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

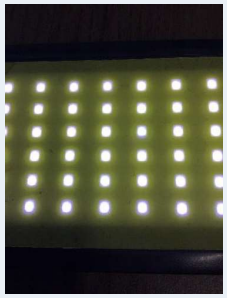
Mercury-added fluorescent lamps have been widely used as light source in general lightings and electronic displays. Invention of blue LEDs by Japanese researchers was followed by the invention of white LEDs through a combination of blue LEDs and a fluorescent body.

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.

Advantages/Strengths

Deep Ultraviolet (UV) LED

Mercury lamps include high-pressure mercury lamps with an emission wavelength of 365 nm, as well as mercury lamps with emissions in the deep ultraviolet region. Mercury lamps with an emission wavelength of 254 nm are primarily used for sterilization applications.

In the deep-ultraviolet region, LEDs have been researched and developed, leading to their mass production in 2015. Deep-ultraviolet LEDs consume less power than mercury lamps, making them suitable for sterilization in areas with limited electricity generation. The demand for deep-ultraviolet LEDs is steadily increasing due to their low power consumption and environmental benefits.

The social integration of deep-ultraviolet LEDs has been progressing in recent years. One of the major advantages of deep-ultraviolet LEDs, compared to mercury lamps, is their compact size, and using this feature, they are primarily being introduced in small to medium-sized products such as sterilization and deodorization equipment and water heaters.

Furthermore, research and development in the field of deep-ultraviolet LEDs have advanced significantly leading to improved conversion efficiency and electrical output, making it possible to have water sterilization systems capable of handling flow rates as large as those in water and sewage systems. In the past, due to considerations of the flow rate, mercury lamps were generally used for sterilizing a certain amount of running water. However, devices equipped with deep ultraviolet LEDs are increasingly replacing them. For example, in Las Vegas, USA, deep ultraviolet LEDs are now used instead of mercury lamps for sterilizing running water in the water supply system.

Comparison between mercury lamps and Deep UV LEDs

	Mercury Lamp		Deep Ultra Violet LED
Dose	30mJ/cm^2	Same Dose & Same Flow rate	30mJ/cm^2
Flow rate	8,760m^3/day		7,500m^3/day
Life span	9,000 hour	Approximately 10% longer service life	10,000 hour
Size	W780×H1,365×D730 mm		W342×H342×D1,200 mm
Weight	320kg	Size 1/6 Weight 3/4	250kg
Use of mercury	Used	Mercury free	Not used

Data provided by Nikkiso Co., Ltd

Deep ultraviolet LED in Las Vegas, USA
Sterilization of the water supply using running water sterilization equipment

Photo provided by Nikkiso Co., Ltd

Applicability

Compared to mercury lamps, the cost of deep ultraviolet LEDs has been decreasing in recent years, leading to more widespread use, especially in developed countries. Another application of this technology is in air disinfection devices equipped with deep ultraviolet LEDs capable of inactivating the virus responsible for COVID-19 (SARS-CoV-2), and these products have gained popularity recently. Additionally, projects aimed at introducing deep ultraviolet LEDs are being implemented in regions lacking adequate water treatment and electricity facilities, with their utility being increasingly recognized. There is a potential for rapid adoption of these LEDs in the coming years due to technical innovation and further restrictions in Annex A of the Minamata Convention.

Air disinfection device equipped with deep ultraviolet LEDs

Photo provided by Nikkiso Co., Ltd

Further Reading

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Environmental Health Department
Ministry of the Environment, Japan
1-2-2 Kasumigaseki, Chiyoda-ku Tokyo, 100-8975, Japan
Tel: +81-(0)-3-5521-8260, E-Mail: suigin@env.go.jp
http://www.env.go.jp/en/chemi/mercury/mcm.html