Mercury Technology Bulletin Series: 011

LED Technology

Background

Requirement of the Minamata Convention on Mercury

Article 4, paragraph 1 of the Minamata Convention on Mercury stipulates the following :
"Each party shall not allow, by taking appropriate measures, the manufacture, import or export of mercury-added products listed in Part I of Annex A after the phasing-out date specified for these products, except where an exclusion is specified in Annex A or the Party has a registered exemption pursuant to Article 6".

However, there are some mercury-added products not subject to control under the Convention as they are not listed in Annex A. These products may become subject to control under the Convention following a further review of Annex A by future COPs. Some Japanese companies today already produce and offer mercury-free alternative products to such mercury-added products. This flyer introduces the development of LED technology in Japan as an example of technology for such alternative products.

Overview of the Technology

LEDs for lighting and electronic display

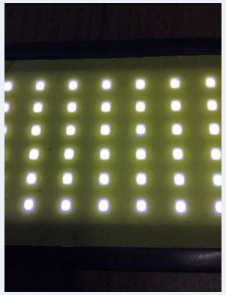
Mercury-added fluorescent lamps have been widely used as light source in general lightings and electronic displays. Invention of blue LEDs by Japanese researchers was followed by the invention of white LEDs through a combination of blue LEDs and a fluorescent body.

The invention of white LED and further performance improvement efforts has made white LEDs widely recognized as an alternative to fluorescent lamps as its performance is better than the performance offered by conventional technologies. Such recognition has led to a call in some quarters for the restriction of the manufacturing of fluorescent lamps. Meanwhile, improvement of mercury encapsulation technology has substantially reduced the mercury content per fluorescent lamp to the extent that most fluorescent lamps in the Japanese market do not fall within the scope of Annex A. However, despite the low amount of mercury included per lamp, these fluorescent lamps still contain mercury, an environmentally hazardous substance, and some Japanese manufacturers have started terminating the production of fluorescent lamps, underlining the rapid acceleration of the shift to LEDs.

Comparison between Fluorescent Lamp and White LED

	Fluorescent Lamp	White LED
Luminous efficiency (lm/W)	100	160
Life span (hrs)	8,000	40,000
Min. operating temperature (℃)	5	-10
Hazardous substance	Use of mercury	None
Output deterioration due to repetitive switching	Large (life span shortened)	None

White LED



Replacement of 365nm ultraviolet lamp to ultraviolet (UV) LED

The use of ultraviolet LEDs (with emission wavelength of 405 nm ~ 365 nm) , which use the same manufacturing technology and same semiconductor material (InGaN) as blue LEDs is spreading and replacing mercury lamps (conventionally the most popular sources of ultraviolet light). In the case of ultraviolet LEDs with emission wavelength 365 nm, their development has reached the stage where the performance is equal to or better than mercury lamps with emission wavelength of 365 nm. Although not required by stipulations of the Minamata convention currently, for uses like the hardening of resin by ultraviolet light at an emission wavelength of 365 nm, replacement of ultraviolet lamps by ultraviolet LEDs is rapidly progressing.

Mercury Technology Bulletin Series:

Advantages/Strengths

Deep Ultraviolet (UV) LED

Apart from high pressure mercury lamps with emission wavelength of 365 nm, low pressure mercury lamps with emission wavelength of 254 nm in the deep ultraviolet region also exist. These low pressure mercury lamps are mainly used for the purpose of sterilization. AlGaN is a semiconductor material for LEDs whose emission wavelength is in the deep ultraviolet region. In recent years, improvement of deep ultraviolet LEDs has been rapidly progressing to the extent that some products are now being marketed. For the purpose of water sterilization, water sterilization apparatus equipped with deep ultraviolet LEDs demonstrating better performance than water sterilization apparatus using low pressure mercury lamps as the conventional light source, and incorporating an optical design which makes the best use of the characteristics of LEDs, is now available in the market. At present, there are only a few companies, including a Japanese one, in the world who manufacture deep ultraviolet LEDs at the commercial production level.

Deep ultraviolet LEDs have the advantage of making water treatment possible in areas with power generation shortages because of their lower power consumption compared to mercury lamps. Due to factors like cost-benefit performance including lower power consumption requirement and the ability to contribute to AI-led agriculture unaffected by the weather, the demand for the introduction of deep ultraviolet LEDs is expected to increase in the coming years.

Comparison between mercury lamp and Deep UV LED

	Mercury Lamp		Deep Ultra Violet LED
Dose	30,000 μJ/cm^2	Same dose	>30,000 μJ/cm^2
Flow rate	3 m^3/hour		3 m^3/hour (50 L/minute)
Life span	8,000 hour	>4 times	35,000 hour
Power consumption	140 W	≒50%	72 W
Size	W: 30 cm *H: 160 cm *L: 45cm	<10% (volume)	W: 55 cm *H:19 cm *L:19 cm
Weight	30 kg	<50% (weight)	13 kg

Water sterilization apparatus equipped with deep ultraviolet LEDs

Data and photo provided by Nikkiso Co., Ltd

Applicability

Compared to mercury lamps, the price of deep ultraviolet LEDs is still much higher and it is likely to take some time for the market for deep ultraviolet LEDs to be established, particularly in developing countries. However, projects to introduce deep ultraviolet LEDs in poor regions with inadequate water treatment facilities and insufficient power generation and supply facilities have started and their usefulness is being recognized. There is a possibility for a faster introduction of these LEDs in the coming years technical innovation and if listed to Annex A by future COPs.

Further Reading

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