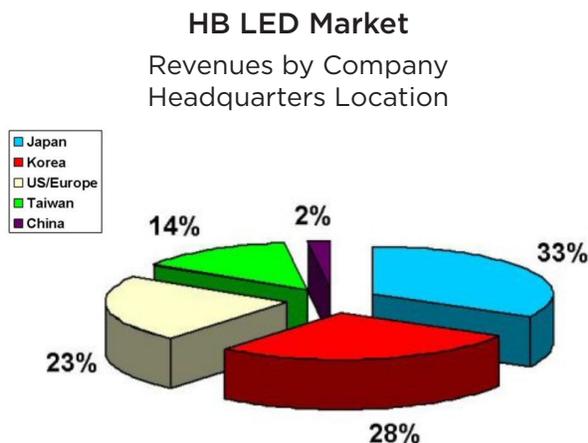


The continued DOE support of manufacturing efficiency and cost-cutting can play a significant role in further improving the chances of keeping solid-state lighting manufacturing domestic.

## U.S. Manufacturing Strength Growing: Cautious Optimism

The pervasive theme of the second annual DOE Solid-State Lighting (SSL) Manufacturing R&D Workshop, held in Boston April 12–13, 2011, was guarded but enthusiastic optimism about the state of U.S. manufacturing in the race to maintain intellectual property superiority and keep a significant share of SSL production in North America. While the 2010 workshop was filled with concern about the loss of market production to Asia, the 2011 workshop was a demonstration of the positive and effective efforts to stem the flow of both technology development and manufacturing to foreign shores.



The high-brightness LED market by headquarters location, based on revenues. The market grew from \$5.6 billion in 2009 to \$10.8 billion in 2010 – a growth rate of 93%. Source: SEMI

Those attending the 2011 workshop heard good news from Ross Young of IMS Research, affecting both the manufacturing and market channels. The growth of LED production increased 55 percent in 2010 to a market value of \$9.9 billion (81 billion units produced). This steep growth is expected to continue through 2015, when market values are expected to hit about \$18 billion. While much of this growth in production is led by foreign sources, U.S.-based manufacturers Cree and Philips Lumileds have steadily accounted for 11.5 percent of worldwide LED production between them. In addition, the growing world market for LEDs is transitioning from mobile phones to monitors (TVs, notebooks, netbooks, etc.) to general lighting, automobile lighting, and signage.

With congressionally mandated lighting efficiency measures in the U.S., and similar measures in Canada and Mexico, slated to take effect in 2012, the North American LED lamp market is expected to grow from \$3.6 billion in 2010 to over \$11 billion in 2015. The U.S. is also a leading producer of the fabrication units used in LED manufacturing. Total revenues for Veeco and Aixtron—two of the world’s top producers of such units—have grown from about \$100 million in the first quarter of 2009 to \$600 million in the fourth quarter of 2010.

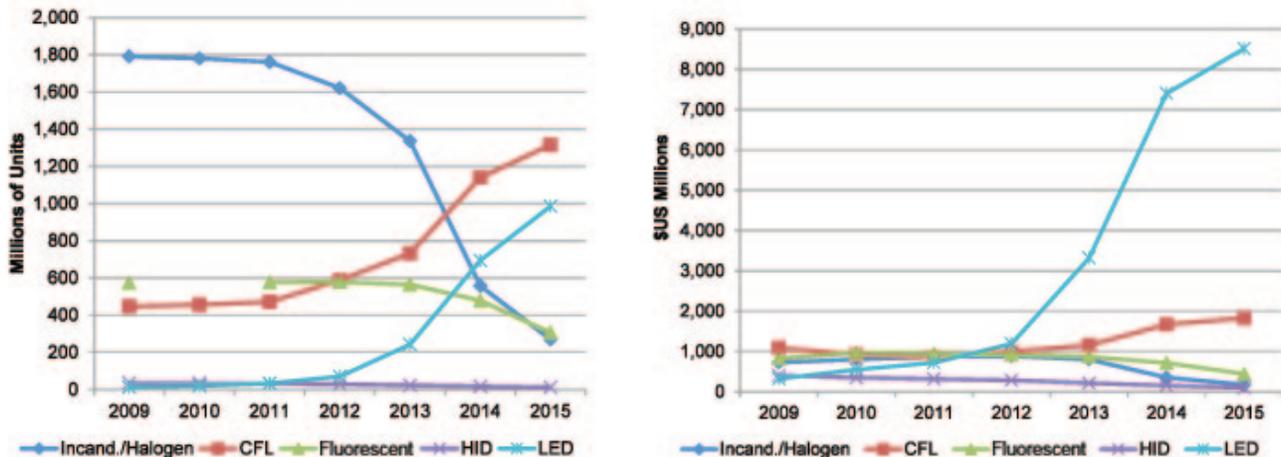
With *price* and *performance* noted as the key factors in consumer acceptance of solid-state lighting, the industry is faced with a number of challenges. Over the past several years, the main focus of the industry, as well as of DOE support, has been the development of increasingly efficient LED sources. To meet the demands of U.S. legislation, which requires increased lumens-per-watt (lm/W) yields from replacement lamps, industry must develop an LED light engine that yields at least 160 lm/W so that it can compete

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– B.J. Lee, Chairman, Epistar Corporation

with other 100W replacement technologies. In 2011, the industry is capable of effectively producing LED 60W equivalent replacement lamps that yield 80 lm/W. However, these 60W replacement lamps carry a retail price of more than \$40 each, which a 2010 McKinsey study indicates will have to be reduced to around \$8 to capture 25 percent of the U.S. market. The consensus in the industry is that the quality and efficiency of LEDs will continue to grow, but the industry must now focus on improving the efficiency of other necessary components, such as drivers, thermal sinks, and optical/fixtures, as well as on overall manufacturing process efficiency. As stated by B.J. Lee, Chairman of Epistar Corporation, an international leader in the LED industry, “To open the new era for SSL, the challenge focuses not only on lumens per watt, but also lumens per dollar.”

### North American Lamp Market Forecast



By 2015, LEDs are projected to grow to about one-third of the North American lamp market on a unit basis and around three-fourths of that market on a revenue basis. Source: IMS Research

### Lessons Learned

Four leading U.S.-based manufacturers—Acuity Brands, Inc.; Lighting Science Group Corporation; Cree, Inc.; and GE Lighting Solutions—related lessons learned in growing an SSL business and developing a business strategy in the U.S.

Represented at the workshop by Vice President of Technology Jeff Quinlan, Acuity Brands is one of the world’s leading manufacturers of lighting fixtures. Headquartered in Atlanta, it has approximately 6,000 associates and operations throughout North America as well as in Europe and Asia, but the majority of production occurs in the U.S. Acuity’s entrance into the solid-state lighting market is exclusively in lighting fixture production. With a strong consumer reputation for excellence, it has aggressively addressed a

policy of lean manufacturing, which combines following several intense production standards and guidelines and eliminating as much waste as possible. Acuity employs several methods of best practice in its R&D and line production. Employees receive a great deal of education pertaining to these methods and are multi-functionally trained to improve and broaden skills, with the goal of maintaining a strong employee culture.

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“We believe to be competitive in the lighting market . . . we have to figure out how solid-state fixtures will weigh less, will consume less, will consume less energy to make, and will consume less time to make.”

– Fred Maxik, Founder and Chief Technology Officer, Lighting Science Group

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Before Acuity implemented its lean manufacturing philosophy, its typical plant output was 280 units per hour, which required 28 people and 5,000 square feet of production space. Today, 16 people produce 300 units per hour in 2,200 square feet, which allows for much greater production per person-hour.

Lighting Science Group (LSG) is a relatively new player in the industry and is unique for two reasons: it is exclusively an LED manufacturer, and all of its employees—sales, marketing, R&D, and manufacturing—are housed in the same building in Satellite Beach, Florida. LSG currently employs 243 staff and 357 contractors, a total of 465 more people than it employed a year earlier. By virtue of its proximity to the National Aeronautics and Space Administration, the company has been able to attract seasoned engineers and technicians who have left the space industry as the space shuttle program comes to an end. According to Fred Maxik, LSG founder and Chief Technology Officer, the open communication derived from the close proximity of its employees allows the company to reach full production capacity within 90 days of initial product design. Based on LSG’s modular manufacturing footprint of 8,000 square feet, production rates average 10,000 replacement lamp units per day.

Many companies find the uncertainties that come with foreign incentives to be compelling reasons for not risking moving production overseas.

In December of 2010, Lighting Science Group became the first U.S. company to domestically manufacture one million LED replacement lamps in less than a year, and has developed retailing partnerships with Lowe’s and Amazon. In addition to its modular process, the company shares Acuity’s environmental and sustainability concerns and has helped incubate a number of component suppliers located close to its manufacturing facilities.

Cree is one of the two largest U.S. suppliers of LED chips, with more than six percent of the world market. Located in Durham, North Carolina, Cree employs over 4,000 people domestically and abroad in 12 locations. Initially building its business in chip production, Cree began manufacturing fixtures in 2006. The growth of the LED industry and the popularity and success of Cree’s downlight products have allowed the company to add over 800 full-time jobs at its Durham headquarters since February 2009. In its most recent expansion, Cree added a 47,500-square-foot LED production facility and 244 new jobs. Like Lighting Science Group, Cree’s proximity to a strong talent pool—in this case, in the Research Triangle area of North Carolina—has greatly assisted the company in attracting top-flight personnel.

GE Lighting Solutions, a subsidiary of the General Electric Company, was established specifically to compete in the solid-state lighting market. While GE Lighting Solutions maintains a worldwide business footprint, the company has committed to developing its LED center of excellence in North America. Beginning in 2008, GE began shifting its priorities from conventional technologies to greener products. This shift is expected to lead to 70 percent internal growth in spending in 2011, with an eye toward solid-state lighting products comprising 60 percent of the company's output in 2012. In that same period, the GE technology engineering group is expected to grow from 460 to 600 engineers worldwide, with 270 of those engineers based in North America and 180 in Europe.

Like many of the U.S. companies, GE Lighting Solutions is concentrating its U.S. engineering and manufacturing functions in one location—in this case Hendersonville, North Carolina—to maximize production efficiency and keep costs under control. With an eye on the potential for sizable U.S. consumer demand, GE has decided to keep its manufacturing localized in North America to shorten its supply chain, improve customer responsiveness, and reduce its inventory risk.

### **A Mixed Bag**

While a sense of cautious optimism permeated the workshop, the specter of the loss of intellectual property, jobs, and market to foreign sources is still a very large concern to those companies striving to remain competitive in the U.S. As Cree Applications Engineering Manager Ralph Tuttle noted, the compelling incentives that many Asian countries offer—such as no taxes for 10 years, recruiting and relocation support, subsidized land and building development, and simple and quick permitting processes—are tempting for U.S. companies seeking to cut costs and remain competitive. For most lighting companies, cheaper labor costs are not as much of a concern as the cost of doing business and the internal tax structure.

Conversely, many companies find the uncertainties that come with foreign incentives to be compelling reasons for not risking moving production overseas. For example, there are prevailing concerns that the financial incentives that initially attracted a company to either outsource or build manufacturing capacity offshore might be retracted within a few years. There are also concerns about foreign workforce stability and the ability to maintain manufacturing quality control, as well as about the potential for adverse environmental impacts.

While DOE financial support of industry R&D has provided both the opportunity and the incentive for U.S. companies to actively explore cost-cutting manufacturing measures that will allow them to remain in North America while staying cost-competitive, many in the industry believe that further government incentives, both national and local, will be needed to grow the domestic industry. Companies such as Cree, Lighting Science Group, and OLED manufacturer Universal Display Corporation have taken full advantage of local incentives—which, while not necessarily large monetarily, have induced them to make significant investments in infrastructure and R&D.

However, Ralph Tuttle of Cree made the bold statement that, in his opinion, the present U.S. tax structure discourages domestic investment in production capacity. “Our corporate tax rate’s non-competitive in the United States,” he said. “High rates result in very high marginal costs simply to do business in the U.S. Think of it as losing 25–30 points of margin on every part manufactured in the U.S. . . . Should tax rates reflect national priorities on new job creation? . . . Tax revenues from new jobs will far outweigh any

reduction in corporate tax revenues due to lower tax rates.” While this was met with some agreement, one workshop attendee made the point that the tax structure hasn’t prevented Japanese auto makers from setting up manufacturing plants in the U.S.

In summary, the outlook for the U.S. lighting industry avoiding the loss of its current technological and market advantages is brighter this year than last, as expressed by the workshop participants. The advent of North American restrictions on older lamp technologies beginning in 2012 (California has already raised its performance standards for incandescent lamps, as have Australia, the Philippines, and other countries), and the trend toward more efficient lighting that will result, are viewed as potentially creating a huge market for LED and, eventually, OLED products. Based on the significant current cost differential between the older and newer lighting technologies, many U.S. companies will strive to keep production in this country to keep costs under control to meet the expected higher volume demand for LEDs as traditional technologies are phased out of production. Philips Lighting predicts that over 50 percent of its lighting revenue will come from LEDs by 2015, and OSRAM Sylvania predicts about 65 percent for the same period. The continued DOE support of manufacturing efficiency and cost-cutting can play a significant role in further improving the chances of keeping solid-state lighting manufacturing domestic.