



INSIGHT

No 3/09

LED – THREE LETTERS, ONE REVOLUTION

INSIGHT SHEDS SOME LIGHT
ON THE WONDER OF DIODES

OBDUCAT ON EXHIBIT

TRADE SHOWS ARE MUST-SEE EVENTS

ACADEMIC WORK

A CLOSER LOOK AT OBDUCAT'S R&D MARKET

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Obducat AB (publ) Box 580 (Visitor's address: Geijersgatan 2 A) SE-201 25 Malmö
 Phone: +46 40 36 21 00 Fax: +46 40 36 21 60
 Layout and production: Navigator Communications, Malmö

TOGETHER WE PROGRESS

Well into the autumn, it suffices to say that Obducat has had a hectic couple of months. Not that this differs much from our usual schedule, but the successful and encouraging share issue has given us the opportunity to work even harder in following our strategy. This coincides with positive reports from other parts of our business field, within LED in particular, about steady recovery from trying times. This naturally means a lot for us as Obducat has been significantly affected by the financial crisis, along with many of our partners and potential customers. With things slowly going back to normal, it's possible to regain focus on increased capacity. Also, customers that still haven't taken the step to incorporate NIL technology will likely feel the need

to make a decision in the near future about whom to team up with; i.e. to pick a supplier in order to stay in the race.

Obducat is currently engaged in several negotiations regarding projects aiming at startup of HVM (high-volume manufacturing) during 2010. Talks include both LED and completely new types of components. Obducat InSight will naturally keep you posted on developments.

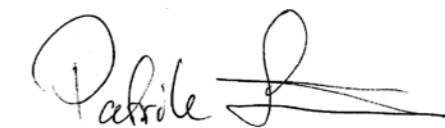
In this issue you can read about different aspects of light-emitting diodes, more often referred to as LEDs. In any case, since they are fast becoming our most important light source next to the sun, it's time to get the facts straight about this bigger-by-the-day application area.

Furthermore, InSight also covers Obducat's all-important R&D market, which despite its limited size means the world regarding what technologies will rule the market a few years from now.

InSight has also been to a couple of recent trade shows, and came back with new knowledge about this window to the market and, as it happens, PV tech.

The next issue of Obducat InSight will be out in December. In it, we note that Obducat has been around for twenty years. At the same time, we are seeing sure signs that the worst turbulence is over. So besides celebrating our anniversary, we plan to go full steam into the next twenty.

Please enjoy.



Patrik Lundström
 CEO



LED – THREE LETTERS FOR THE FUTURE



The FL32 from project-on-design is the brightest LED-fired projector on the market.

LEDs – light-emitting diodes – are drawing a whole lot of attention these days. And well deserved at that. Since it is also a fairly complex and diverse field, InSight let Obducat's Senior Application Engineer, Marc Beck, explain some of the different aspects of LED, and what Obducat has to offer the industry.

Since more than 3 years Obducat has put its focus onto the LED industry being one of the fastest developing markets for the coming decade. The consumer market desires LEDs in major application areas such as displays and general lighting. The major advantage of LEDs compared to conventional light sources is that an LED can emit more light per consumed electronic power than most other known sources (at the moment only fluorescent tubes have a comparable efficiency). Incandescent bulbs waste most of their electric energy in form of heat and infrared radiation being the reason why the European Union now banned them from the market. Initially they will be replaced by low energy lamps based on the same principle as fluorescent tubes but since the tubes contain mercury they are not a desirable source in the long run. LEDs will increasingly replace conventional light sources used in general lighting applications in the coming years. Despite their energy conversion efficiency LEDs did not attract interest for general lighting since they did

not emit enough light per device to be used for displays or general lighting. This has been changed with the availability of nanotechnology where nanostructuring of different parts of the LEDs allowed significant improvements of the light extraction efficiency. High brightness LEDs with or without beam shaping are already used as light sources in projection displays, LED displays, backlighting of LCD displays, and general lighting (e.g. car head lights). Some cities started to illuminate some roads with high power LEDs. What has been accomplished in the R&D labs of the LED companies had to be turned into a process being capable for high volume manufacturing of large quantities of LEDs. Here Obducat has played a crucial role and found a unique pathway. Obducat's technology can be used for the applications named above since they benefit from light extraction enhancement. We will discuss patterned sapphire substrates (PSS) and photonic crystals on semiconductors (PhC) allowing light extraction enhancement and beam shaping.

PATTERNED SAPPHIRE SUBSTRATES

Sapphire substrates are the most common base materials to grow an LED on. The light generated in an LED has initially no preferential direction of radiation and therefore a larger amount of the light travels towards the sapphire substrate and not the top surface of the LED. By nano-structuring the interface between the sapphire and the first layer of the

“ ONE OF THE FASTEST DEVELOPING MARKETS FOR THE COMING DECADE.”

grown LED it was possible to obtain reflection and to redirect the light to yield a 33% emission enhancement compared to conventional non-patterned LEDs. It has also been shown that the emission enhancement increases with decreasing size of the pattern, which influences also the crystal growth originating from this interface when the LED structures are deposited. Nanostructuring of the sapphire surface can most easily be accomplished by nanoimprint lithography (NIL) and all sapphire-based LED's can benefit from this enhanced reflectivity and light emission.

PHOTONIC CRYSTALS ON LED TOP SURFACES

Transferring a periodic or quasi-periodic pattern into the top layer of an LED can enhance the emission characteristics further. In physical terms a major part of the light an LED emits suffers from total internal reflection at the interface of the LED crystal and the surrounding air. Structuring this interface with a so-called photonic crystal can circumvent this phenomenon. The quantum mechanics behind such a structure allows the light to penetrate this interface resulting in light emission enhancement. Moreover, a proper design of the photonic crystal's geometry allows influencing the emission direction (beam shaping).

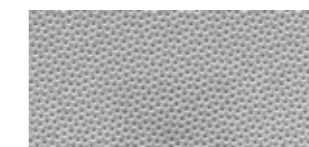
OBDUCAT'S ROLE IN THE GAME

Obducat's nanoimprint technology has shown to be superior to other solutions when it comes to the application area LED. Nanopatterning of substrates used for manufacturing of LEDs has proven to be a challenge due to waviness and presence of defects. Optical lithography methods suffer from loss of focus due to these irregularities, and e-beam lithography is too slow and expensive. Common nanoimprint technologies employing hard stamps also fail due to the presence of the mentioned defects. Therefore Obducat developed a flexible mould, the intermediate polymer stamp (IPS[®]), and employs this for imprint into a UV-crosslinkable polymer in a simultaneous thermal and UV process (STU[®]). Due to Obducat's patented soft-press[®] technology where pressurized air is used to apply the pressure on the mould the stamp can adapt to the curvature of the surface defect thereby allowing nanopatterning of these surfaces with a minimum defect level. These technologies have evolved in recent years and protected by patents all around the world. Obducat's long experience in manufacturing of imprint tools and development of production compatible

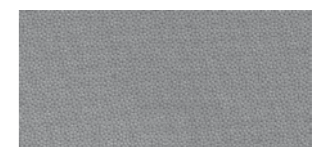
materials and processes now finally culminated in the release of the Sindre[®]400 HVM (high volume manufacturing) platform, an industrial NIL tool currently allowing to nano-pattern LED substrates at a throughput of 30 wafers/hour with wafer sizes up to 4 inches in diameter. It's the first NIL tool on the market with HVM capability meeting the requirements of the industry like high quality, high throughput at lowest possible cost of ownership.



Fully automated chip test stand for blue HB-LED based on photonic crystal. The bright spot is blue light emitting from a single LED chip at a forward current of 20 mA only.



Scanning electron micrograph of an intermediate polymer stamp (IPS) showing a 12 fold symmetry photonic quasicrystal pattern.



Scanning electron micrograph of the imprinted 12 fold symmetry photonic quasicrystal pattern. The imprint was obtained with an IPS as shown

SHOWING OFF

A natural part of Obducat's working year is to participate in, or attend at, a number of major trade shows. They present a chance to get thoroughly updated on partners and competitors, great networking opportunities and, not least – an unparalleled way to show Obducat's latest findings to the rest of the world. Here are two recent examples: Intersolar in the U.S. and EU PVSEC in Germany.



Chances are that northern California in July is hot, humid and very sunny. Fittingly, it is also the setting for Intersolar – "North America's Premier Solar Trade Event" – a yearly trade show held in San Francisco and dedicated to the field of solar power. Obducat participated with a booth, and could demonstrate the Sindre®400 system in grand style, with a specially produced film together with dedicated application notes and information about how NIL and patterning can be further introduced to the PV industry in order to increase solar-cell efficiency.

PV INTEREST ON THE RISE

This year's Intersolar was held in conjunction with Semicon West, which clearly is the bigger show of the two. However, during this year's exhibition, there seemed to be a significant shift in interest towards the PV industry. With Obducat's decision to approach the PV industry in mind, and judging from the positive reaction at Intersolar, the timing for this endeavor is optimal. This gives Obducat the possibility to already at an early stage build a market position within the PV application area. During Intersolar, Obducat enjoyed a well-positioned booth and many visitors. A common reaction was interest and delight in a "new" technology that can support the roadmap that the PV industry has set for itself. Another positive side to Obducat's participation was the many start-up companies that showed great interest in our technology; Obducat's nanoimprint lithography offers them an opportunity to differentiate from other compa-

“NIL IS ONE OF FEW TECHNOLOGIES THAT TRULY ENABLE THE PV INDUSTRY TO ACCOMPLISH ITS ROADMAP TARGETS.”

nies within the industry. This also underlines the extreme importance of increased solar-cell performance and improved cost-efficiency to the commercial development of photovoltaics.

A GOOD SPOT AT A GOOD MEET

Another big event in Obducat's calendar is the EU PVSEC. Behind this less than flowing abbreviation stands the European Photovoltaic Solar Energy Conference and Exhibition. In this, its 24th year, it was held in Hamburg, Germany, 21st to 25th of September. It is the world's biggest exhibition specialised in the photovoltaics sector, and therefore very influential in the industry. So much so, that many well-established companies in the PV industry pick EU PVSEC as their only exhibition participation. By securing a near-perfect booth location early on, Obducat could again introduce the Sindre®400 system in a highly effective way.

RECOGNITION TAKES PERSISTENCE

Although partaking in these two trade shows have proven successful and a good way to reach out to the market, overnight success doesn't exist in the PV industry. The general response to Obducat's offer has been overwhelmingly positive, but convincing an entire industry is a question of sheer persistence – and many more trade show appearances. On the other hand, NIL is one of few technologies that truly enable the PV industry to accomplish its roadmap targets. Needless to say, Obducat is up for the challenge.

R&D ORDERS

In Obducat's day-to-day business, there is a natural focus on the Sindre® platform. It comprises the systems that are tailored for mass production, and therefore also the gateway to commercial success. Beneath Sindre® lies its sibling, the Eitre® platform, aimed at Obducat's R&D and academic customers. It was this that originally paved the way for Sindre®, and still represents an important tool for customers around the world interested in developing nanotechnology further:

Obducat's transition into an industrial, rather than R&D-based, company is still a fairly recent development. For many years, Obducat was a small operation trying to find ways to perfect its lithography method, however the links to its R&D roots are still strong; this is where the work that creates demand takes place, the work that will drive the market potential a couple of years down the road. Furthermore, the nanotech landscape of tomorrow is likely to be formed by today's small companies pioneering new technologies. Many of Obducat's bigger customers have initially been R&D customers, usually acquiring an Eitre® system to try NIL out before deciding on any larger orders. Also, a presence in the R&D and academic communities is a good way to stay updated with emerging technologies. Conversely, when Obducat's technology proves itself in this sector, it also improves Obducat's chances to being used in spearheading research.

RENOWNED NAMES ON THE CUSTOMER LIST

In some cases, the mere fact that a renowned research facility is interested in a certain technology sends a signal to the market that heightened interest is due. One such instance was in 2008 when Data Storage Institute (DSI), based in Singapore, ordered an Eitre®6 system. DSI may not be a household name, but it is one of the world's supreme research and development centres in the information storage industry. Although there is no shortage of such examples, many of our customers tend to be very discreet with their choosing, and prefer not to be named.

NIL IN KANPUR AND RICHLAND

In the academic world, being less secretive, Obducat can be more open with by whom they are favoured. InSight asked two distinguished places of learning about their opinion, and enquired how they put Obducat's technology to use in their work.

Dr. Prabhat Dwivedi and Prof. Ashutosh Sharma of the Indian Institute of Technology in Kanpur (IIT Kanpur) said the following*:



“Obducat's nanoimprint lithography (NIL) is the single most essential and user-friendly R&D tool for micro- and sub-micron patterning of hard and soft surfaces along with thin films of polymers and other materials, which is the first step towards the fabrication of moulds, masks, stamps and masters for subsequent processing for patterning applications. Unlike the photolithography methods, which can be used only for patterning of UV sensitive materials, NIL can be used for patterning of virtually any material regardless of its properties. Our NIL facility is used by different research groups of the institutes very frequently.”

Pacific Northwest National Laboratory, Richland, Washington. (PNNL is one of the U.S. Department of Energy's ten national laboratories, managed by DOE's Office of Science. PNNL performs research for other DOE offices as well as government agencies, universities, and industry, delivering science and technology solutions to meet today's key national needs):

“The laboratory in its Materials Science area has purchased an Obducat Eitre®3 system. The system was chosen based on its flexibility (ability to do several types of embossing as well as nanoimprint lithography) compact footprint and simplicity. The laboratory was also impressed by the positive experience of other Obducat users. PNNL intends to use the system across many disciplines in materials science basic research.”

* Dr. Dwivedi and Prof. Sharma were kind enough to also supply us with the preliminary result of one of the interesting projects utilising Obducat's NIL technology, Fabrication of bio-inspired polymeric surfaces with controllable wettability. Unfortunately, the strict space restrictions that Obducat InSight is limited to made it impossible to include in this issue. Obducat plans to highlight this at a later stage.



OB DucAT'S ANNUAL REPORT AWARDED

Obducat's annual report for 2008 recently received an honorary mention from the Swedish Shareholders' Association. Obducat was one of two recipients awarded for having the best annual report listed on the NGM stock exchange. InSight asked Obducat's CFO, Jonas Hansson, a few questions on the subject.

1. HOW DOES IT FEEL AS NEW CFO TO HAVE YOUR FIRST ANNUAL REPORT FOR OB DucAT AWARDED AS ONE OF THE BEST IN SWEDEN?

– Naturally I'm happy, and I see it both as an encouragement and a challenge. This means we're doing good things, but it also creates a healthy pressure to develop coming years' reports even further.

2. WHAT DO YOU THINK TIPPED THE SCALE IN OB DucAT'S FAVOUR?

– We have probably succeeded in presenting a mix that is both pleasant to look at and fairly accessible. Since Obducat is active in a highly technical field, I also hope that we show our business in a manner that's easy to follow.

3. WILL THIS CHANGE YOUR APPROACH TO THE WORK WITH UPCOMING REPORTS?

– Well, as I said, the pressure's on ... In fact, the annual report for 2009 will be completely digitalised and presented as a website linked to www.obducat.com. This will open up a lot of possibilities, from computer-generated graphics to filmed segments, all in order to make the report better.



SWEDEN

Head office
Obducat AB (publ)
Box 580 (Visitor's address:
Geijersgatan 2 A)
SE-201 25 Malmö
Phone: +46 40 36 21 00
Fax: +46 40 36 21 60

U.K.

Obducat CamScan Ltd
Pembroke Avenue,
Waterbeach
Cambridge CB5 9PY
Phone: +44 1223 86 10 66
Fax: +44 1223 86 10 77