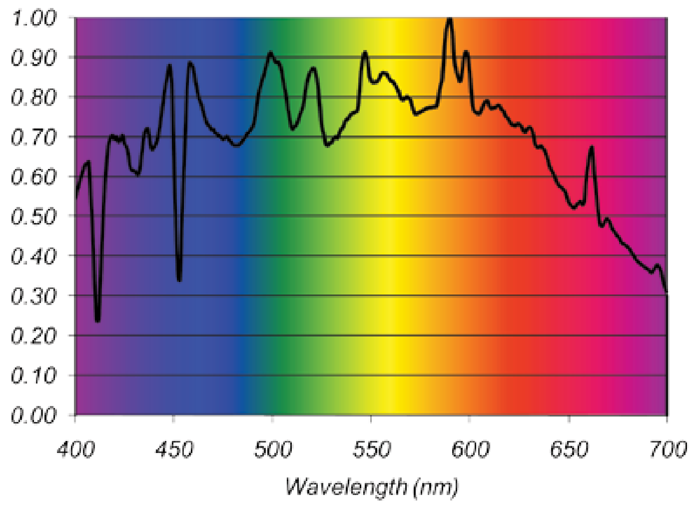
Not only does the electrode-less design permit higher efficiencies, it also allows lamp life to extend to tens of thousands of hours before significant output reduction, and several times that before lamp failure. Lamp efficiencies in the LEP range vary from 60lm/W to around 100lm/W (about double that of metal halides). Operational life (L70) ranges from 10,000 to 50,000 hours, depending on the correlated colour temperature and colour rendering index (CRI). These numbers are increasing with each production model, as R&D is continuing to improve the control system, the RF coupling, and the fill mix in the envelope.

The CRI of the LEP lamps ranges from a moderate 75 to an impressive 95, depending on the gas fill and the usual trade-off between efficiency and CRI. (See the table below.) In common with all light sources, some wavelengths are easier to produce than others, leaving the choice between a good balance of colours and moderate output, or plenty of the easy-to-make colours and their consequent over-abundance in the mix.

As with the CRI, the correlated colour temperature of an LEP lamp depends on the mix of materials used in the gas fill, with current products ranging from 5300K to 9000K. The ENT-31-02 LEP lamp used in the award-winning film and TV fixtures from Hive has a colour temperature of 5600K, a CRI of 94, an efficiency of 67lm/W and a life of 10,000 hours. The colour temperature change for this lamp is a fairly gentle increase (blue shift) of approximately 0.08K per hour, or 800K during its long life. This is sufficiently significant to require periodic colour temperature corrections where the output is being used for photographic or video applications, or where there are lamps of radically different ages in the rig. According to LUXIM's engineers, it is possible to adjust the correlated colour temperature of an LEP lamp by a few hundred Kelvins, by modifying the amplitude of the RF excitation via the lamp's data link.

Being on a much smaller scale than the sulphur lamp, LUXIM's LEP lamps produce light in quantities that are useful for commercial, street lighting, plant growing, instrumentation and architectural purposes, including some projection and entertainment applications. LUXIM's first commercial products a few years ago were in the 170W region, but its current offerings range up to 500W with a light output of 45,000lm (the equivalent of 750W of metal halide). Outputs are set to increase up to an impressive 1kW in future products.

The LEP lamp fills the need for a very compact, long-life, high-efficiency, high-CRI light source at a density, light output and efficiency that may never be met by LEDs. Electrode-less plasma discharge technology deserves a top position on your list of technologies to watch. ▶|



Above: Spectral distribution for ENT-31-02
Below: Comparison of some different versions of the LEP lamp

Lamp	STA-25-03	INT-30-02	INT-30-03	INT-30-04	ENT-31-02	STA-40-01	STA-40-01	STA-41-01	STA-41-02	STA-75-01
Lumens	12,000	2260	1950	2800	17,800	16,000	14,000	23,000	17,000	45,000
CCT	5200K	6400K	7650K	6500K	5300	6000K	5300K	5200K	5200K	5200K
CRI	75	95	95	95	94	80	94	75	95	75
Life	50,000	10,000	10,000	10,000	10,000	30,000	30,000	50,000	30,000	50,000
Voltage	24	28	28	28	28	28	28	28	28	28
Amps	6.3	8.5	8.5	8.5	9.5	9.2	9.2	9.2	9.2	12.5
Power	160W	238W	238W	238W	266W	258W	258W	258W	258W	375W
Usage	General	Instrument	Instrument	Instrument	Entertainment	Growing	Growing	General	General	High mast