EDS UPDATE

By M. Nisa Khan Ph.D.

As president of LED Lighting Technologies, Dr. M. Nisa Khan educates the lighting industry and consumers about LED lighting. She has a bachelor's degree in physics and mathematics, and master's and Ph.D. degrees in electrical engineering. Email her at nisa.khan@iem-asset.com

Inorganic-Semiconductor LED Safety

Certain questions require manufacturer's answers.

On August 1, 2008, the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA), under Proposition 65, California's Safe Drinking Water and Toxic Enforcement Act of 1986, added gallium arsenide (GaAs) to its list of cancer-causing chemicals. In part, the act requires the governor to publish, annually, a list of chemicals known to cause cancer or reproductive toxicity.

High-efficiency, visible LEDs don't include GaAs, but some medium-efficiency, visible LEDs contain GaAs and gallium arsenide phosphide (GaAsP), which could be harmful.

Some manufacturers argue that GaAs isn't found in today's most efficient LEDs, which are made with aluminum indium gallium phosphide (AlInGaP), aluminum indium gallium nitride (AlInGaN), and indium gallium nitride (InGaN). Others say GaAs is common in other consumer electronic devices such as lasers in CD/DVD players and the RF power amplifiers in mobile phones.

So, they ask, what's the big deal? Although these arguments appear plausible, questions remain on the toxicity of popular LEDs.

Not new news

In the mid-'80s, and independently, researchers D.R. Webb and H. Yamauchi demonstrated the solubility of arsenic under certain conditions and showed systemic absorption of arsenic from GaAs in animals. Their studies prompted the 1987 National Institute of Occupational Safety and Health (NIOSH) alert, which included establishing procedures for decontamination, waste removal, transport and disposal for GaAs- and As-contaminated materials.

For some time, then, the compound-semiconductor and manufacturing industry has acknowledged the possible environmental, health and safety hazards associated with producing GaAs- and indium phosphide- (InP) base wafers and epitaxial layers. (Epitaxy is a method of depositing film on a monocrystalline substrate.)

Such production requires combining In and Ga atoms with highly toxic arsine (AsH_3) and phosphine (PH3) gases. Once the solid-state compounds were formed, most industry experts believed, initially, they were insoluble and therefore harmless.

Further, the 1987 alert didn't discuss maintenance operations specifically; it also didn't address the consumer environmental, health and safety hazards (caused from exposure to either GaAs or InP and related compounds).

Even higher risk

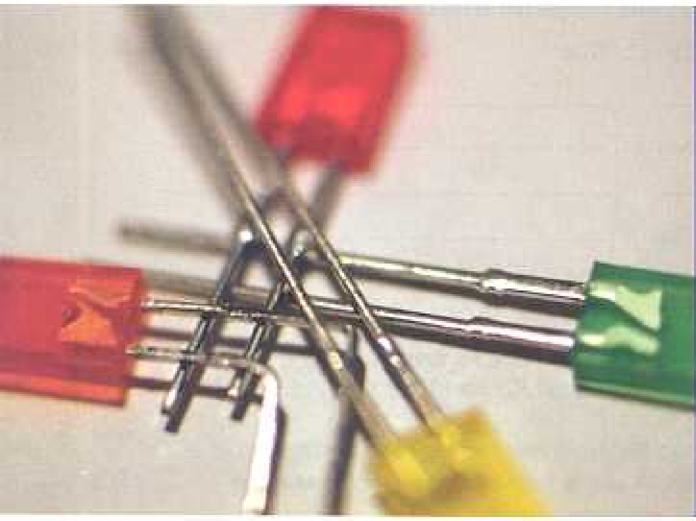
Although some studies have been performed on the toxicity of GaAs' material system, very few environmental, health and safety investigations are currently available on InP and phosphorus-based materials. However, logic says, although phosphorus isn't toxic, like arsenic, the production of InP wafers and related ternary and quaternary epitaxial layers involves similar or higher danger because PH_3 is even more toxic than AsH_3.

Do PH_3 gases or contaminants emit from LED lamps that contain phosphorus in their compounds? Can manufacturers omit such compounds – or substitute something safer? Such questions require manufacturers' answers.

The familiar ammonia (NH_4), derived from nitrogen compounds, could be a concern, too, although to a much lesser degree than PH_3.

Known LED hazards

In an LED lamp, typically, the compound-semiconductor chip is a 1 x 1mm die placed over a hard, thermally conductive substrate encapsulated with a clear, polymer, dome lens. This enclosure, although waterproof, isn't always hermetically sealed. Over time, excessive heat and humidity may produce harmful PH_3 and NH_4 gases from the P- and N-based compounds. Further, crushing an LED lamp could break the domed enclosure and



For everyday handling, use or installation, LEDs aren't toxic. Also, it's safe to be near them. However, if LEDs become too efficient, they produce high-intensity, laser-like light that harms your eyes. Also, prolonged exposure to blue light from any source can cause photo-biological harm. Thus, minimize any exposure to blue light.

produce a breathable, and toxic, aerosol dust.

Obviously, the lighting industry needs extensive fact studies. I feel particular unease about a related, PH_3 study done on Sudden Infant Death Syndrome (SIDS). In 1994, B. A. Richardson, an Honorary Research Fellow, Winchester, England, found the possible primary cause of SIDS as phosphorous and antimony (a toxic, crystalline element) contained in mattresses. His study strongly implied that PH_3 can be generated and distributed into the atmosphere from phosphorus compounds subjected to heat and humidity.

The study found that mattress zones, affected by the warmth and perspiration of the sleeping infant, were infected by Scopulariopsis bevicaulis – a fungus considered capable of spawning from materials containing phosphorus compounds.

High-efficiency red and orange LEDs comprise AlInGaP – a phosphorus compound.

Risk assessment needed

A complete appraisal of environmental, health and safety factors will require formal hazard identification, and risk assessment, for LED industry workers and facilities; analysis of potential health effects for communities adjacent to manufacturing facilities and, finally, consumers that will experience both accidental breakage and expired products. Regulators of environmental, heath and safety for LED-lighting manufacturers, and distributors, must address these critical issues and offer meaningful cautions and recycling, to minimize the environmental impact by these systems. ■

To read related articles on this subject, visit www.signweb.com/EDS and www.signweb.com/lighting.