Lighting: A Better Market for OLED Technology

OLED lighting (with Indium based transparent conductive layers) has received considerable attention in 2009 from both the lighting and OLED communities. There are at least three different reasons for this. First, there are now OLED lighting products in the marketplace or close to being introduced; until this year, the OLED lighting story was all about R&D projects. Second, if progress continues toward addressing the technical and economic issues related to OLED materials, design and manufacture--and most observers are optimistic--there will be a compelling case to be made for OLED-based next-generation lighting technology. And finally, lighting appears to represent a better market than displays for OLED technology.

OLED Lighting Products in 2009: Expensive but Available

In the past year or so there have been strong indications that OLED lighting is on the verge of moving from "lab to fab." Osram, through the well-known lighting designer Ingo Maurer, has introduced the world's first "functional table light" based on its OLED technology. Philips has started selling its OLED-based lighting wafers under the name Lumiblade, and General Electric (GE) has announced that it will begin volume production next year of flexible OLED-based lighting panels. (GE's roll-to-roll manufacturing process for OLEDs was much discussed at industry conferences during 2008.)

It would still be easy for a cynic to dismiss these developments on a number of grounds. First, there's pricing. According to press reports, the Ingo Maurer table light is being priced at $25,000 and a piece of Lumiblade material the size of a mobile phone costs $700. Second, the actual production volumes of these products are almost vanishingly small. The Maurer light was initially introduced in a limited edition of 25. Lumiblade is being sold as a do-it-yourself kit for lighting designers and seems to be selling in only the dozens per month. And GE's promise of "volume" production in 2010 is just that, a promise.

But, as analysts see it, these developments are actually reasons for excitement not cynicism. This is exactly the way that e-paper technology started out. The first e-paper products were also absurdly expensive, flexible clocks and watches costing thousands of dollars. Today, e-paper is the technology used in all the leading e-book readers and in many electronic shelf label products. It took two or three years from absurdly expensive flexible clocks to e-paper products that are produced in large volumes and that are affordable or even cost effective. E-paper is in a number of ways a very similar product to OLEDs, and it is believed that it would be no surprise if OLED lighting followed a similar market trajectory.

Successful technology revolutions often begin with high-priced or novelty products; fiber optics is another example. So the market evolution patterns we

see emerging in the OLED lighting market are quite encouraging on those grounds alone. In addition, the fact remains that a year to 18 months ago it was impossible to point to an OLED lighting product that could actually be purchased at any price. Today they are expensive but available.

Towards the General Illumination Market: Improving Performance and Economics

As of mid-2009, OLED lighting is unquestionably a reality, but it is also an oddity. However, if it can be taken beyond this oddity phase the arguments for OLED lighting being a significant business opportunity are quite compelling:

- OLED lighting appears to dovetail well with current, perceived needs for energy efficiency. A key driver for the OLED lighting market is therefore government policy to promote such efficiency. Regulatory requirements in certain geographies are reducing or eliminating the competition from (otherwise much less expensive) incandescent lighting. In addition, both the U.S. Department of Energy and various European governments are providing funding for OLED lighting projects. The upfront cost of OLED lighting is likely to be higher than most of its alternatives, but this will be tempered by the likely long lifetimes and low energy consumption of OLED lighting. This "total cost" argument is not likely to be overly persuasive with smaller users (the average household) for example. However, owners and managers of large office and industrial buildings could well be impressed with the total savings that OLED lighting offers in the future.

- The technology that is usually touted as being the next big thing in solid-state general lighting, high-brightness (i.e., inorganic) LEDs, are actually complementary with OLEDs rather than direct competition. The HB-LED is a small point source of light (a spotlight) while an OLED lamp is a planar sheet of light (a floodlight). The two therefore shine in different market niches. OLED lighting can (in theory, anyway) be scaled up into very large-area lighting devices, for example, a capability that can only be matched by configuring many discrete ILEDs into an array and/or incorporating light diffusion subsystems. This is important from a market development point of view, since otherwise HB-LEDs would present OLEDs with a major market challenge; and from a technical standpoint, they are more developed than OLEDs. That said, OLEDs may offer better white light quality than HB-LEDs--a persistent criticism of HB-LED lighting to date.

- OLED lighting is the first flexible lighting technology with a potentially large addressable market. EL lighting is fairly flexible but offers dim light and its practical applications don't extend much beyond low-end signage and instrument panels. OLED lighting by contrast could

> capture much larger markets for large-area industrial and architectural lighting and may eventually become widely used in general illumination. It will be a long time before the arrays of fluorescent tubes so ubiquitous in today's offices and factories start to be replaced by OLEDs, but we think it should certainly now be considered a distinct possibility for the future.

The problem with all of this, however, is that as a general illumination technology, OLEDs are not quite there technically. But they are improving quickly. Two or three years ago, they were at an energy efficiency that was well under half that of today's most widely used energy efficient light, the CFL. Now they are close to achieving the same efficiency and the U.S. Department of Energy has a roadmap that shows that OLED lighting could substantially improve on the efficiencies currently being achieved by CFLs, perhaps by as much as a factor of two. OLEDs also seem to be approaching CFLs in terms of lifetimes.

In any case, while general illumination is (quite literally) the glittering prize for any new lighting technology including OLEDs, there are other ways to generate money from OLED lighting while the OLED lighting market waits for better performance numbers. Some of these markets are no more than niches, for example special medical applications. But others apparently offer substantial revenues. In particular, OLEDs seem well suited to backlighting markets. OLEDs have an advantage over HB-LEDs in this application because they do not need additional (and costly) optics to spread the light around, but for high-end backlighting applications (in laptops, for example) they may still be a little performance challenged. But for more modest application requirements, such as those of keypad backlighting, OLEDs can already deliver the goods.

OLED Lighting: Birth of an Industry

Yet another reason for optimism about OLED lighting is that there are clear signs that an identifiable OLED lighting industry is beginning to form and some substantial firms are becoming involved. For example, OLED lighting has the lighting industry's biggest names behind it, including Philips, Osram and GE. To this list of OLED backers can be added Kodak, Konica Minolta, Mitsubishi, Panasonic, and Sumitomo as well as a longer list of established smaller but solid firms such as Novaled, Universal Display and others. The involvement of such firms is certainly going to be a big plus for OLED lighting in a number of ways.

The largest of the companies mentioned above have access to the biggest and best marketing channels. In addition, their brand names could ensure credibility for OLED lighting and get it onto the shelves of mainstream chain stores and distributors. This kind of backing, we believe, is in and of itself a good reason to see OLED lighting as a long-term opportunity.

Many good technologies founder when they are unable to garner enough marketing clout after the initial kinks in the technology have been worked out. Firms of the kind listed above can make OLED lighting happen. Another way in which the involvement of such substantial firms can make a difference is on the technical side, where they can harness their vast R&D resources to achieve improved performance metrics for OLED lighting. As we have seen, these metrics are not yet good enough to establish OLED lighting as a major player in the general illumination or the high-end backlighting markets.

Finally, it is important to recognize that the formation of an OLED lighting industry is not all "demand pull." The ranks of the industry are also being swelled by firms that no longer see the thrill in OLED displays. These displays have never really taken off as expected. Small OLED displays have been available for some time and the revenues from these devices add up to hundreds of millions of dollars annually. However, they offer very low margins and have a hard time competing with small LCD displays. OLED displays have been used mostly for MP3 players and for cell phone sub displays and although they are gradually finding their way into higher value main displays, this is happening only slowly.

The one place that OLED displays might have been able to make a big splash in better times is in the TV market. OLED TVs are ultrathin and offer highly vibrant colors. They are also very expensive and while they seem likely to compete effectively with high-end LCD TVs, they will still compete with LCD displays, which are only getting better. Sony has had a medium-sized OLED display on the market for some time, but has recently shelved plans for a larger OLED TV offering. Effectively, we believe, the OLED TV business has been set back a year or more by the recession.

To all of these negative factors currently impacting the OLED display business must be added the fact that active matrix OLEDs (AMOLEDs) have proved hard to build. And while all of the above problems are likely to get solved over the next five to seven years, right now OLED lighting looks to many like a better prospect for OLED technology than displays. Not only do OLED firms not have to deal with the AMOLED question and competition from LCDs, but there is the promise of government funding and regulations that would certainly benefit the OLED lighting industry.

Opportunities and Challenges

It's easy to conceptualize an OLED lamp, flush against the ceiling, replacing a fluorescent fixture or, indeed, replacing a passive ceiling tile with a tile that glows. And, as we have discussed above the vision of large, low-cost R2R-manufactured OLED lamps enabling walls of light is beginning to intrigue some of the biggest lighting firms, firms that have the money to make it happen.

The general consensus is that flat-panel lighting is likely to emulate flat-panel displays by starting out with products of modest capabilities (backlighting for cell phones and consumer electronics, for example), then evolving performance over time to capture more demanding applications. But these more demanding applications--even according to the more sober firms that have been in the lighting industry a long time--could involve some fascinating new opportunities.

By combining color with shape, organic LEDs could create a new way of decorating and personalizing people's surroundings with light, for example. Of course, there are still many challenges to the commercialization of OLED lighting. Some of these are technical and some are marketing oriented. We do not know, for example, to what degree consumers will be willing to pay for relatively expensive OLED lights (when they become available) when incandescent and fluorescent lights are so inexpensive. Will the extra efficiency and the ability to create novel kinds of lighting be enough to open up substantial general illumination for organic lighting? OLED lighting may be able to offer remarkable things such as flexible lamps, but again no one yet knows where the demand lies for that capability and where the perceived value will justify the additional cost.

There are no clear answers to such market questions yet. In part, this is because OLED display and lighting technologies are at such an early stage of their lives. Although OLED displays have already been shipping for almost ten years, their manufacturing operations are many generations behind LCD fabs. The largest OLED display yet fielded is only 11 inches in diagonal, and most of the devices on the streets are in the 2- to 3-inch realm.

The potential for low-cost printing and R2R manufacturing processes also opens up exciting possibilities for price points that would greatly accelerate the adoption of OLED lighting. But so far, nobody has yet proven out their materials set and manufacturing processes in a real-world, high-volume environment. GE promises to do so next year. We are at the beginning of OLED lighting evolution, and it's clear that early stage capabilities won't necessarily reflect the competitive picture years down the road. Which particular material sets, structures, architectures, manufacturing regimens, etc. hold the greatest long term potential is a completely open question at the present time.

OLED Lighting: What to Look Forward to in 2010

It's the beginning of a new year, and like any other we like to look back on the year past and look forward to see what's cooking for the year ahead. For OLED lighting, this is of especial importance: the industry saw its first commercial products, albeit extremely expensive ones, in 2009, which begs the question, will 2010 be the year for "affordable" OLED lighting-ones you and I could possibly purchase?

The answer to this question appears to be "no." While companies have achieved significant strides in OLED performance, materials costs as well as the high cost of manufacturing (low volumes) still leave OLEDs with a high price tag. This is not to say that there's nothing to look forward to this year. On the contrary, as we discuss below, we expect to see more "products," ones being commissioned by designers and luminaire companies, as well as museums and the like. This on-slot (onslaught) of products will bring OLED lighting to the forefront of public attention, possibly giving the attention needed to push up demand and thus justify the construction of large-scale manufacturing lines for OLED lighting. This will hopefully bring down the price, making 2011 the first year for a "more affordable" OLED lighting product.

Year in Review

Last year was supposed to see the commercial takeoff of OLED televisions. But instead, OLED lighting seems to have taken the front seat for OLED producers. The opportunities for OLED displays have not proved as great as OLED advocates, (trade groups and industry promoters) had once hoped and this is the reason some of them have turned to lighting applications. Lighting seems to present opportunities that are both simpler technically than displays and where the entrenched technologies (light bulbs, fluorescent tubes) sometimes seem easier to push aside than the entrenched technology in displays, LCD. A further benefit for lighting: there is often significant government funding for R&D in this space. OLED lighting has received substantial public sector support in both Europe and the U.S. One additional appeal of OLED lighting is that it is extremely simple compared to a display; that is, a lamp can be as simple as one large pixel while an FPD has many thousands of pixels and may well need an active matrix backplane.

So instead of large OLED televisions, the big news for OLEDs in 2009 was the introduction of the first OLED lighting products. In particular, Osram, through the well-known lighting designer Ingo Maurer, introduced the world's first "functional table light" based on its OLED technology. This availability, of course, was not in the stores, but rather at lighting trade shows and those OLED lighting products that became available did so in very small quantities. However, it was enough to give some clarity on what has been achieved and what still needs to be achieved in the OLED market.

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What's on the Horizon?

The Big Three lighting companies-General Electric (GE), Osram, and Philips-appear to be setting the stage for OLED lighting, indicating the level of acceptable performance and introducing lighting panels with that performance for designers to get a feel for.

Late in November 2009, Osram announced the development of its Orbeos OLED panel-the company's first OLED product on the market. Orbeos, which is priced at EU250 ($358), can be switched on and off without delay, is continuously dimmable, and unlike LEDs its heat management is simple. Its brightness level is typically 1,000cd/m² with power input of less than a watt. In ideal operating conditions it has a lifespan of around 5,000 hours. The company claims that after demonstrating what it considers to be high performance (efficiency and lifetime), it is now shifting its focus from technical development to "process management and reliability for future products." This type of statement leaves us to believe that 5,000 hours is an acceptable lifetime for an OLED lighting product. As well, it also indicates that the first "real" products will be in the form of small tiles, instead of one large sheet.

Osram does not expect to have a volume OLED lighting product until 2016. The company plans to transition into this high volume starting in 2012 by selling to the design community; here, the target customer will value some unique quality of the product, such as transparency.

Philips started selling its OLED-based lighting wafers under the name Lumiblade, but has been quiet on the OLED front since that time. When releasing the Lumiblade product, Philips announced that it would start shipping commercial products in 2010.

General Electric (GE) previously announced that it would begin volume production of flexible OLED-based lighting panels in 2010. (GE's roll-to-roll manufacturing process for OLEDs was much discussed at industry conferences during 2008.) GE's most recent announcement in OLED lighting was in December 2009 with its agreement to work with Power Paper, an Infinity Group portfolio company, to jointly develop self-powered OLED lighting devices. The collaboration, which will run for 12 months, will combine Power Paper's thin-film batteries with GE's OLED technology. The goal of the project is to develop "a first generation of self-powered OLED lighting products and identify next generation technologies with enhanced capabilities."

Not Just the 'Big Three'

In addition to the big three lighting firms, there are many other companies involved to a high degree in OLED lighting. Certain materials suppliers and OLED suppliers are also likely to play a major role in shaping the performance of

the first generation of OLED lighting products. Specifically, Merck, Novaled, LG Electronics (through its acquisition of Kodak's OLED business in December 2009), Sumation, Universal Display Corp. (UDC), DuPont and Dow Corning will play a major role. The giants of the printing industry such as Avery Dennison, Toppan Printing and Dai Nippon Printing may also lend a hand, given their expertise in functional printing technology.

We also expect to see new companies coming on the scene this year. One such company, Visionox, which spun out of technology of Tsinghua University, entered the industry several years ago but didn't really hit the radar until last year. At the China International Exhibition and Forum on Semiconductor Lighting held in Shenzhen in October 2009, the company demonstrated its OLED lighting product for decorative illumination-marking Visionox's transformation of OLED lighting technology into production. Visionox says that these products are currently available only in small volume but that in "coming years" the company plans to enter the general lighting and other lighting markets.

We expect more companies like Visionox to appear in 2010; these companies will most likely demonstrate a technology on a small scale before being acquired by one of the larger companies in the industry.

In Summary

To re-cap, we expect 2010 to be the year of more OLED lighting products, as well as moves by some of the larger companies to start transitioning into high-volume manufacture. This transition will mainly be a focus on manufacturing as opposed to actual construction of high-volume lines. We expect the big three lighting companies to demonstrate new products, i.e. new ways of incorporating OLEDs into lighting products, at the upcoming lighting fairs.