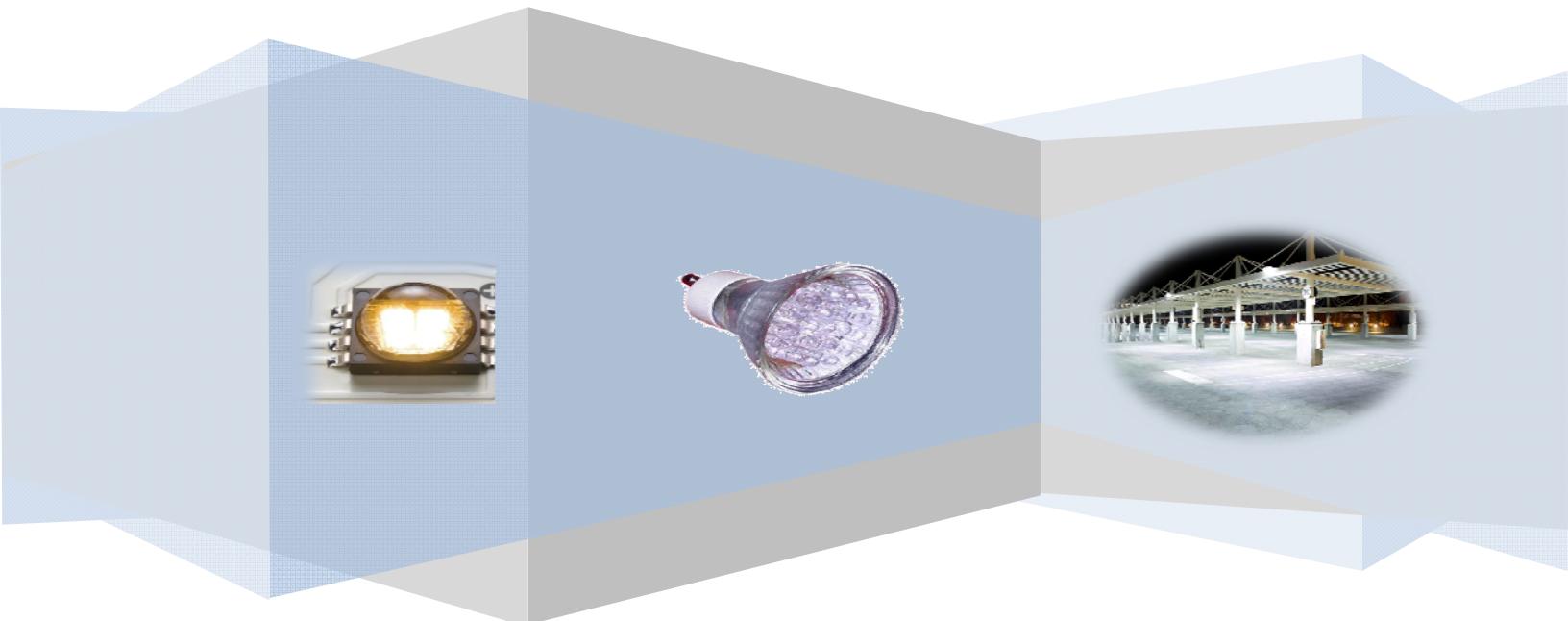




Case Study: Cree, Inc.

Local Markets and Global Competitiveness: A Value Chain Analysis

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Executive summary

Cree's experience highlights the importance of research and development (R&D), value chain dynamics and market demand in strategic growth and offshore production decisions. U.S. federal funding provided critical support to Cree's R&D of light emitting diodes (LEDs), especially during its early years. Moreover, the Department of Energy (DOE) Solid State Lighting Program (SSL) provided financial backing and a platform for partnerships to accelerate the development and commercialization of LEDs. The American Recovery and Reinvestment Act stimulated some market demand in energy-efficient LED lighting in U.S. cities and universities. In addition, Cree's Advanced Energy Manufacturing Tax Credit award in 2009 allowed it to invest \$150 million in Durham, NC and create more jobs. The state of North Carolina offered Cree a Job Development Investment Grant worth up to \$2.236 million in benefits, along with other state and local incentives to meet its local hiring goals. In September 2010, Cree announced it expected to create an additional 244 jobs in Durham by 2012, with an average annual salary of \$42,726 (Bracken, 2010).

However, Cree faces persistent market barriers to wider adoption of LED lighting in the United States including high upfront cost, light quality issues and low consumer awareness. Market missteps in the early introduction of compact fluorescent lighting helped make the U.S. market cautious and slow to embrace LEDs in general illumination. Furthermore, wider adoption of LEDs in the United States has been hampered by low energy prices, a sluggish new construction market and lack of utility rate structures that reflect the lower energy use by LEDs.

The Chinese market, in contrast, does not have all of the adoption challenges that persist in the United States. China has a growing population of over 1.3 billion people and a booming construction industry. The Chinese government has a top-down approach and established milestones to adopt energy-efficient technologies and achieve energy saving targets. China has been investing in LED lighting and has attracted high-quality LED chip makers such as Cree to meet increasing domestic and global demand. These dynamics have created considerable market demand for LED lighting in China.

Key findings from the value chain and Cree's location decisions analysis reveal the following:

1. **Cree is one of the five main lead LED firms.** These firms are vertically integrated, are leaders in technology development and make up approximately half of the global market. Outside these firms, the market is fragmented with many players that manufacture LED chips, LED packages, LED luminaires, and LED bulbs.
2. **Cree's most important offshore production location drivers have been market size and local demand.** China is Cree's largest and fastest-growing market accounting for almost 40% of its global sales. Cree exports from its Chinese operations to other countries especially in Asia. Sales revenues from Asian countries outside China account for 30% of Cree's global sales. On the other hand, the U.S. market accounts for only 20% of Cree's sales.
3. **China's 'indigenous innovation' policy rewards companies that develop and register patents in China.** The policy is meant to encourage technological development and will limit government procurement to companies operating in China. Cree's recent expansions in China provide it with wider access to government contracts that are increasingly focusing on LED lighting, especially LED street lighting.
4. **Access to materials was not a factor in Cree's decision to expand in China.** Surge in demand for LEDs has created a pinch point in the supply chain and lengthened lead times. Cree has been expanding operations and believes that it has sufficiently secured its supply chain.
5. **Lower production and labor costs were not principal drivers in Cree's offshore production decisions.** These factors increased the attractiveness of the Chinese market but were not key drivers in Cree's location decisions.
6. **High-value intellectual property manufacturing activities will remain in the United States.** Cree believes that its competitiveness is partly imbedded in its ability to protect its intellectual property (IP), primarily through developing innovative LED products. The United States continues to provide the best protection of IP.

Overview

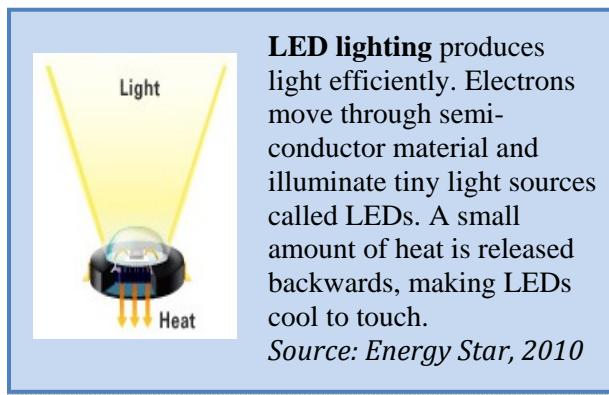
In the lighting industry Cree's name is synonymous with "exceptional high quality, innovative and prototype LEDs." Richard Upton, the President of the American Lighting Association said, "Cree is a company that spends a lot of time on product development. They are not about selling a product, but about coming up with the next generation of lighting solutions" (Upton, 2010).

Cree, for its part, likes to refer to itself as the "23-year-old startup company." The North Carolina-based company is entrepreneurial and a lead player in the "LED Lighting Revolution." The company has built its name and reputation on the development and manufacture of its blue and green LED chips, as well as its industry-leading XLamp, LED components and award-winning LED lighting products.

LEDs are semiconductor-based (see Figure 1), directional, do not contain mercury, and offer better quality and energy-efficient lighting compared to traditional lighting technologies.¹ In addition, LEDs can offer longer operating life (>50,000 hours), lower operating costs, improved durability, compact size and shorter startup time (Bardsley Consulting et al., 2010).

Several U.S. cities, including Raleigh, NC, Austin, TX, Los Angeles, CA and Ann Arbor, MI, have begun installing LED street and area lights to save on energy and maintenance costs (Bardsley Consulting et al., 2010). The U.S. Department of Energy (DOE) estimates that rapid adoption of LED lighting in the United States over the next 20 years can deliver savings of about \$265 billion, avoid 40 new power plants, and reduce lighting electricity demand by 33% in 2027 (Energy Star, 2010). Primary market barriers to wider adoption of LED lighting in the United States have been high upfront cost, light quality issues and low consumer awareness.

Figure 1. LEDs are efficient, directional



¹ Incandescent and/ or some compact fluorescent light sources.

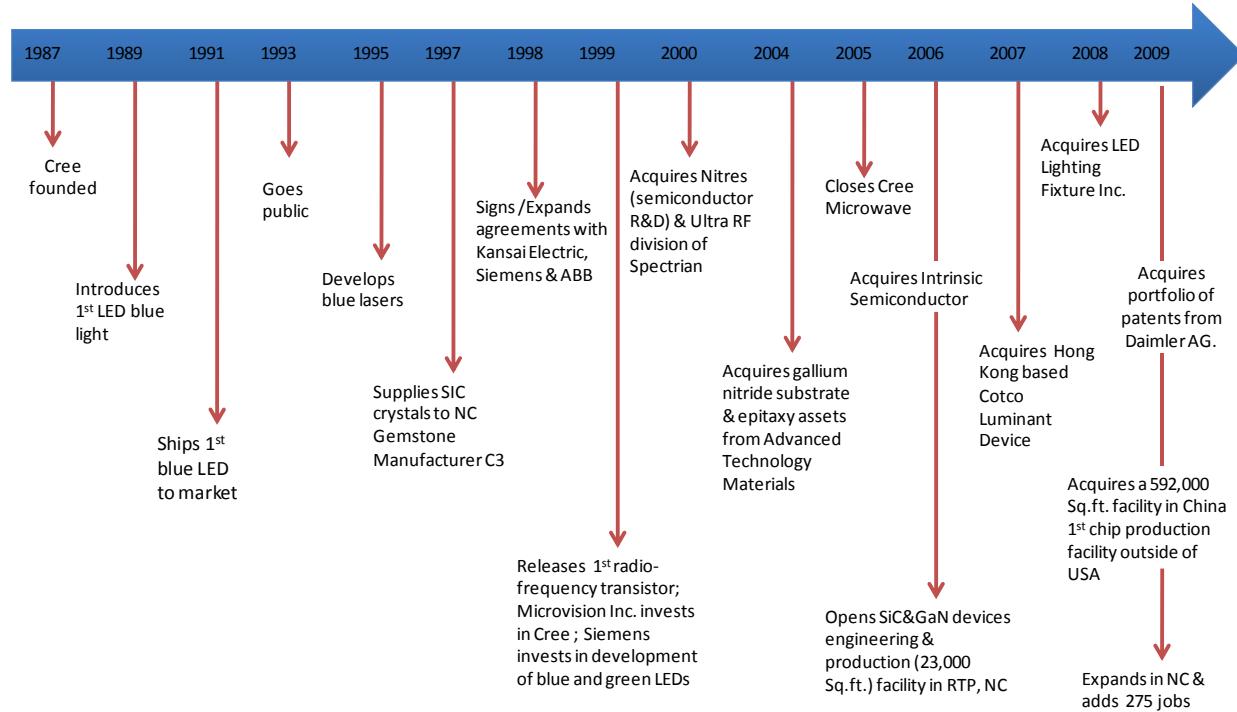
Cree produces many types of LED products, but the firm's primary focus is high-power LEDs for the general lighting market. The company is a market leader in LED chips, LED components, LED lighting products, power switching and wireless communications devices (Cree, 2009a). Cree develops and manufactures its semiconductor materials and devices primarily based on silicon carbide (SiC), gallium nitride (Bardsley Consulting et al., 2010) and related compounds (Cree, 2009a). The physical and electronic properties of SiC and GaN offer technical advantages over traditional silicon, gallium arsenide (GaAs), sapphire and other materials used for certain electronic applications.

Cree's commercial 6-inch down light (last generation) has an estimated 6-9 month payback period, and recently the company has introduced a new product that is priced about 50% less than the previous one (Merritt, 2010). The company has been growing in all its facilities in Durham, NC and abroad. In 2009, Cree was awarded an Advanced Energy Manufacturing Tax Credit (48C) by DOE, which reflects the \$150 million that is being invested in expanding its manufacturing capacity in Durham, N.C.

History

Cree was started at North Carolina State University by Eric and Neal Hunter and Calvin Carter, who researched SiC applications. In 1987, the founders spun off from the university to start Cree Research and to continue experimenting with silicon carbide, primarily with federal funding (see Figure 2). By 1991, the company shipped its first-to-market blue light LED and went public in 1993. Until about 2005, Cree was a merchant chip supplier with a limited number of customers, located primarily in Asia. When Cree decided to enter the LED lighting component business, the company emerged from its role as a chip supplier to become a leading player in lighting LEDs. The company then started to climb the value chain, focus on traditional marketing channels, develop new sales outlets and create a brand image for Cree as a “revolutionary LED lighting leader.”

Figure 2. Cree time line



Source: CGGC

Acquisitions

Cree has strategically combined external acquisitions and internal R&D to broaden its offerings and increase market reach into LED lighting fixtures, power switching, and radio-frequency RF products (Hoovers Online Pro 2010). In 2007 Cree acquired Cotco Luminant Device, based in Hong Kong and with manufacturing facilities in China, for about \$200 million (Cree, 2007). This acquisition provided Cree with expanded packaging,² R&D capabilities, a broader LED component portfolio, a lower-cost manufacturing facility, and expanded sales channels in China (Cree, 2007). In the same year, the company signed a distribution agreement with World Peace Industrial Company to sell and support Cree XLamp products in China (Datamonitor, 2009). In July 2008, the company opened the Cree Shenzhen Engineering Center in Shenzhen, China (Datamonitor, 2009).

Later, in February 2008, Cree acquired NC-based LED Lighting Fixtures, Inc. (LLF) for about \$77 million. The purchase included an R&D center, a commercialized LED lighting portfolio, sales channels, and manufacturing subcontractor relationships to accelerate the adoption of

² LED chip packaging is the assembly of one or more LEDs along with electrical connections, optics, and thermal and mechanical systems.

energy-efficient LED lighting for the general illumination market.

In November of 2009, Cree announced an expansion in China through the acquisition of a 592,000-square-foot facility in Huizhou, Guangdong Province to meet local and international demand. The facility will be Cree's first chip-production facility outside North America and is also targeted to house expanded future components manufacturing (Cree Inc., 2009b). However, epitaxial wafer³ growth, which is unique to Cree's LED chips, will not be done at the new facility.

Sales and locations

Headquartered in Durham, North Carolina, Cree operates in the United States, Europe, Japan, Malaysia, Hong Kong, and China (Datamonitor, 2009). Cree offers LED products such as blue and green LED chips, high-brightness LEDs, lighting-class power LEDs, LED fixtures, and bulbs. LED products account for about 87% (\$494.4 million) of Cree's sales. The rest of Cree's revenues are from licensing fees, contracts, materials products, and power-switching and radio-frequency devices (see figure 3). The company partners with global distribution networks to reach the bulk of its customers and uses direct sales with very large main accounts.

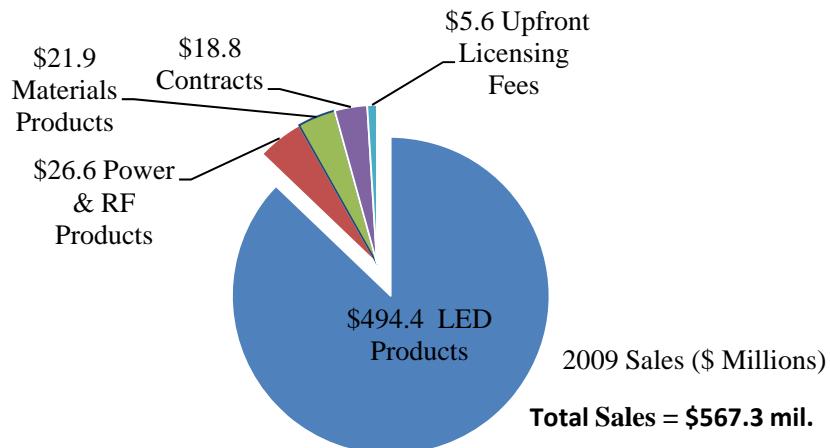
Cree now has over 2,100 employees in the United States, 2,400 in China and roughly 200 employees in other locations (Merritt, 2010). As a result of a surge in demand for LEDs, the company has recently hired over 600 people in its U.S. locations and is planning to hire about 130 more this year (Merritt, 2010).

Cree has been growing rapidly due to the increase in demand for LEDs in automotive and backlighting applications and continuing adoption of LEDs in general lighting. The company recorded revenues of \$567.3 million in the fiscal year ended June 2009, an increase of 15% over 2008 (see *Source: CGGC based on (Cree Inc., 2009a)*

³ Epitaxial wafers are layers of silicone monocrystals on a substrate used in semiconductor devices.

Table 1). In April, 2010, Cree announced record revenue of \$234.1 million for its third quarter of 2010 fiscal year. This is 78% higher than the \$131.1 million reported in 2009 (Cree, 2009a).

Figure 3. Cree's global product sales, 2009



Source: CGGC based on (Cree Inc., 2009a)

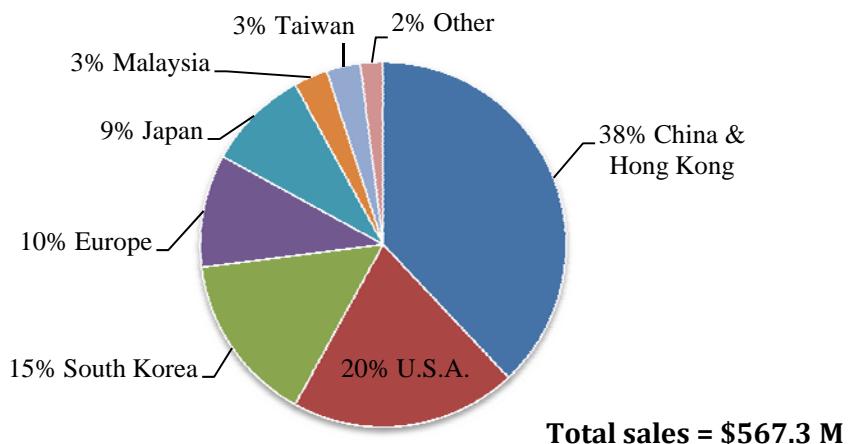
Table 1. Cree's revenues and employees, 2003-2009

Year	Revenues (\$ mil)	Employees
2009	567.3	3,172
2008	493.3	3,168
2007	394.1	2,578
2006	423.0	1,364
2005	389.1	1,322
2004	306.9	1,235
2003	229.8	1,121

Source:(Hoovers Online Pro 2010)

Asia accounts for about 66% of Cree's sales, the United States 20%, Europe 10% and other parts of the world 2%. China is Cree's fastest growing and largest market, accounting for almost 40% of its global sales (see Figure 4).

Figure 4. Cree's global sales % by region/ country, 2009



Source: CGGC based on (Cree, 2009a)

Promoting LEDs to reshape the lighting industry

Cree has been actively involved with national and local governments, organizations and consumers to raise awareness about LED energy efficiency and long-term cost savings. The company has created business case websites such as LED City,⁴ Lighting the LED Revolution⁵ and LED University⁶ to provide information on energy use, cost savings and LED lighting applications.⁷ In May of 2010, Cree announced an agreement with Habitat for Humanity to provide \$1.5 million worth of high-efficiency LED downlights for kitchens in new Habitat homes in the United States (Merritt, 2010). Cree expects Habitat homeowners to save about \$300-\$500 in energy cost over five years. In addition, Cree supports programs such as Light Up the World to provide solar-powered LED lighting to promote economic development in low-income countries. Business case websites and partnership programs have helped Cree tap the market barriers, increase awareness and offer opportunities for contractors, engineers and designers to experience the advantages of LED lighting in the United States and other countries.

⁴ <http://www.ledcity.org>

⁵ <http://www.creelrevolution.com>

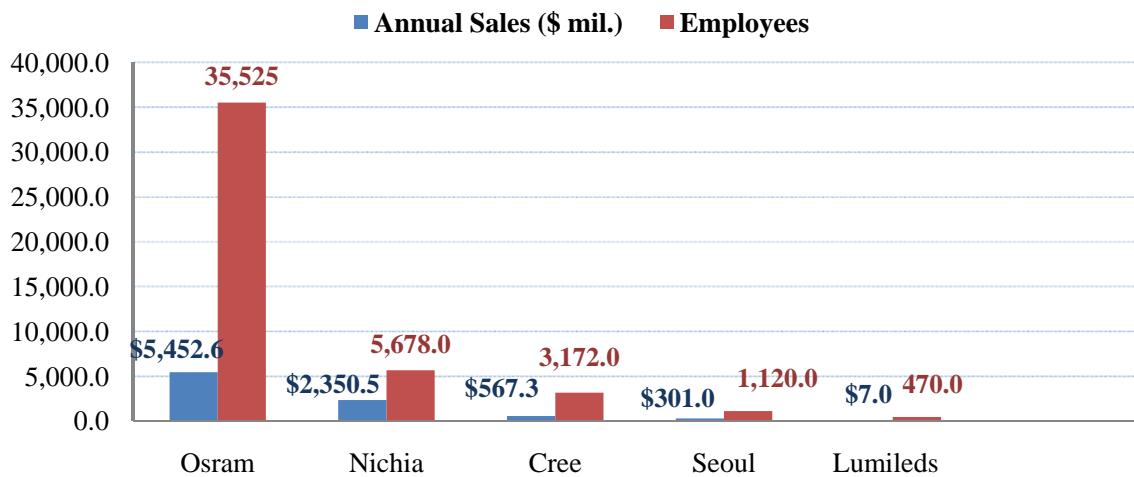
⁶ <http://www.leduniversity.org/index.asp>

⁷ Applications such as street lights, parking decks, indoor lighting and others.

Value chain dynamics

LED manufacturers often specialize in LED chips, LED packages, LED luminaires, and LED bulbs. Five primary players in the LED lighting industry make up about half the market (see figure 5). These are Nichia, a privately held Japanese firm; Philips Lumileds; Osram, a division of Siemens; Cree; and Seoul Semiconductor, a South Korean LED manufacturer (Bhandarkar, 2010b). These firms are vertically integrated across the LED value chain. They are leaders in the technology development and manufacturing of LED chips and packages. Cree is distinguished from other LED chipmakers by manufacturing its own wafer material that is used in making LED chips.⁸ Cree, Philips and Osram manufacture LED chips, packages, luminaires, and lamps. Seoul Semiconductor manufactures LED chips, packages and lamps. Nichia makes only chips and components. A second tier of LED manufacturing firms includes Toyoda Gosai, SemiLEDS, Bridgelux, and Epistar (Bhandarkar, 2010b). The rest of the LED lighting market is fragmented between firms that focus on specific parts in the LED supply chain (Bhandarkar, 2010b).⁹ Outside the LED industry, many firms supply LED manufacturers, such as semiconductor firms that design LED driver chips used to control the functionality of LED chips, and high-tech equipment manufacturers that supply specialized manufacturing tools.

Figure 5. Lead firms' sales revenues and employees, 2009



Note: Osram employee figure refers to the lighting company total, not just LED lighting.

Source: CGGC based on (Hoovers Online Pro 2010)

⁸ Other manufacturers purchase sapphire to make their chips.

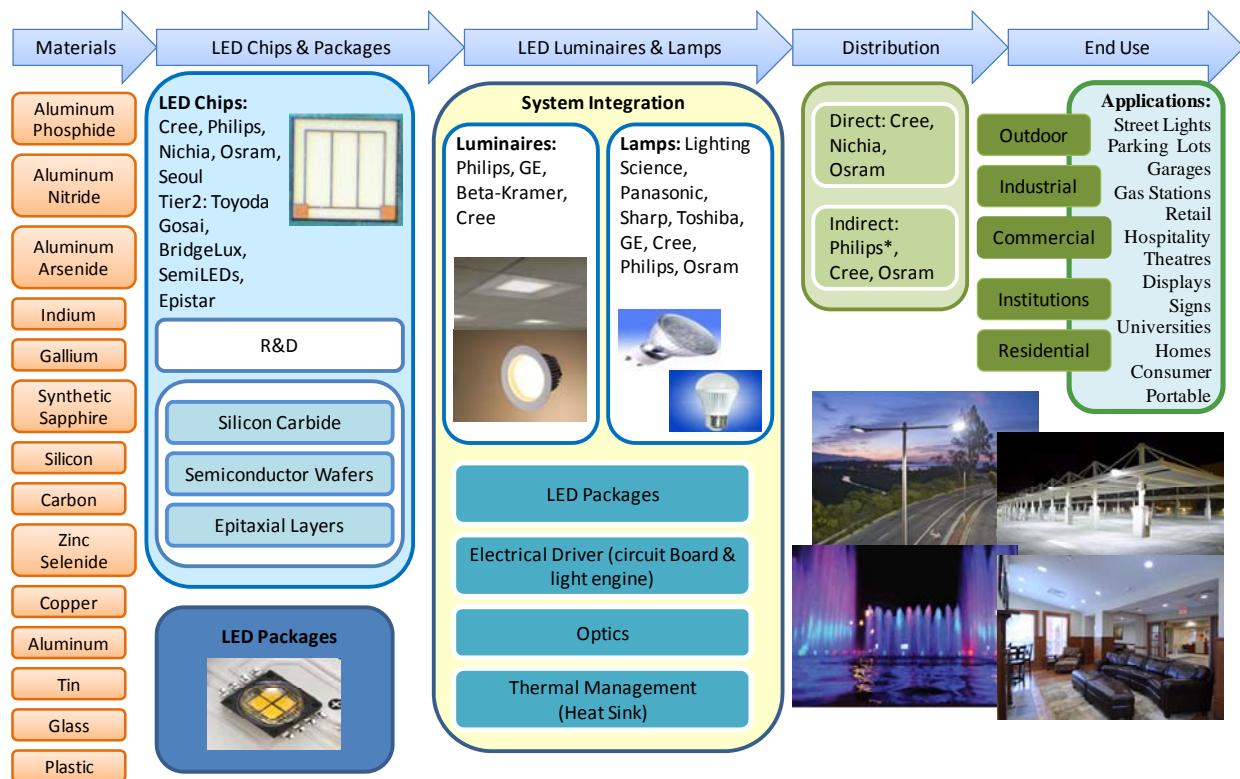
⁹ There are hundreds of other manufacturers that produce low-quality LEDs, most of which are in China (Bhandarkar, 2010b).

Cree prides itself in sourcing locally as much as possible (Merritt, 2010). This year Cree is installing capital equipment in Durham, valued at about \$85 million, primarily coming from California, Oregon, Arizona and Florida. So far in 2010, the company has spent about \$125 million on material costs in Durham, and about 90% of it has been procured from material suppliers in the United States. Until recently, lead times in the supply chain stretched out when the market was growing rapidly. Nevertheless, Cree has been able to secure its supply chain and bring its capacity to normalcy by expanding in the United States and other locations (Merritt, 2010).

Value chain

The LED industry value chain, from left to right, is typically segmented into materials, LED chip manufacturing, LED packages, luminaires, lamps, distribution and end use (See Figure 6).

Figure 6. LED industry value chain



*Philips has exclusive distribution rights with Future Electronics

Source: CGGC

LED chips: The LED chip is a semiconductor device that emits incoherent optical radiation that may be in the ultraviolet, visible, or infrared wavelength regions (Bardsley Consulting et al., 2010). There is not a standardized process to make LED chips that takes the substrate and grows a layer of crystals with a complex combination of gases at a particular temperature. The uniformity of growing the crystals is critical to producing high-quality chips (Bhandarkar, 2010b). The process is complex, capital-intensive and requires high-caliber human resource capacity.

LED packages: LED packages refer to the assembly of one or more LEDs, including the mounting substrate, encapsulant, phosphor if applicable, electrical connections, and possibly optical components along with thermal and mechanical interfaces (Bardsley Consulting et al., 2010).

LED luminaire: This is the complete lighting unit that integrates LED components and is directly connected to an electrical branch circuit (Bardsley Consulting et al., 2010). It consists of a light source and driver along with parts to distribute the light, and to connect, position, and protect the light source (Bardsley Consulting et al., 2010). Luminaires can contain from one up to several hundred LED packages.

LED lamp or bulb: There are two general categories of LED lamps: an integrated LED lamp, which refers to an assembly that is integrated with a LED driver and has a standardized base to connect it directly to an electrical circuit; and a non-integrated LED lamp, which refers to an assembly with an ANSI¹⁰ standardized base but without a built-in LED driver (Bardsley Consulting et al., 2010). Non-integrated LED lamps are designed for connection to LED luminaires (Bardsley Consulting et al., 2010).

LED market

LED sales in general illumination are estimated to have reached \$337 million in 2007 and are expected to grow to \$1.65 billion in 2012 (Datamonitor, 2010). The LED sector is expected to take major leaps from 2010 to 2020. From 2010 to 2015, LED retrofits and other energy-saving lamps, will replace incandescent lamps, which today make up 95% of residential light sources (Datamonitor, 2010).

¹⁰ American National Standards Institute

LEDs are often used in consumer electronics, back lighting, automobile displays, traffic lights, street lighting, and display signs. General illumination and liquid crystal display (LCD) televisions and computer screens are the fastest growing applications for LEDs. Rapid adoption of HB-LEDs and the emergence of new applications have resulted in a surge in demand for LEDs, constraints in manufacturing capacity and a slowdown in average selling price for HB-LEDs (Rebello, 2009).

Adoption of LEDs in the United States

Federal funding in the United States for innovation and energy efficiency provided financial backing for companies, such as Cree, to emerge and focus on new technology development. DOE's Solid State Lighting Program generated funding opportunities and a partnership platform to accelerate the development and commercialization of LEDs. The American Recovery and Reinvestment Act stimulated demand for energy-efficient products on state and institutional levels and created incentives for companies to invest. Nevertheless, wide adoption of LED lighting in the United States has been slow. Problems associated with the early introduction of compact fluorescent lighting have made the U.S. market cautious and slow in embracing LEDs for general illumination.

In early 2009, many U.S. cities proposed the adoption of energy savings measures that included LED street lighting in their programs to utilize stimulus funding. In anticipation of an increase in demand, partially due to stimulus-funded LED deployment plans, companies such as BetaLED, a leading U.S.-based LED street lighting manufacturer and its suppliers, such as Cree, had to increase capacity. Also, new LED street-lighting companies emerged to capture the opportunity, and a large number of low-quality products have appeared in the U.S. market. The issue of product standards and accountability became a problem and some product failures slowed adoption.

Other factors that have slowed adoption in the United States include low energy prices,¹¹ high upfront costs, slowdown in new construction, and low consumer awareness. Moreover, the majority of utility companies do not have programs or rate structures that encourage lower

¹¹ Energy prices are low in most of the United States, so customers have less incentive to switch to LEDs.

energy use by LED lights (Orth, 2010). Most utilities in the United States own street lights that they lease to cities. The lease covers installation, electricity, cost of light fixture, pole and maintenance. Utility companies are grappling to develop a rate structure that takes into consideration the high upfront cost, low maintenance and low energy use. So far, N.C. Progress Energy and Pacific Northwest are the only two utilities that have come up with rates to help defray these costs (Orth, 2010).

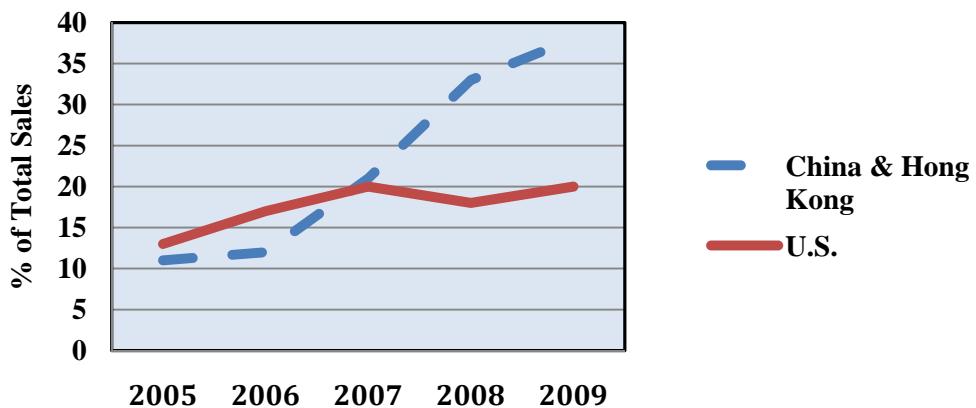
China's LED market: market opportunity for Cree

With a growing population of over 1.3 billion, China is now recognized as one of the world's most promising and competitive market in a number of industries. New construction is growing rapidly in China, with plans to build over 200 cities and over 85,000 kms of new road infrastructure to accommodate its growing population. China's energy efficiency industry has been identified as a high-growth sector, with projected spending of about Renminbi (Rmb) 2.1 trillion (USD 300 billion) from 2008 to 2013 on products and services that cut energy use (Kang, 2008). Sector firms that are positioned to capture local Chinese demand are going to gain considerable market share. In 2009, energy-saving lamps became hot items in China. The prevalence of global energy-saving trends, the implementation of national energy conservation subsidies, and the current national policy of promoting energy efficiency have all contributed to energy-savings lamps becoming popular in China by 2009. Demand is likely to grow for years to come (PR Newswire, 2010a).

By 2010, China's LED industry will deliver US \$2.32 billion in annual sales, compared to US \$1.18 billion for 2008 (Liu, 2008). China's LED public lighting market is projected to grow three to five times over the next four years (Liu, 2008). The total LED applications revenue in China in 2008 was RMB 45 billion (US\$ 6.5 billion), up 50% from 2007, with the largest applications being architectural lighting and display (PR Newswire, 2010). LED streetlights are a focus of the Chinese solid-state lighting program with increasing emphasis on quality and performance standards. Currently, a new national streetlight program is being implemented that will cover 21 cities and is anticipated to install at least 10,000 LED street lights with a potential of up to one million street lights (PR Newswire, 2010).

China plans to overtake Japan's leadership in LEDs in 2010 and has made progress in its LED efforts on several fronts, including: technical innovation; application and development capacity; device reliability research; and formulating testing rules and standards. A stream of new LED companies is entering the Chinese market at all levels of the value chain, including epitaxy, chips, lighting fixtures, and other applications (PR Newswire, 2010). These companies have received some government support but are mostly funded by private investment. The Chinese government is trying to improve the quality of their LED products and therefore has been attracting high-quality chip makers such as Cree (see Figure 8).

Figure 7. Cree's sales in China and the United States



Source: (Hoovers Online Pro 2010)

Chinese government support

The Chinese government has been implementing policies to curb energy demand by 20% per unit of GDP by 2010. President Hu Jintao has pledged the government's commitment to promote the adoption of energy-efficient technologies as part of China's development strategy. In 2007 a high-level State Council working group headed by Premier Wen Jiabao was established. This high-level effort resulted in a number of policies, including an energy-efficiency performance rating system for government officials, elimination of tax incentives for energy-intensive enterprises, stronger regulatory environment, and new central government-backed investment funds (Kang, 2008).

Local governments have promulgated the national policy including promotion incentives, advocacy, and financial subsidies, which have led to an increase in the use of energy-saving lights (PR Newswire, 2010a). In 2008, Cree and the Tianjin city government started the first LED city lighting project in China. The plan was to use Tianjin as a showcase for LED lighting application (Liu, 2008). In 2009, Cree announced that Huizhou is joining Cree LED City program, an international initiative aimed at promoting the deployment of energy-efficient LED lighting (Cree, 2009b). Huizhou has completed several LED streetlight trials and is in the process of deploying LED streetlights in the ZhongKai Hightech Industrial Zone (Cree, 2009b).

"We are very excited to have Cree's investment in our city. Solid state lighting is a key strategic green industry for China. From the government's perspective, we will do our best to support Cree through government projects as well as government policies. We believe this investment will be a win-win project for Cree and China's SSL industry,"
--Mr. YeBin Huang, Huizhou's Party Secretary.

Source: (Cree, 2009b)

Location decisions

"We are in China because it is our largest market and it is a fast growing one," says Greg Merritt, Cree's VP of Marketing. Cree's main offshore production location drivers have been market size and local demand. Nevertheless, federal and local incentives can strongly influence the decision as well. On September 20th, 2010, Cree announced a \$135 million investment in a new expansion in its Durham, NC facilities (Bracken, 2010). This expansion is anticipated to create about 244 jobs with an average annual salary of \$42,726 by 2012 (Bracken, 2010). The decision was made once North Carolina presented Cree with attractive incentives after the company's announcement that it was considering expansion in China or Malaysia. The state offered Cree a Job Development Investment Grant that is worth up to \$2.236 million in benefits (Bracken, 2010). In addition, Cree will receive state and local incentives that are worth more than \$4 million, provided that it meets its hiring goals (Bracken, 2010).

Global location decisions are part of a wider long-term strategy to continue to be competitive, to grow local and global market share, and to continue to reshape the lighting industry. Cree has simply recognized China's growing appetite for energy-efficient lighting and decided to respond. The Chinese market does not face the same adoption challenges as the United States. China is

going full scale in adopting LED technology, a considerable amount of new construction is happening, and the government is backing energy efficiency. Now Cree is preparing itself for the challenge of scaling its United States and Chinese operations to meet growing demand and seize the market opportunity. However, given the importance of intellectual property to Cree, we think that Cree will continue to keep its high-value proprietary parts of its production in the United States.

Table 2 provides a snapshot of the factors that have led Cree to manufacture in China. The pull factors refer to conditions that make U.S.-based manufacturing attractive. Push factors refer to forces that lead to offshore production outside the United States (Spragg, 2008).

Table 2. Summary table of location decision drivers

1. Local demand: factors that create local demand
Pull <ul style="list-style-type: none"> ❖ Retrofit activity has created demand in the commercial sector. ❖ Demand is increasing for energy-saving products.
Push <ul style="list-style-type: none"> ❖ New construction has slowed in the United States but is growing in China. ❖ Limited U.S. demand and long-term growth require Cree to expand globally. ❖ China is the largest and fastest-growing LED market.
2- Government as key actor: Incentives to companies, regulation, support for R&D.
Pull <ul style="list-style-type: none"> ❖ The United States possess a good investment in the environment, strong protection of intellectual property, and investment in R&D. ❖ 2009 American Recovery and Reinvestment Act helped create demand for LEDs and local incentives. ❖ U.S. government contracts are important to Cree. ❖ Energy-related regulation, including a ban on incandescent lighting by 2014, will help create demand.
Push <ul style="list-style-type: none"> ❖ U.S. regulations make the process of market entry for new products longer than that in China. ❖ China has more aggressive investment incentives such as tax breaks, subsidies, and low-cost loans. ❖ China's top-down strategy and energy-efficiency milestones create demand for LEDs. ❖ China's indigenous innovation policy limits government procurement to companies in China.
3- Private sector as key actor: Investment patterns, relevant trends and location decisions
Pull <ul style="list-style-type: none"> ❖ Cree's U.S. operations are high in value and represent 80% of its total assets. ❖ LED R&D and design continue to be U.S.-centric.
Push <ul style="list-style-type: none"> ❖ China's market size and LED market growth are the primary factors in Cree's location decisions. ❖ A large portion of global production of LED packages, lamps and luminaires is in China. ❖ Cree's largest market is China (40% of revenues), while its U.S. market accounts for 20%.
4- Role of R&D and intellectual property: Technology issues relevant to location decisions, e.g. materials, proprietary concerns
Pull <ul style="list-style-type: none"> ❖ Concern about intellectual property has kept R&D and high-value-added operations U.S.-based.
Push <ul style="list-style-type: none"> ❖ China offers generous R&D tax holidays. ❖ Firms often start to offshore R&D after offshoring production to tap into local talent, innovation and incentives.
5- Labor: Including costs and availability of needed skills
Pull <ul style="list-style-type: none"> ❖ The United States has the largest talent pool with the necessary education requirements, ability to relocate and soft skills.
Push <ul style="list-style-type: none"> ❖ Cree focuses on innovation and finding top talent globally. ❖ China has been improving the quality of its education to offer high-skilled, low-cost labor. ❖ Labor costs have been increasing in China but continue to be lower than in the United States.

Conclusion

Cree has been an innovative company that has successfully continued to make high-quality LED chips and move up the value chain. Cree's acquisitions in the United States have been oriented to expanding its R&D capabilities, climbing the value chain and accelerating the deployment of LED lighting. The company has attempted to shape the lighting industry and achieve higher rates of adoption through its LED awareness programs. Recent surge in demand for LED lighting has raised concerns about supply chains. However, Cree is convinced that it has been able to sufficiently secure its supply chain and increase capacity to meet its production needs.

Cree is committed to the U.S. market with its focus on continued innovation, product improvement and using U.S.-based suppliers. Recent emphasis on energy savings in the lighting sector and new legislation that phases out incandescent lighting have benefited Cree and positioned it to be a major player in LED lighting. Moreover, federal, state and local incentives have allowed Cree to continue to develop new products, expand its U.S.-based manufacturing and create more jobs in the United States.

Cree's location decisions reflect the company's strategic position as a global leader in the industry. Consequently, Cree has expanded its operations in China to respond to growing demand for LEDs in the local and export markets, and to strengthen its presence in its largest market. Chinese demand has been driven by strong government support, activity in new construction and infrastructure, a growing population, and growing global LED exports. Lower production costs, including labor, has not been a major driver for Cree's location decision, but more of a bonus factor. Cree has decided to take advantage of market opportunities in China while being aware of the intellectual property risks.

We expect Cree to continue to keep and grow its proprietary production in the United States, while growing certain production segments in China. Wider adoption in the United States will depend on either the industry's ability to decrease upfront costs or a rise in energy prices to further justify the shift to LED lighting. We do not foresee that Cree will bring production activities that have been shifted to China back to the United States, given the current market dynamics.

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