ElectronicsIQ.

Information Quarterly from Linde Electronics.

THE LINDE GROUP

Summer 2012

Welcome to ElectronicsIQ, your update from Linde Electronics.

The global LED market is prospering. Applications such as LCD TV backlighting and low-power illumination contributed to a 108% growth in high-brightness LED revenues in 2011, according to analysts at Strategies Unlimited. This trend is set to continue, with revenues expected to peak at USD16.2 billion in 2014.

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LED Lighting: It's the Cost that Matters

In 2010, many new LED suppliers entered the industry and rapidly ramped up production. This made 2011 a challenging year for LED makers. Supply grew by 41% in 2011 (measured in standard units of 500 × 500 micron chips), compared to only 10% growth in demand. This resulted in a significant over-supply throughout 2011, as shown in the following figure. In 2012, rising LED penetration has helped to consume some of the over-supply, but excess capacity is still a problem.

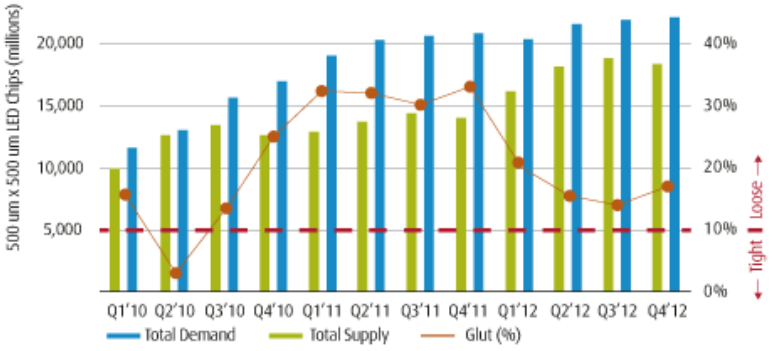

Figure 1: LED Supply/Demand for Backlight and Lighting Applications

Source: NPD DisplaySearch Quarterly LED Supply/Demand Market Forecast Report

There are two major applications for LEDs: backlights for LCD panels and LED lighting. Currently, LED backlight penetration is nearly 100% in mobile PCs and in small/medium LCD products such as mobile phones. LED penetration in LCD monitors and LCD TV panel penetration continues to rise, which is good for the LED demand outlook. However, the number of LED chips per panel decreases with improvements in technology and reengineering of the backlight structure.

LED demand for LCD TV backlights decreased from 2010 to 2011. The demand for LEDs in backlights will continue to increase through 2013 due to the growing popularity of new, low-cost direct LED backlight designs for LCD TVs. The number of LED packages per LCD backlight unit will peak in 2012, and continued growth in penetration of LED backlights will lead to a slight increase in LED demand in 2013. LED demand is then forecast to decrease in 2014 since fewer LED chips will be used per panel.

For these reasons, the focus has turned to LED lighting and to driving LED lighting market demand. Lower power consumption and increased flexibility in fixture designs for LED lighting has generated great interest. But interest in LED lighting does not always lead to purchases of LED lighting products. Some hesitate because they are waiting for prices to fall.

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Market observers have been anticipating the LED lighting market for a long time. But the price of LED lighting is indisputably higher than existing lighting products with similar advantages, such as energy-saving bulbs and T5 fluorescent tubes. Vendors of other technologies compete with LED lighting using a variety of marketing positions, which causes unpredictable LED lighting product prices and cost reductions. Some LED lighting vendors go into niche markets such as lighting design and interior design in the US and Europe; some take the wholesale style price-busting route, selling a 7W bulb for USD5.50. To go back to the basics and examine LED lighting costs, let's examine the NPD DisplaySearch analysis of the cost structure for a 7W LED bulb, as shown in the figure below. As the figure shows, the largest cost of the LED bulb is the LED itself. At retail, this product sells for about 1.3 times the price of the total material cost. Compared to the traditional 13W energy-saving bulb, the 7W LED light bulb costs twice as much, creating an obstacle for LED lighting adoption. In order to sell for less than USD7.49, the total material cost has to be reduced. But how is this achievable? Can the cost structure be improved by reducing the costs for the driver IC or heat sink? Yes, but those do not offer much opportunity due to their small share of the cost. Reducing the LED light source's price could be much more effective. But how can we reduce the LED light source's price? The cost of a 1W LED (5050 package) is USD0.463/pc, and a 7W LED bulb uses seven LEDs, so the total light source cost of that 7W LED bulb is USD3.24. However, if we use 14 LED backlights (5630 package), the cost of the light source falls to USD1.46, so the light source cost is reduced about 56%. This type of price reduction could lead to higher adoption.

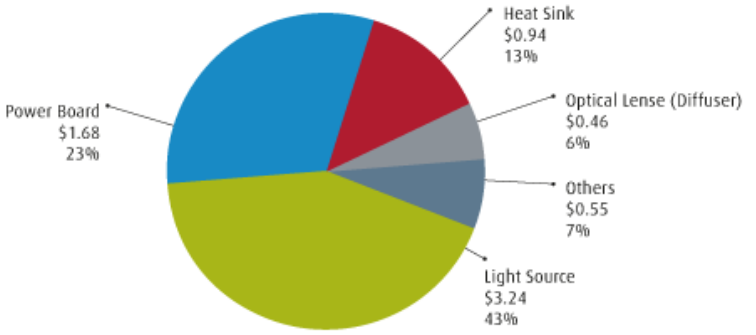
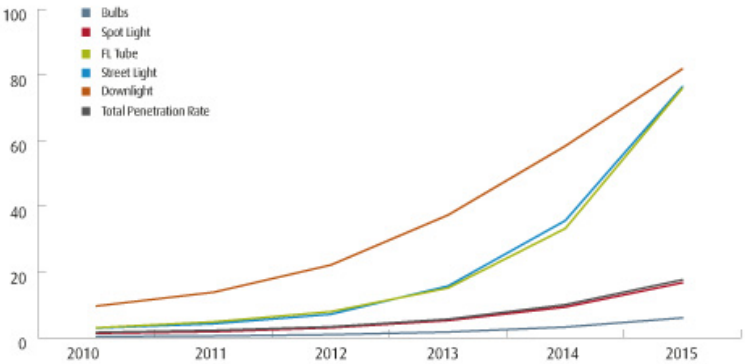


Figure 2: 7W LED Bulb Cost Structure

Source: NPD DisplaySearch Quarterly LED Supply/Demand Market Forecast Report



0.4%	0.6%	1.6%	1.8%	3.3%	6.1%
1.7%	2.3%	3.4%	5.7%	10.1%	17.1%
3.1%	4.9%	8.0%	15.2%	33.3%	76.0%
3.0%	4.3%	7.2%	15.8%	35.7%	76.5%
9.7%	13.9%	22.2%	37.4%	58.4%	81.9%
1.4%	1.9%	3.1%	5.3%	9.4%	16.8%

Figure 3: 2010-2015 LED Lighting Penetration by Application

Source: NPD DisplaySearch Quarterly LED Supply/Demand Market Forecast Report

According to the NPD DisplaySearch Q1'12 Quarterly LED Supply/Demand Market Forecast Report, the 2010 LED lighting average penetration rate was 1.4% and is forecast to reach 16.8% in 2015. As a replacement for incandescent bulbs, LED spotlights have a high penetration rate. Price is a very important factor in the penetration rate of LED lighting, so why do LED lighting manufacturers use 1W high power LEDs to design their products? The first reason is differences in specifications between backlight LEDs and lighting LEDs, especially in colour temperature and colour rendering index. The second reason is optical design; using fewer LED light sources makes products easier to design. Suppliers who overcome the problems of specifications and optical design will have a considerable competitive advantage. LED is an innovation that will change the lighting market, providing design flexibility, lower power consumption, and environmental benefits. However, for the LED lighting market to grow, the LED light source cost is what matters above all.

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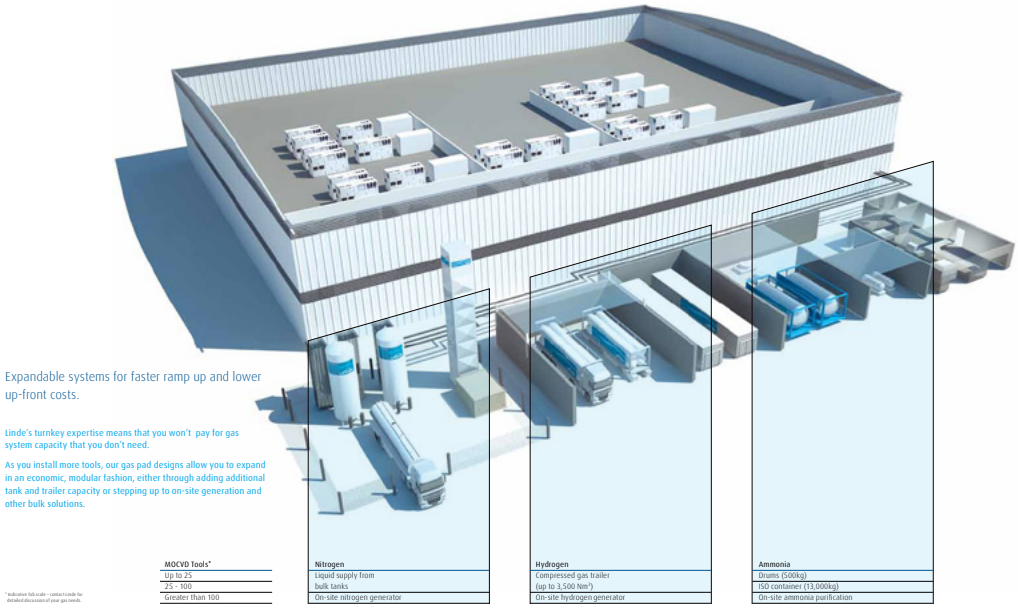
The role of high purity gases in LED manufacturing

The global LED market is prospering. Applications such as LCD TV backlighting and low-power illumination contributed to a 108% growth in high-brightness LED revenues in 2011, according to analysts at Strategies Unlimited. This trend is set to continue, with revenues expected to peak at USD16.2 billion in 2014.

The Chinese LED market is leading this growth – the analyst group iSuppli estimates that the country's LED market will reach up to USD11.1 billion by 2015. This rapid growth is reinforced by lucrative incentives and subsidies, which the Chinese central and local government anticipate will help to stimulate its LED manufacturing industry even further.

Ultra-high purity specialist gases help to facilitate the growth of the global LED industry by maximising the efficiency of the LED manufacturing process. Specifically, very large volumes of high purity ammonia (NH_3), hydrogen (H_2), nitrogen (N_2) and metal organics play a crucial role in the LED manufacturing process. The most critical stage in LED manufacturing – and the cost-intensive one from a materials' point of view – is the growth of the active semiconducting layers by epitaxial deposition. This is accomplished by a process called metal organic chemical vapour deposition (MOCVD).



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Of all the specialist gases used in LED manufacturing, ammonia and hydrogen represent the largest portions of gas costs. Their purity is also critical to the performance and quality of the LED device since they form the majority of the atmosphere in which the crystal layers are grown. If moisture or oxygen molecules are present in these gases, even in trace concentrations, oxygen atoms can become incorporated into the crystalline structure of the LED device and affect its light output. Since ammonia is required in high flow rates during the slow nitride crystal growth process, even trace quantities of impurities can lead to a significant number of unwanted atoms being incorporated in the device. To combat this problem, state-of-the-art LEDs are made using ammonia that typically undergoes at least two stages of purification.

The growth of the LED industry is reflected in the increasing volumes of specialist gases needed by LED manufacturers. Each MOCVD process chamber consumes approximately ten tonnes of ultra high purity ammonia gas per year. With the new generation of LED fabs that include 50 to 100 or more MOCVD reactors, cost-effective high purity supply must be achieved at very high volumes in order to support these large fabs. Similarly to ammonia, hydrogen gas purity is also critical in LED manufacturing, however delivering high purity hydrogen cost-effectively to manufacturers' sites is impacted by regional variations in supply infrastructure and raw material supply specifications.

To meet these demands, Linde has developed innovative ammonia and hydrogen supply technologies, which provide high flow rates and stable ultra high purity required for LED manufacturing, supplying customers such as Kaistar, Lextar, Huga and Cree. The company's SPECTRA™PURE high flow ammonia delivery system features integrated purification, ensuring delivery of the driest possible ammonia at stable flow rates in line with the requirements of the LED industry.

As the global LED industry expands and fab sizes and MOCVD tools increase, the challenge for gas suppliers is to evolve from commodity vendors to providers of technologies in the delivery of specialist materials, while developing solutions that help reduce costs further and increase cell and LED chip efficiency. Linde is already taking the lead in becoming the technology partner of choice for LED manufacturing processes.

For further information, download the following:

Linde in LED manufacturing brochure
Linde SPECTRAPURE ammonia datasheet

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My Life at Linde,
Ian, Head of Product Management

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What motivates you to get out of bed in the morning?
I like coming into work knowing that there are going to be new opportunities in Asia, some of which may only be seven or eight hours old!

Describe your colleagues in three words
Friendly, diverse, collaborative.

How long have you been a part of the Linde team?
I joined BOC Gases in the US nearly 20 years ago. I subsequently moved to the BOC Edwards electronic gases and vacuum equipment business, then re-joined the gases business in the UK during the Linde acquisition of the BOC Group in 2006.

What does your role entail?
My team works with our customers, industry OEMs, engineering, R&D, marketing and sales teams to identify opportunities to innovate and help our customers overcome any challenges they may face. We deliver new hardware-based solutions and services with clear value and performance benefits. This could be something as simple as a higher flow gas manifold or as complex as an ultra-high purity on-site gas generation plant.

What has been your favourite project to work on and why?
Our programme to demonstrate and qualify fluorine as not only an environmentally responsible choice but the highest performance and most cost effective solution for chamber cleaning in large scale thin film silicon processes. It's very satisfying that one innovation project has prevented hundreds of thousands of tonnes of CO2 equivalent PFC emissions, making an entire industry much greener.

What is the quirkiest fact that we might not know about Linde?
Our early clean combustion technology has helped make all of the wine bottles and flasks for the famous Ernst and Julio Gallo winery in California.

Is there anyone within the organisation who inspires you and why?
I think that our CEO Professor Dr. Reitzle sets an exceptional example of vision and determination to improve.

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Linde at the heart of the Chinese LED industry

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To facilitate the growth of the LED manufacturing industry in China, Linde has established an ultra high-purity ammonia (NH_3) plant in Xiamen City, in the south east of the country. When the site opened in November 2010, it was the first operating plant to produce ultra high purity ammonia and now supplies customers using world leading technology in purification, packaging and analytical metrology across China.

Linde has a long history in the distillation and purification of electronic specialist gases. Using its most advanced technology – the patented Y-column distillation and purification system – the company has built plants at seven different locations around the world supplying a variety of gases, the latest being the Xiamen facility.

The plant, which has a capacity of 500 tonnes per year, produces high-purity NH_3 at 7N (99.99999%) level. It plays a critical role in helping Chinese LED manufacturers to increase the efficiency of their production process and to reduce costs.

Based on the plant's patented technology, Linde is able to further benefit its customers by establishing an on-site purification system if an extra high volume of ultra high-purity ammonia is required, as is often the case in the LED industry.

Linde's continued commitment to supporting the growth of the LED industry hasn't gone unnoticed by Chinese LED manufacturers. To date, several leading LED manufacturers have chosen Linde as their specialist gas supplier, including Kaistar, Lextar, Huga, Cree, Neo-Neon, Focus Lighting Technology and Walsin United Technology. The new ammonia plant in Xiamen City further highlights Linde's commitment to serving customers at the heart of electronics manufacturing markets.

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The Latest from Linde

According to the latest figures from analysts at IHS iSuppli, the Chinese LED market will reach USD 6.9 billion in 2012 and up to USD 11.1 billion by 2015. The analyst firm is equally up-beat about the display industry – they expect to see a 30% growth in large panel area capacity globally this year, with a huge 151% increase in China.

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Kaistar to benefit from the first on-site Ammonia plant in China

Kaistar, a joint venture of Epistar, Taiwan's leading manufacturer of LED chips and China Electronics Corporation, has chosen Linde to deliver bulk gases and high purity ammonia (NH_3) to its new production facility in Xiamen, China. Kaistar will benefit from unprecedented access to Linde's expertise in purification, packaging and analytical methodology, as the company's new LED fab will be constructed close to Linde's recently established NH_3 plant – the first plant in China to produce ultra-high purity NH_3 on-site.

Samsung signs long-term agreement with Linde

Linde has recently signed a significant long-term agreement with Samsung Electronics to supply high purity gases for the company's latest 8.5 generation TFT-LCD manufacturing plant in Suzhou Industrial Park, China. Under this agreement, Linde will provide Samsung Electronics with a turnkey installation of the TFT-LCD plant's bulk gases supply systems, with a gas-on-line date of the end of 2012.

Service

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Contact Details:
Linde Electronics
391A Orchard Road,
#23-05 Ngee Ann City Tower A
Singapore 238873

Email: electronicsinfo@linde.com
Web: www.linde-gas.com/electronics