



## Company profile:

# Lasers drive welfare and new applications

In this article we discuss how laser products contribute to the increase of welfare and standard of living in modern society.

Modulight, Inc. is a fast growing technology company headquartered in Tampere, Finland, with sales offices in Tampere and Lafayette, CA. The company was established in year 2000 and achieved its first profitable result in 2002.

By today we have manufactured more than 250,000 semiconductor laser diodes at Modulight for applications to defense, industrial, medical, security, space and telecom industries.

We emphasize four critical success factors in all our operations. Firstly, all Modulight's laser products have reliability built-in as one of their inherent characteristics. Secondly, whenever we engage our customers, we are agile and we maintain customer focus. Finally, all our partnerships aim at increasing our customers' value proposition – not just by providing in-specification product. This enables mutually sustainable profitability.

## High power lasers update

During 2005 Modulight has launched a range of high-power laser bar and chip products for use in direct, pumping and fiber laser applications. These and coming high-power laser products will boast higher optical output power, improved power conversion efficiency and higher brightness than current lasers on the market.

The products will enable Modulight customers to penetrate new applications with reduced cost, improved efficiency and functionality. Many applications in welding, cutting, drilling and even medical were previously impossible to address with semiconductor lasers, due to high cost and or too low power. By combining Modulight's expertise in high power conversion efficiency and reliability our customers are paving the way for new era of laser use.

Our new multimode and single-mode lasers will revolutionize these applications through:

- Miniaturization, functionality and cost;
- Increased power density and fiber coupling efficiency;
- Improvement in power conversion efficiency.

These factors will result in disruptive convergence of industrial processes towards more sophisticated production methods, advanced military applications and medical treatments. Modulight is working with several leading companies to enable this transformation.

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## Letter from the Editor

This Issue describes many activities of the Laser Pilot Factory of the LCC Finland, which is currently in operation, also providing information about the capabilities and resources of the Laser Application Laboratory (LAL) of the Institute of Production Engineering of TUT.

We have started to advertise our member companies in the Newsletter. You are welcome to contact us and submit useful information of your company's profile in the coming Newsletters. The advertisement is free of charge for the member companies as a service of LCC Finland.

Have a nice winter time, which seems to be finally approaching.

Pekka Savolainen  
LCC Finland, Manager  
pekka.savolainen@hermia.fi

## In this Issue

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# Heptagon – pioneering company in micro-optics

Heptagon is a Finnish-Swiss company. It was established in 1993 to design and sell diffractive optical elements. In 2000, Heptagon acquired a replicated micro-optical elements manufacturing facility from Centre Suisse d'Electronique et de Microtechnique SA (CSEM) in Zurich. Heptagon's roots are in the world's leading R&D on diffractive optics at the Helsinki University of Technology and the University of Joensuu, and on the development and commercial applications of the production technology at CSEM Zurich, giving Heptagon over 20 years of micro-optics experience.

Today, Heptagon develops, designs, and manufactures diffractive and refractive micro-optics and subsystems. Heptagon has over 25 employees in Rüslikon, near Zurich (Switzerland) and in Otaniemi, Espoo (Finland).

Micro-optics represent the next generation of optical components. They enable a collection, distribution or modification of light. The cost-effective miniature components are designed to replace conventional bulk optics with the additional benefit of greater functionality, resulting in new products that would not have been possible using conventional optics.

Heptagon's highly skilled engineers support the customer from initial concept, design implementation and right through to

full-scale production to ensure that new applications are developed in an integrated process. This "one stop shop approach" minimises risk for customers and accelerates time to market.

Heptagon propriety volume production method (REEMO®), which is ISO9001 certified, is an extension of the standard UV-replication process to large-area glass or opto-electronic wafers. Micro-optical components are manufactured on 6-8" wafers, which can be further processed with thin-film optical coatings and then diced into individual micro-optic components or opto-electronic modules. They have excellent thermo-mechanical stability (telcordia specified for telecomm applications) and they withstand IR-reflow (even lead-free processing up to 280 °C). High-quality components can be fabricated very cost-effectively, in particular, at medium to high volumes (thousands to millions of components per month). Recent developments include double-sided wafer-scale replication and over-moulding Heptagon's production facility, including 300 square-meters of clean rooms, is located in Switzerland.

Heptagon's components are currently used in a variety of global market segments, including lighting, telecommunications, mobile datacomms and consumer electronics. New business opportunities in other markets, such as laser printing, materials processing, medical diagnostics, auto-ID/machine vision and instrumentation, are also being investi-

ed. Heptagon's customers are large multi-national companies as well as medium and small -size high-tech and start-up companies.

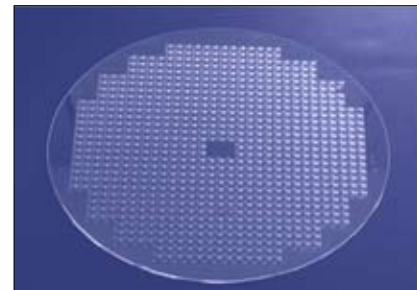


FIGURE 2. In wafer-scale UV embossing (REEMO®) of micro-optic components, the glass wafer with the UV-embossed microstructure is subsequently diced to produce individual components, which are packaged as required for an application. Generally, the size of the diced components is similar to that of small electronic components. This means that standard packaging can be used, such as a common tape and reel Assembly with, e.g., LED gives very small and thin module solutions.



FIGURE 1. A diffractive optical element (DOE) is used as a pattern generator for a virtual laser keyboard in personal data assistants (PDAs) and mobile phones. The replicated DOE projects a visible keyboard pattern that serves as a guide for the user's fingers. Finger position is detected by a plane of infrared light and a CMOS sensor module.

Photo credit:  
VKB, Inc.

continues from page 1

## Low noise laser update

During 2005 Modulight has initiated volume deliveries of a range of low noise Distributed Feedback (DFB) and Fabry-Pérot (FP) lasers. These products are delivered in various connector, fiber and isolator configurations.

These products are used in a range of applications including defense, instrumentation and security. Modulight customers worldwide have replaced previous market leading product from Fujitsu Eudyna with Modulight's low noise laser products. Modulight is committed to supporting these customers with more than 10,000 units next year alone.

## 10G Ethernet update

Modulight launched the world's first laser aimed at the 10Gb/s Ethernet in 2003. Modulight has participated in IEEE P802.3aq 10GBASE-LRM Task Force standardization work for this rapidly growing market, led by industry leaders such as Agilent, Big Bear, Finisar, and Intel.

Modulight 10Gb/s strategy is based on working with the leading companies to supply products for this high-end mass market as 10Gb/s ports are starting to replace 1Gb/s Ethernet ports in enterprise and other applications at accelerating rate.

## Laser helping higher standard of living and welfare society

The revolution of lasers is already happening today! Robust lasers designed & manufactured by Modulight enable increasing number of applications to benefit from the laser technology.

Fundamental limitation for commercialization is not in technology but in understanding customer needs and effectively collaborating to form productive networks. By combining state-of-the-art know-how with outstanding customer support Modulight helps to increase standard of living in the modern society.



Seppo Orsila  
Modulight, Inc.  
CFO & VP Marketing  
Modulight, Inc.

[www.modulight.com](http://www.modulight.com)

# Laser Pilot Factory has started its operations

## Open-doors in December

A Laser Pilot Factory, one of the three divisions of Laser Competence Centre Finland (LCC Finland), is a new type of service concept, which offers application tests for companies in the field of micro-machining. With the latest versions of a pulsed fibre laser for micro-cutting and grooving and a high-power diode laser system for micro-joining, Laser Pilot Factory offers very accurate and high-quality micro-machining.

Using these resources at the Factory a company will be able to exploit the newest laser technology at small starting costs, small risk, and quickly. There is no need to use the company's own personnel for application tests, just make use of know-how and equipment available at the Factory.

## Services

- Application tests using companies' own parts
- Equipment tests using equipment of ei-

ther the company or the Factory

- Consultation about use of diode lasers or pulsed lasers in production
- Workshops including theory and practise about use of diode lasers and pulsed lasers in different applications (1-2 days)
- Newsletters from the test results and capabilities of the equipment

## Open-doors at week 50

The Laser Pilot Factory is going to arrange an open-doors event at week 50 to demonstrate the equipment and R & D capabilities. Welcome!

[Monday 12.12. at 13:00 – 17:00](#)

[Wednesday 14.12. at 9:00 – 12:00](#)

[Friday 16.12. at 14:00 – 17:00](#)

Location: Tampere University of Technology, 3. floor of the machine building, laboratory K3111

# Laserkoetehdas on aloittanut toiminnan

## Avoimet ovet joulukuussa

Laserkoetehdas on uusi palvelumuoto, jossa teollisuusyritykset voivat teettää laser sovellustestejä uusimmalla tekniikalla lyhyellä aikataululla ja yksinkertaisesti. Laserkoetetaan alkuvaiheen laitteisto painottuu laser-mikrotyöstöön: leikkaukseen, poraukseen, pinnan strukturointiin, juottamiseen ja yleensä liittämiseen. Laserkoetetaan nyt hankittu laitteisto on uusinta tarjolla olevaa ja tekee mahdolliseksi erittäin tarkan ja hyvälaatuisen työstön.

Laserkoetetaan avulla yritys voi ottaa käyttöönsä kaikkein uusimman laser-tekniikan pienellä panostuksella, riskillä ja nopealla aikataululla. Sovellustestien tekemiseen ei tarvitse sijoittaa omaa henkilöstöä, vaan yritys voi käyttää Laserkoetetaan osaamista ja laitteistoa.

## Palvelut

- Työstötestejä yrityksen omilla työkalupaleilla
- Laitetestejä joko Laserkoetetaan tai yri-

tyksen omien laitteiden kanssa

- Konsultointia diodi- ja pulssilaserien käytöstä tuotannossa
- Tutustumispäiviä ('work shop'), joissa käydään läpi käytännössä ja teoriassa diodi- ja pulssilaserien käyttöä eri sovelluskohteissa (1-2 päivän mittaisia)
- Uutiskirjeitä, joissa kerrotaan kappalestien tuloksista ja laitteiden mahdollisuuksista

## Avoimet ovet viikolla 50

Järjestämme avoimien ovien tapahtuman viikolla 50, jolloin esittelemme laitteita ja niiden tarjoamia mahdollisuuksia. Tervetuloa!

[Maanantai 12.12. kello 13:00 – 17:00](#)

[Keskiviikko 14.12. kello 9:00 – 12:00](#)

[Perjantai 16.12. kello 14:00 – 17:00](#)

Sijainti: Tampereen teknillinen yliopisto, konetalon 3.kerros, laboratorio K3111

# Equipment at Laser Pilot Factory

## *Know-how of laser micro processing*

The Laser Pilot Factory has received, installed, and taken into use two new work cells for micro-processing and micro-welding.

For micro-processing, the Factory is using an ultra-short-pulse fibre laser (Corelase X-lase), which is installed into the high-speed work cell (Singulase LD10). With this technique it is possible to do very accurate and high-quality surface structuring, grooving, drilling, and cutting for various materials.

Another application area of the Factory is micro-welding, using a diode laser

(Laserline LDM). The diode laser is connected to an accurate 6-axis clean room robot (Stäubli RX60). The diode laser could be used for welding plastics and thin-metals and soldering electronic components.

Applications of an ultra-short-pulse laser:

- Cutting small metal parts
- Accurate surface structuring
- Drilling very small holes
- Accurate multi-layer material grooving
- Cutting PCBs
- Cutting Silicon

The ultra-short-pulse laser is applicable to a very accurate processing of many different materials.

Applications of a diode laser:

- Plastic welding
- Thin-metal welding
- Soldering
- Marking

The diode laser is applicable to cost-effective, reliable, and rapid welding and to the soldering of plastics and thin-metals.

Contact: Dr Jouni Hölsä, phone: +358 (3) 31153113, email: jouni.holsa@tut.fi

## Singulase LD10 työasema

Corelase X-lase on integroitu Singulase LD10 työasemaan. Laser-koetetaan Singulase LD10 on varustettu Etelin DynX lineaarimoottoreilla, millä voidaan saavuttaa yli 1.5m/s nopeus ja yli 1.5g kiihtyvyyttä (nämä arvot riippuvat voimakkaasti halutusta liiketarkkuudesta). LD10 on täysin suojattu solu, jonka sisäisiä tapahtumia valvotaan työstön aikana 4 kameran avulla.

Singulase LD10 on tarkoitettu erityisesti herkkien low-K ja monikerros materiaalien uritukseen. Sitä voidaan myös käyttää muistipiirien korjaukseen, MEMS valmistukseen ja ITO litografian korjaukseen. LD10 on kompaktin kone tällaiseen tarkoitukseen tarjoten täydellisen ratkaisun puhdistiloihin. Laserkoetettaessa LD10:tä käytetään hyvin erilaisiin mikrotyöstön sovelluksiin, niiden testaamiseen ja tutkimukseen.



Singulase LD10 sisältä. Keskellä näkyy oranssi Corelase X-lasen työstöpää.

## Singulase LD10 work cell

Corelase X-Lase is integrated into a Singulase LD10 work cell. The Laser Pilot Factory receives Singulase LD10 with Etel DynX linear drives, which enable the workstation to achieve an operational speed beyond 1.5 m/s and acceleration above 1.5 g (these figures depend on required contouring accuracy). The LD10 is a fully covered work cell with four cameras monitoring the process inside.

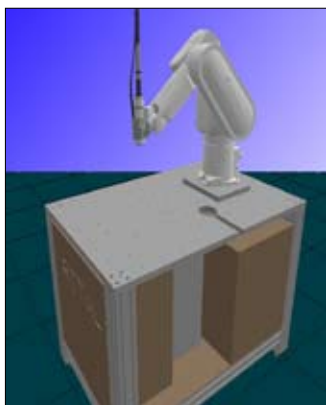
The Singulase LD10 is especially designed for fragile low-K and multi-layer material grooving. It can also be used for micro-tooling as a memory cell repair, MEMS-tooling and ITO lithography repair. The LD10 is the most compact machine available for such a use, providing an all-in-one solution for clean room environment where space is a premium. The LD10 is going to be used for number of different laser micromachining processes in Laser Pilot Factory.

Caption: Inside view of Singulase LD10 with Corelase X-Lase intelligent processing head.

## Stäubli RX60 puhdistilarobotti

Laserline LDM diodilaser on yhdistetty Stäublin 6-akseliseen puhdistilarobottiin. Yhdessä räätälöityjen kiinnittimien kanssa tämä muodostaa työstösolan muovien ja metallien liittämiseen. Työsola sijaitsee erillisessä laser-suojatussa tilassa.

Stäubli RX60 on suurinopeuksinen käsivarsirobotti puhdistiloihin ja korkean tarkkuusvaatimuksen sovelluksiin. RX sarjan roboteilla on korkea tarkkuus, suuri nopeus ja suuret kiihtyvyydet. Näitä robotteja käytetään yleisesti maalaamiseen, automaattiseen kokoonpanoon ja mittaukseen, mutta erityisen hyvin RX robotit soveltuvat elektroniikan tuotantoon ja piikiekkujen käsittelyyn. Tällä alalla Stäublilla ei ole enää montaa varteenotettavaa kilpailijaa.



Diodilaserosolun simulointimalli.

## Stäubli RX60 Clean room robot

Laserline LDM diode laser is connected to a Stäubli 6-axis clean room robot. Together with specialized fixtures it creates a work cell for plastic and metal welding. The work cell is to be located in an isolated laser safe room.

Stäubli RX60 is a high-speed, articulated manipulator for clean room and high precision applications. The RX series of the manipulators is known for slim wrists, high precision, high speed, and acceleration. While used in a diversity of applications including painting, automated assembly and measurement, the RX robots are the best known in the electronics market, where clean room robots are used for wafer handling. In this industry, Stäubli has fewer competitors.

Caption: Simulation model of diode laser cell.

# Laserkoetehtaan laitteisto

## Mikrotyöstön tieto&taito

Laserkoetehtaalte on nyt käytettävissä ja toiminnassa kaksi uutta työasemaa mikrotyöstöön ja mikroliittämiseen.

Mikrotyöstöä varten Laserkoetehtaalte on lyhyen pulssin kuitulaser (Corelase X-lase) asennettuna suurnopeus työstöasemaan (Singulase LD10). Tällä tekniikalla voidaan tehdä erittäin tarkasti ja hellävaraisesti pinnan strukturointia, uritusta, porausta ja leikkausta lukuisille eri materiaaleille.

Mikroliittäminen diodilaserilla (Laserline LDM) on toinen Laserkoetehtaan sovelluskohde. Diodilaser solussa

on asennettuna tarkka 6-akselinen puhdastilarobotti (Stäubli RX60). Diodilaserilla voidaan muun muassa liittää muoveja, ohuita metallilevyjä ja juottaa elektro-niikka.

Sovelluksia pulssilaserille:

- Pienten metalliosien leikkaus
- Pinnan tarkka kuviointi
- Hyvin pienten reikien poraus
- Tarkkojen urien työstö
- Piirilevyjen leikkaus
- Piin leikkaus

Pulssilaserilla voidaan tehdä erittäin tarkkaa työstöä hyvin laajalle joukolle eri materiaaleja.

Sovelluksia diodilaserille:

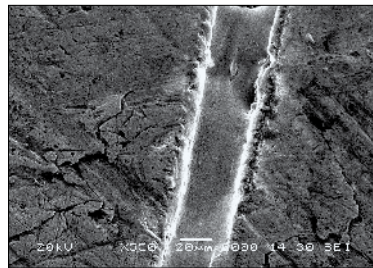
- Muovien hitsaus
- Ohuiden metallien hitsaus
- Juottaminen
- Merkkkaus

Diodilaserilla voidaan kustannustehokkaasti, luotettavasti ja nopeasti hitsata ja juottaa muoveja ja metalleja.

Yhteystiedot: Jouni Hölsä, puhelin: 03 – 3115 3113, sposti: jouni.holsa@tut.fi

## Corelase X-LASE, lyhyen pulssin kuitulaser

X-lase on erittäin lyhyen pulssin (noin 20 pikosekuntia) kuitulaser, jolla voidaan tehdä niin sanottua 'kylmää työstä' (adiabaattinen ablaatio). Se on optimoitu mikrotyöstöön ja siinä on siten noin 15µm lasersäteen halkaisija työstöpisteessä. Erittäin korkea hetkellinen teho saavutetaan megahertzien taajuudella. X-lase on kompakti muotolukittu kuitulaser, mikä tarjoaa erinomaisen säteen laadun, todella lyhyet pulssit, korkean toistotaajuuden ja siten minimaalisen lämmöntuonin mikrotyöstöön. Korkea työstön laatu tekee X-lasesta täydellisen valinnan teollisuuden erilaisi-



Corelase X-lasella teräkseen leikattu ura Uran leveys on pienempi kuin 30µm.

in mikrotyöstön tarpeisiin.

Kompakti koko, kuituliitäntä ja monipuolinen työstöpää tarjoavat helpon integroita-vuuden. Laserkoetehtaan X-lase on varustettu työstöakselin suuntaisella CCD-kameralla, erillisellä suur tarkkuus CCD-kameralla, takaisinheijastuman ja plasma intensiteetin mittauksella.

## Corelase X-LASE, a short-pulse laser

X-Lase is an ultra-short (~ 20 ps) pulsed fibre laser operating in a so-called "cold", or more specifically, adiabatic ablation regime. It is optimized for micro-machining with a 10 – 30 µm spot size. High average power is achieved by an adjustable MHz range pulse repetition rate. X-Lase with its excellent beam quality, ultra-short pulses, and high repetition rate is a compact mode-locked fibre laser for materials processing at minimal thermal load. High processing quality at a speed typical of macro-processing makes X-Lase a perfect industrial tool for micro-material processing.

Its compact size, fibre delivery, and intelligent process head enable easy integration and flexibility. It is coming to the Laser Pilot Factory with an on-axis CCD camera, a separate high magnification microscope CCD camera and a plasma intensity measurement system. Importantly, all the measurements are integrated into the intelligent process head.

Caption: Steel processed with X-LASE without recast, burr or debris.

## Laserline LDM400-300 diodilaser

Laser-koetehtaan Laserline LDM diodilaserissa on 300W keskimääräinen teho, 940nm aallonpituus ja 5m pitkä kuitu. Työstöoptiikalla saavutetaan nyt 0.4mm halkaisijaltaan oleva lasersäde fokuksessa. Laser on varustettu pilotilaserilla (näkyvä punainen aallonpituus), 2" työstöoptiikalla, CCD-kameralla ja Dr. Mergenthalerin pyrometrilla.



Laserline LDM kuituunykkyetty diodilaser

Tämä uusi kuituunykkyetty LDM modulaarinen diodilaser soveltuu muovien liittämiseen, juottamiseen, kuitulaserin pumppaukseen ja mikrohitsaukseen. Tämä hyvin kompakti moduli on ke-

hitetty pohjautuen Laserlinen pitkän kokemuksen kuituunykkyetty diodilasereista ja materiaalin työstöstä. Modulilla on pitkä elinikä, korkea luotettavuus ja helppo integroita-vuus. Suljettu huoltovapaa vesijäähdytys takaa optimaaliset käyttöolosuhteet diodeille ja siten pitkän elinikän koko laitteelle.

## Laserline LDM400-300 diode laser

A Laserline LDM unit arriving at the Factory will have 300W average power, a 940 nm wavelength and a 5 m long fibre. Direct optics will achieve the spot diameter of 400 µm. It is equipped with a visible pilot laser, 2-inch working optics, a CCD camera, and a pyrometer.

The new fibre-coupled OEM diode laser modules, LDM series, are suitable for applications in plastic welding, soldering, and pumping the fibre lasers or micro-welding metals. These extremely compact modules have evolved from Laserline's long experience in fibre-coupled diode lasers for materials processing. They meet the highest expectations on lifetime, long-term reliability, and ease of integration. A closed loop, maintenance-free water circuit assures optimum operating conditions of the diodes and thus a particularly long lifetime. If despite these measures a component fails, there are easily exchangeable replacement units available on stock.

Caption: Laserline LDM fiber connected diode laser.

# Laser Application Laboratory LAL

The Institute of Materials Science and the Institute of Production Engineering at the Tampere University of Technology founded a cooperation unit, called "Laser Application Laboratory - LAL", in the spring 2000 to develop laser-based surface treatment processes for large-area industrial applications spanning from studies of various materials and coatings to automated production systems. During the past five years LAL has been in cooperation with more than 100 companies.

## Equipment

LAL has planned and equipped with modern lasers and ancillary equipment for surface treatment processes. The layout of LAL is as flexible as possible.

### Lasers

- Haas HL4006D, 4 kW Nd:YAG-laser
- Rofin-Sinar DL060H2, 6 kW diodelaser

### Robots

- Fanuc S700 RJ, 6 axis robot with 5 m linear track
- KUKA 125/2, 6 axis robot and 2 axis rotating table

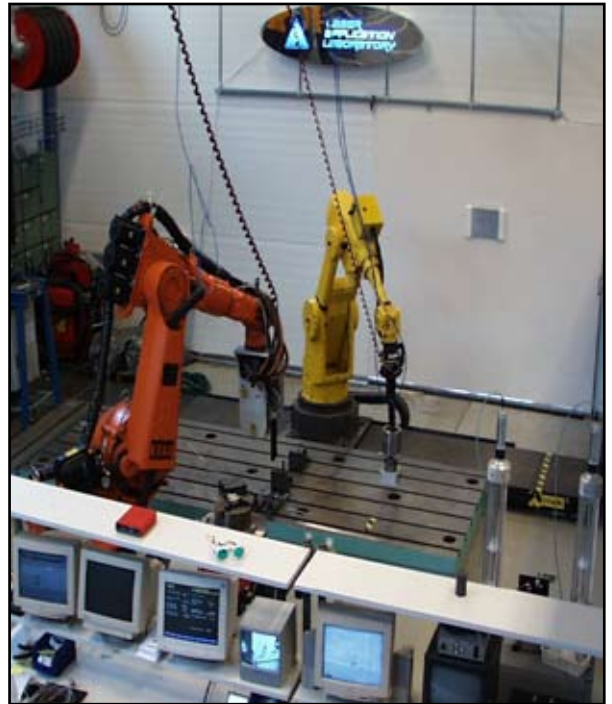
### Ancillary equipment

- Primes FBM, beam analyser
- Coherent, laser power meter

## Processes

### Cladding

Laser cladding can be implemented in a one-step or two-step process. The one-step laser deposition technique consists of injecting powder into a laser beam where the powder is heated or melted and subsequently deposited onto the substrate. Simultaneously, a very thin layer of the substrate material is melted, which ensures good metallurgical bonding and minimal dilution between the coating and the substrate. The two-step laser deposition consists of a laser treatment of pre-deposited coating. The pre-deposition can be manufactured by several thin and thick coating techniques. The most frequently used process is one-step laser cladding. One-step laser cladding offers significant benefits over conventional coating methods, such as thermal spraying and arc welding. The major advantages are lower porosity in the deposited layer, excellent fusion bonding and minimal dilution. Despite obvious benefits over conventional methods, laser cladding is not yet wide-spread in industrial applications. High investments cost, low efficiency of the laser sources, high maintenance costs and lack of technology for coating large-substrate areas have all discourages the use of lasers for coating processes. However, due to rapid technological develop-



Overview of Laser Application Laboratory.

ments in high power diode lasers, the coating processes now show very high industrial potential. For example, 6 kW HPDL enables Ni-, Co- and Fe-based laser-clad tracks of 20 mm in width, 3 mm in thickness with a traverse speed of 400 mm/min, and powder feed rate of 120 g/min.

### Hardening

Laser surface hardening was the first industrial laser heat treatment process. Laser surface hardening is based on fast heating and cooling of steel. The laser beam only heats a small target area, while the rest of the target acts as a heat sink. This sequence changes steel's microstructure from perlite to austenite and further to martensite, which increases the hardness.

The biggest advantages of laser hardening are a limited energy distribution and small distortions. Heat effect can be easily adjusted, which makes possible precise hardening patterns in depth and areas. Flexible beam delivery and good thermal control enable hardening of very thin parts, too. Since only strategic surfaces are hardened, time, energy, and finishing time are saved.

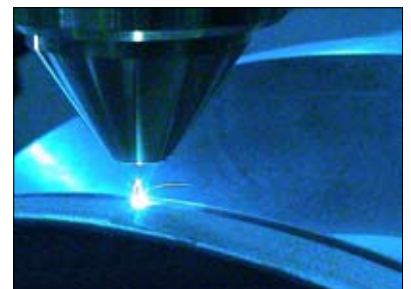
In theory, nearly all laser resonators can be used for laser hardening as long as laser power is adequate. In practise, only CO<sub>2</sub>, Nd-YAG, and HPDL, are used for laser surface hardening. Due to inflexible beam delivery and poor energy coupling, the CO<sub>2</sub> laser is not the most efficient choice. Good absorption to steel materials, flexible beam delivery, and manipulation make the Nd-YAG and HPDL lasers the best selection for laser surface hardening.



HL4006D.



DL060H2.



Cladding with Nd:YAG Cladding with Nd:YAG.

## Projects

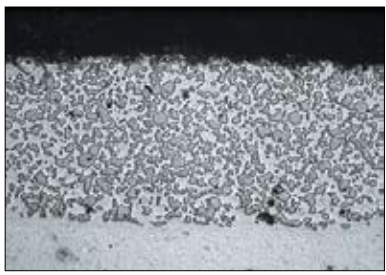
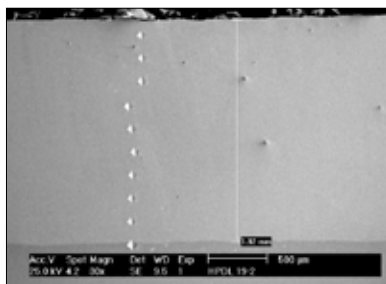
The biggest ongoing projects of Laser Application Laboratory are

- HERCULES (High-Efficiency Engine R&D on Combustion with Ultra-Low Emissions for Ships), is a large-scale cooperative R&D project supported by the European Commission and the Swiss Federal Government (BBW & BFE). HERCULES will develop new technologies to drastically reduce gaseous and particulate emissions from marine engines and concurrently increase engine efficiency and reliability, hence reducing specific fuel consumption, CO<sub>2</sub> emissions and engine lifecycle costs.

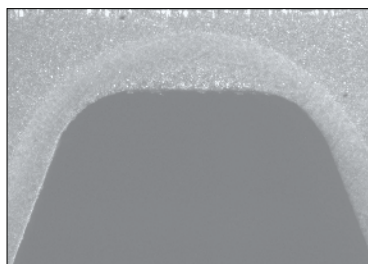
- LasPinPro is a research project funded by National Technology Agency of Finland TEKES. In addition of Tampere University of Technology (TUT) and LaserCo, the participants of the project include several Finnish industry partners. Time span of the project is 2003-2005. The objective of the project is to increase the utilisation of high-quality laser claddings in Finnish industry. High power diode laser (HPDL) cladding process and new claddings based on new materials will be developed within the project. Furthermore, a laser hybrid spraying method based on a high power laser and thermal spraying will be developed and demonstrated. The approval methods and design instructions for laser claddings will be established to meet the requirements of industrial users. The entire project will be carried out in concurrent projects of LAL and LaserCo.



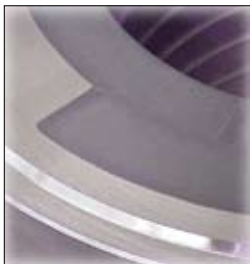
Cladding with diodelaser.



Microstructure of laser coatings (Stellite 6, Stellite 21, Ni-30%Cu, WC/NiCrBSi)



Hardening of cog wheel



Hardening of crosscut end of cylinder

## Laser Application Laboratory - LAL

Tampereen teknillisen yliopiston Tuotantotekniikan laitos ja Materiaaliopin laitos perustivat keväällä 2000 yhteistoimintayksikön laseravusteisen materiaalitekniikan ja valmistustekniikan tutkimiseksi. Yhteistoimintayksikön nimeksi asetettiin Laser Application Laboratory (LAL). Yhdistämällä kahden eri laitoksen voimavarat tietyn tekniikan soveltamisessa on saatu huomattavia etuja. Teollisuutta on voitu palvella aina materiaalien ominaisuuksien tutkimisesta koko tuotantojärjestelmän suunnitteluun ja simulointiin saakka. Viiden toimintavuoden aikana LAL on ollut yhteistyössä yli 100 yrityksen ja yhteisön kanssa.

### Laitteet

Laboratorion laitekanta soveltuu parhaiten laseravusteisiin pintakäsittelymenetelmiin ja projekteista suurin osa onkin ollut tällä alueella. Laboratorio suunniteltiin helposti muunneltavaksi ja se onkin osoittautunut oikeaksi ratkaisuksi.

#### Laserit

- Haas HL4006D, 4 kW Nd:YAG-laser
- Rofin-Sinar DL060H2, 6 kW diodilaser

#### Työasemat

- Fanuc S700 RJ teollisuusrobotti 5 m:n lineaariradalla
- Diodilaserin käsittelyyn KUKA 125/2

#### Mittausvälineet

- Tehomittari
- Sädeanalysointilaitteet PRIMES

### Prosessit

#### Pinnoitus

Laserpinnoituksessa on saavutettu erinomaisia tuloksia sekä uudelleen sulatuksella (pinnoite lisätty esim. HVOF:n avulla) että suoraan jauheesta.

#### Pintakarkaisu

Laserpintakarkaisussa lämmöntuonti pystytään rajaamaan tarkasti. Tällöin vain halutut kohdat karkenevat. Toisaalta suurehkojenkin pinta-alojen (jopa 2 m<sup>2</sup>/h) karkaisu 3D-pinnoille on mahdollista.

#### Hitsaus ja muut laserprosessit

Laboratoriossa voidaan testata myös muita laserprojekteja kuten hitsausta ja leikkausta. LAL:lla on laaja yhteistyöverkko, jonka puitteissa löytyy useita lasereita lähialueen oppilaitoksista.

### Projektit

Suurimmat meneillään olevat projektit:

- HERCULES (High-Efficiency Engine R&D on Combustion with Ultra-Low Emissions for Ships), EU-rahoitteinen projekti uusien laivamoottorien kehittämiseksi
  - LASPINPRO, Laserpinnoituksen uudet teknologiat, pinnoitteet ja niiden teollinen hyödyntäminen, Tekes-rahoitteinen projekti
- LAL:n henkilöstön muodostavat tutkijat materiaaliopin ja tuotantotekniikan laitoksilta. Keskimäärin tutkimushenkilöstön vahvuus on 6 tutkijaa.

#### Yhteystiedot/Contact information

Professor Petri Vuoristo, tel. 03 3115 2287, petri.vuorist@tut.fi

Tech.Lic Jorma Vihinen, Laser Application Laboratory, tel. 03 3115 2616, jorma.vihinen@tut.fi

Veli Kujanpää – Antti Salminen  
– Jorma Vihinen

## Lasertyöstö

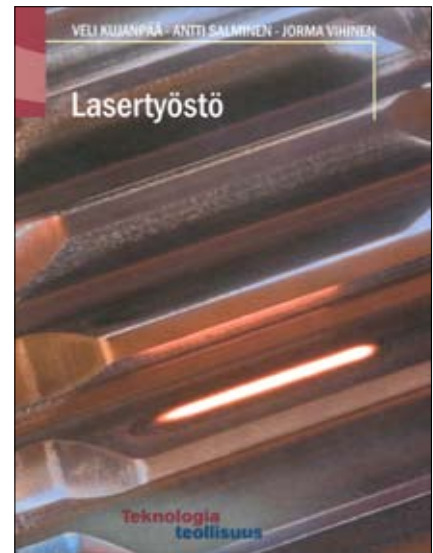
Uusi suomenkielinen oppikirja "Lasertyöstö" julkistettiin tänä syksynä Alihankinta-messuilla Tampereella. Kirjan tarkoituksena on toimia perusteoksena lasertyöstön opetuksessa eri oppiasteilla, mutta samalla palvella lasertyöstöä tuotekehitykseen ja tuotannon kehitykseen käyttävän työkaluna. Kirjan ovat laatineet laserteknologian huippuasiantuntijat Lappeenrannan ja Tampereen teknillisistä yliopistoista. Tekijöiden työt on tukenut yritysten edustajien ryhmä, joka on huolehtinut siitä, että kirjasta on hyötyä myös käytännön työhön.

Kilpailu pakottaa yritykset yhä parempaan tuottavuuteen. Isot muutokset tuottavuudessa saadaan aikaan vain muuttamalla valmistusmenetelmiä radikaalisti tai tuottamalla uudenlaisia konstruktioita. Lasertyöstö on yksi nopeimmin kehittyvistä tekniikan aloista ja tarjoaa merkittäviä ratkaisuja tuottavuuden kehitystarpeisiin.

Lasertyöstö on yksi nopeimmin kehittyvistä tekniikan aloista. Vaikka ensimmäiset sovellukset lasertyöstöstä ovat 1970-luvulta, sen nopea invaasio konepajoihin alkoi toden teolla vasta 90-luvun puolivälissä ja jatkuu edelleen. Uusien, monipuolisten lasertyyppien (suuritehoinen Nd:YAG-laser, DC-laser, diodilaser ja nyttemmin kuitulaser) ja muiden uusien innovaatioiden (yhä lyhyemmät pulssin pituudet, skanneritekniikat, jne.) tuleminen kaupallisille markkinoille ovat edelleen kiihdyttäneet lasertyöstön merkityksen kasvua. Tämän hetken ennuste on, että vuoteen 2010 mennessä lasertyöstön markkinat yli kaksinkertaistu-

vat ja erityisen suurta kasvu tulee olemaan lasermikrotyöstössä.

Tähän saakka lasertyöstöstä on suomen kielellä julkaistu vain hyvin vähän materiaalia, mutta kokonaisuutta käsittelevä yleisteos on puuttunut. Teknologiateollisuus julkaisi 1997 ja 1998 jo loppuunmyytyt tiedotteet CO<sub>2</sub>-laser- ja Nd:YAG-laserhitsauksen käytöstä konepajateollisuudessa. Aiemmin oli ilmestynyt myös tiedote pulssi-Nd:YAG laserin käytöstä hienotyöstöön. Näiden tiedotteiden julkaisemisen jälkeen on tapahtunut paljon kehitystä. Laserhitsaus on muuttunut ja monipuolistunut huomattakseen aivan uusista sovellusalueista. Ko. tiedotteet eivät myöskään sisältäneet monia lasertyöstön tärkeitä alueita, kuten laserpintakäsittelymenetelmiä, lasermerkkausta tai pikamallinnusta. Tämän kirjan tarkoituksena on toimia perusteoksena lasertyöstön opetuksessa eri oppiasteilla, mutta samalla palvella lasertyöstöä tuotekehitykseen ja tuotannon kehitykseen käyttävän työkaluna. Kirjassa on pyritty käytännön läheiseen käsittelytapaan ja välttämään kovin syvä-



lisiä teoreettisia tarkasteluja. Prosessien kuvauksia on myös elävöitetty lukuisilla käytännön esimerkeillä. Terminologiassa on yritetty löytää suomenkieliset vastineet hyvin monivivahteiselle käytössä olevalle englantivoitteiselle lähes slangisanastolle, muuttamatta kuitenkaan jo vakiintuneita, ehkä monien kieli-ihmisten kavahtamia väännöksiä englannin kielestä.

### Laser machining

A new Finnish text book "Laser Machining" ("Lasertyöstö") was published at Alihankintamessut this autumn. The purpose of this book is to function as a basic text book on laser machining on different educational levels. The book can also serve crucial information for production engineers, when they are looking for new solutions for different development needs. Descriptions of processes have been enlivened with

numerous practical examples.

Continuous competition forces companies to increase their productivity all the time. The big improvements in the productivity are achieved only by changing manufacturing methods radically or by producing new constructions. The laser machining is one of the quickest developing technique which offers significant solutions to the needs for development of the productivity.



## EV Group

Heptagon invests in nanoimprint lithography production equipment

EV Group (EVG, Austria) has installed an EVG640NIL precision alignment system tooled for nanoimprint lithography at Heptagon, Finnish-Swiss specialist of replicated refractive and diffractive micro-optical elements and subsystems. The EVG640NIL tool has been installed at Heptagon's new clean room at the production site in Rüslikon, near Zurich in Switzerland. The EV Group equipment will be used for the fabrication and replication of micro optic devices. Nanoimprint Lithography (NIL) is a next-generation lithography method that utilizes a low-cost, high-resolution and large-area patterning process.

<http://www.evgroup.com/>;  
<http://NILCom.org/>  
[www.heptagon.fi](http://www.heptagon.fi)

EV Group to supply NIL Fab, Inc. with High-throughput NanoImprint Lithography System for Prototyping and Low-Volume Production

October 20th, 2005 - EV Group, which has the world's largest installed base of nanoimprint lithography (NIL) equipment, announced the sale of an EVG570 High Volume Hot Embossing System to NIL Fab, Inc., today.

NIL Fab, inc. is the world's first NIL contract manufacturer that opens a new world of prototyping roadmap compliant, low cost analytical devices and other consumer related products.

NIL Fab's Phase 1 facility will offer prototyping services and low volume production for biosensors, Lab-on-a-chip, optics and photonics, magnetic storage, OLEDs and other applications that make use of low cost NIL processes and materials.

About NIL Fab

NIL Fab Inc. is a leading edge center for prototyping and fabricating next generation devices. It is being established by the Canadian NanoBusiness Alliance in partnership with the National Research Council of Canada. NIL Fab's Phase 1 operation is being set up at the National Research Council's Industrial Materials Institute (NRC-IMI) near Montreal adjacent to NRC-IMI's existing NanoImprint Lithography Research Lab.

Contact:

Neil Gordon  
President, NIL Fab, Inc.  
[Neil.Gordon@NILFab.com](mailto:Neil.Gordon@NILFab.com)

Contact:

Helge Luesebrink  
EV Group  
[H.Luesebrink@EVGroup.com](mailto:H.Luesebrink@EVGroup.com)

# Greetings from Palm Springs, CA

Mika Aho, Modulight reports



Palm Springs, CA, USA

Compound Semiconductor Week is a key event for the compound semiconductor industry. Compound Semiconductor Manufacturing Expo (CS-MAX) – one of the three parallel conferences – provided a perfect forum for people involved in the manufacturing of compound semiconductor devices, from engineers to FAB managers. This year the event was held in Palm Springs, CA, USA from the 30th of October to the 2nd of November.

CS-MAX's plenary sessions featured keynote talks from leading industry players, such as Anadigics, Emcore, Kopin, OIDA, Rohm&Haas, Unaxis solutions, and Yole Development. Mr. Mika Aho of Modulight chaired the Special optoelectronics plenary papers session, with interesting presentation of: Dr. Rick Clayton, consultant - speaking about III-V optoelectronic integration issues and the MIT Communications Technology Roadmap (CRT), Dr. Michael Lebby of OIDA who shared his organization's roadmap for the founding Indium Phosphate (InP) industry, and Dr. James O'Gorman of Eblana who spoke about planar photon bandgap lasers – a new technology for the 21st century optics.

OIDA's executive director, Dr. Michael Lebby, suggested in its roadmap a common foundry solution for epi-growth and fabrication – just like the silicon industry did 20 years ago. The new business model would require a move toward multi-source agreements (MSAs) or standards that would en-

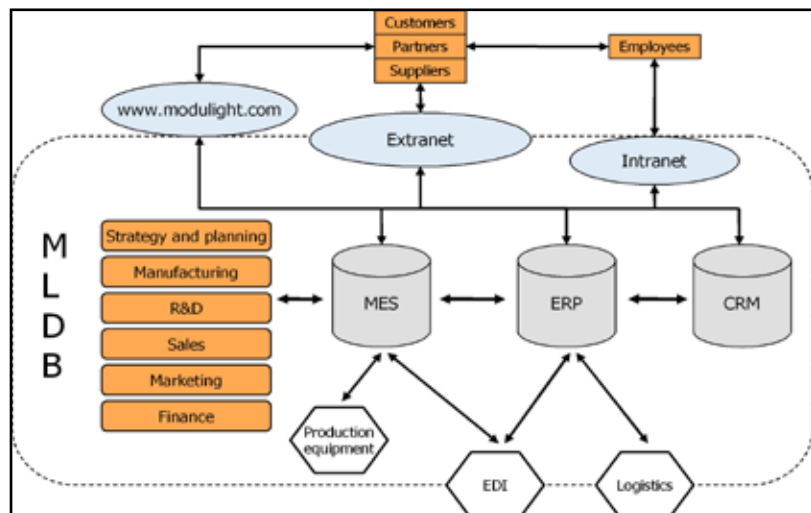
able a simpler manufacturing process. According to Dr. Lebby, there won't be real, proper commitment until around 2009. In 2009, the customer base will be more flexible because there will be fewer suppliers to choose from. Once there are fewer suppliers, the customer has to go with the market price and have to accept MSA specifications. Finally, this will reduce the complexity of devices and difficulties when establishing a foundry.

Modulight's paper and presentation discussed a novel, holistic database system that stores all product, product development and production data in a relational

database, and its integration to commercial ERP and CRM applications. The benefits of the system integration are clear for each employee from shop floor to top management in terms of money, time and risks. As traditional manufacturing execution systems lacks of business critical data, such as cost, pricing and availability information in readable format, our system is what finally links production, finance, marketing, sales and strategy processes together. Having this embedded in the system provides large cost savings, more agile customer service and improved profits. Finally, everything translates into a capability of making rapid and controlled change management.



Mika Aho  
mika.aho@modulight.com  
www.modulight.com



Modulight's database centered IT-system

## Photodetectors line up for 40G transmission systems

Scientists at the University of Texas in the US have fabricated photodetectors designed for 40 Gbit/s optical-transmission systems. The use of multimode-waveguide structures enabled the devices to achieve high responsivity and high bandwidth simultaneously. See <http://fibers.org/articles/news/7/10/5/1>

## Optoelectronic chips give hope to all-optical memory

Electronic control over the speed of light is demonstrated in three types of optoelectronic chip. See <http://fibers.org/articles/news/7/10/11/1>

## Spray drying makes better YAG

A low-temperature process for synthesizing YAG could benefit manufacturers of solid-state lasers. See <http://optics.org/articles/news/11/10/13?alert=1>

## Visible silicon laser makes its debut

Red emission is reported from a silicon laser doped with Europium ions. See <http://optics.org/articles/news/11/10/11?alert=1>

## Photonic crystal fiber

Researchers at US firm Aculight have developed a microchip-laser seeded photonic crystal fiber (PCF) amplifier that generates diffraction-limited 0.45 ns duration pulses with a peak power of 1.1 MW. Based on a large-core, Yb-doped PCF, the amplifier is also said to have a peak spectral brightness of greater than 10<sup>10</sup> solkW/(cm<sup>2</sup>sr Hz). (Optics Letters 30 2694)

## VCSELS

Placing different sized current-confinement apertures at different locations in a VCSEL's DBR mirrors allows the source to emit high-powers single-mode, according to scientists from Arizona State University, US. Led by Yong-Hang Zhang, the team says it has fabricated a VCSEL that operates at room temperature, emits 7.5 mW continuous wave and has a side mode suppression ratio of 20 dB. (Applied Physics Letters 87 161108)

## Laser Sources

Charles Lieber's group at Harvard University, US, has grown gallium nitride (GaN) nanowires that have a lasing threshold power density of 22 kW/cm<sup>2</sup>. "To our knowledge, this is the lowest lasing threshold at room temperature reported for GaN materials," say Lieber and colleagues. "It is also comparable to that of the CdS nanowires used to realize the first single-nanowire electrically-driven laser." (Applied Physics Letters 87 173111)

## Fiber-optics

Scientists in the UK and Australia say that the use of a custom-designed taper can give multi-mode fiber (MMF) devices the performance of single-mode fiber (SMF) components. In a proof of principle experiment, the team from the University of Bath, UK, and the Anglo Australian Observatory and Redfern Optical Components, both of Australia, made a MMF Bragg grating device with the narrow spectral width of an SMF grating. (Optics Letters 30 2545)

## £3 Million grant for research at Cambridge

The University of Cambridge has been awarded a £3 Million grant (app. €4,4 Million) from the Engineering and Physical Sciences Research Council (EPSRC) for research into molecular and polymeric semiconductors. The research project will focus on the chemistry and physics of organic semiconductors. Researchers from the Department of Physics will be

working with colleagues from the Department of Chemistry. The project will have applications in materials, materials processing (using techniques such as ink-jet printing), and investigation of semiconductor optical and electronic properties. (Euro NanoTech News, 1st of November)

## NODE launched in Sweden

The first annual Symposium on nanowires, which took place in October in Akademiska Freningen of Lund University (Sweden), acted as a kick-off event of the EU-funded Integrated Project NODE (Nanowire-based One-Dimensional Electronics). NODE focuses on a bottom-up approach to fabrication and integration of nanoelectronic devices, based on self-assembling semiconductor nanowires. The primary target of NODE is to deliver replacement and add-on technologies to silicon CMOS, such as FET devices for logics and III-V bipolar transistors for RF applications. (Euro NanoTech News, 1st of November)

## Germany: FAL joins Nanoimprint project

The German Federal Agricultural Research Centre (FAL) has become a partner in the European NANOIMPRINT project (€3 million, 2005/2008). The project is focusing on the development of innovative materials into which nanometer-scale imprints of interesting target molecules are made using new methods. These imprints help identify the molecules specifically and bind them. Apart from for binding pollutants such as pesticides, the method seems to be particularly useful for the generation of resources with biotechnological processes for the conversion of regenerative raw materials. (Euro NanoTech News, 1st of November)

## Heidelberg Instruments installs a DWL66 system at Centre Spatial de Liege

Heidelberg Instruments (Heidelberg, Germany) has installed a DWL66 maskless lithography system at Centre Spatial de Liege (CSL, Liege, Belgium). The DWL66 system is a high resolution direct write pattern generator for low volume mask making and direct writing, with a resolution down to 20 nm. It will be used for fabricating masks for a Laser-LIGA process operated in partnership with Technifutur, the Belgium technical learning centers. (Euro NanoTech News, 1st of November)

## Silicon chip puts the brakes on light

Scientists at IBM have built a silicon chip that uses the combination of built in miniature heaters and photonic crystal technology to control the speed of light pulses. The silicon waveguide circuit, reported in Nature (438 65), operates in the popular telecoms window of 1.5 μm and reduced the group velocity of light by a factor of up to 300. See <http://fibers.org/articles/news/7/11/4/1>

## Coherent has acquired privately-held US firm Iolon

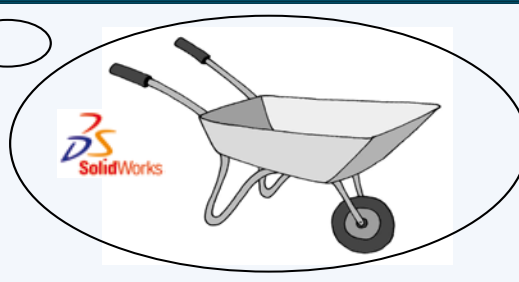
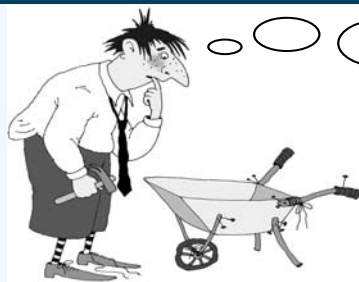
for \$5 million in cash. Based in San Jose, California, Iolon produces widely tunable lasers and other components such as tunable filters and receivers for optical networks. Coherent plans to use this technology in products for the instrumentation and display markets and says it will transfer Iolon's physical assets to its facility in Santa Clara, California. <http://optics.org/articles/news/11/11/5?alert=1>

## IPG Laser of Germany has installed a 20 kW system

at the German Federal Institute for Materials Research and Testing (BAM) in Berlin. The ytterbium, water-cooled YLR-20000 laser emits at 1070 nm and delivers the 20 kW output through a flexible 200-micron core fiber. The system will be used for materials processing research on alloys and steel. <http://optics.org/articles/news/11/11/5?alert=1>

Wahl optoparts, a subsidiary of Jenoptik, has opened a new site

## Haaveista totta?



Kokonaisratkaisut suunnittelutyöhösi osoitteessa [www.cadon.fi](http://www.cadon.fi)

## Success in nanoscience continues at TUT

TUT was successful in receiving two post-graduate positions out of 14 available from the "Nanoscience Graduate School" of the Academy of Finland, recently founded and coordinated by the University of Jyväskylä. The recipients were Antti Härkönen at ORC and Kimmo Kaunisto at the Dept. of Chemistry.

## Nokia Foundation awards research on optical fibre telecommunications

Matei Rusu, a post-graduate student at ORC, receives € 5,000 from the Nokia Foundation for his innovative research on a high bit-rate fibre laser. The work concentrates on generating optical pulses shorter than 1 picosecond at the main telecom wavelength of 1550 nm. Rusu employs a gain-switched diode laser to act as an optical clock for a passively mode-locked fibre laser. Once in operation, the system is believed to be a novel cost-effective light source, which would enable data-rates of up to 1 terabit/s by means of optical time-domain multiplexing of several channels.

in Mühlhausen,

Germany, for making injection molded plastic optical components. Using assets acquired from Kodak's optical imaging systems unit, Wahl expects annual production at the site to rise to more than 5 million units over the next few years. <http://optics.org/articles/news/11/11/5?alert=1>

The University of Southampton, UK, has pledged to rebuild the research facilities that were destroyed by a fire on October 30. The fire affected the Mountbatten building, which housed fiber-drawing towers, a microelectronics fabrication facility run by spin-off firm Innos and research labs belonging to the Optoelectronics Research Centre. The cost of replacing the building and the specialist equipment is estimated to be £50 million (\$88.2 million). <http://optics.org/articles/news/11/11/5?alert=1>

## QPC's New Fiber Coupled Single Emitters featuring Brightlase™ Technology

Quintessence Photonics Corporation, a world leader in the design and manufacture of high brightness, high power semiconductor lasers, recently introduced the new BrightLase™ fiber coupled single emitter semiconductor laser. The hermetically sealed 8 pin package is ideal for integration into high volume OEM applications. Manufactured with the Quintessence's BrightLase™ semiconductor technology, these fiber coupled single emitters lead the industry in brightness, power, and reliability across a wavelength range from 780nm to 1000nm. <http://optics.org/press/10350>

## Quantum Cascade Lasers: Test Them Now!

LASER COMPONENTS now offers diode laser heads in the mid infrared for testing at a flat fee for a maximum of 4 weeks. QUANTA-OEM is the size of a cell phone and is factory-preset. In other words: Connect to the power supply and start measuring! Multi Mode QCL at 4.7, 5.5, 9.6 and 10.9 um and Single Mode DFB-QCL at 9.5, 11.3, 12.4 and 12.6 um are currently in stock. These offers are valid through 12/31/05. Test fees will apply in full to purchases within 6 months. <http://optics.org/press/10589>

## Showa Denko plans GaN LED capacity ramp

Japanese chemicals giant Showa Denko makes a significant move into the LED business with plans to ramp production of GaN-based chips emitting in the green and near-ultraviolet.

See <http://compoundsemiconductor.net/articles/news/9/11/4?alert=1> Balance sheet displays Bookham's cash boost Thanks to lower operating expenses, tax breaks and a public offering of stock, InP chipmaker Bookham is improving its cash position markedly.

See <http://compoundsemiconductor.net/articles/news/9/11/1?alert=1>

Novalux, a US developer of extended cavity surface emitting

lasers called NECSELS, says it has delivered high-power blue sources

to its partners in the display market. Emitting over 500 mW at 460 nm, the blue NECSEL has been designed for microdisplay-based devices such as rear-projection televisions. Novalux says it is now working on other colors and plans to show the first laser-based rear-projection television at the CES show in Las Vegas in January 2006. <http://optics.org/articles/news/11/11/10?alert=1>

Jenoptik Laserdiode of Germany and Kantum Electronics of Japan have founded a joint venture called Jenoptik Laserdiode Japan Co Ltd

which will have its headquarters in Tokyo. The German firm will hold a 33% stake in the venture with the rest being owned by Kantum. The joint venture will sell high-power diode lasers into the Japanese market. <http://optics.org/articles/news/11/11/10?alert=1>

Kopin, the US microdisplay maker, has received a \$750,000 from the US Department of Defense

The contract covers the development of a display driver for Kopin's full-color CyberDisplay SXGA active-matrix LCD, which is being adopted by the US military. <http://optics.org/articles/news/11/11/10?alert=1>

nLight of the US has named Lastek Group as its exclusive distributor in Australia and New Zealand

Lastek will be responsible for the sale and service of all of nLight's CW and quasi-CW high-power visible and near-infrared diode laser product lines. <http://optics.org/articles/news/11/11/10?alert=1>

Consumer electronic giant Philips is merging its mobile display system business unit with Taiwanese firm Toppoly

to create a joint venture called TPO. Toppoly has production facilities in Taiwan and China for advanced mobile display technologies such as low-temperature polysilicon and active-matrix OLEDs. Philips will contribute a substantial intellectual portfolio to the venture. <http://optics.org/articles/news/11/11/10?alert=1>

KOHERAS INDUSTRIK™ – FIRST High Power Laser based upon Photonic Crystal Fiber

KOHERAS INDUSTRIK™ HPM15 is the first high power (15W) CW laser based upon Ytterbium doped double-clad Photonic Crystal Fiber (PCF). Due to the unmatched characteristic of the PCF this fiber laser module features a unique combination of highly stable output power, excellent beam quality with diffraction limited output and a relatively narrow spectral width. <http://optics.org/press/10699>

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00511 Helsinki Fax 09-774 55330 Email [vacserv@clinet.fi](mailto:vacserv@clinet.fi)

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- Vacuum Technology
- Flow Measurement & Control
- Pressure Measurement & Control
- Gas Analysis
- Wafer Metrology
- Leak Detection

# Upcoming Conferences

- 7th Electronics Packaging Technology Conference (EPTC), December 07-09 Singapore
- Microelectronics, MEMS, and Nanotechnology, 11 - 14 December 2005, Brisbane, Australia
- Photonics West, 21 - 26 January 2006, San Jose, USA
- OFC'06 Conference and Exposition, March 5-10, 2006 Anaheim, USA, [www.ofcfoec.org](http://www.ofcfoec.org)
- ILSC 2007, The 2007 International Laser Safety Conference (ILSC), March 19 - 22, 2007, San Francisco, CA USA, <http://www.laserinstitute.org/conferences/ilsc/>
- PICALO 2006, 2nd Pacific International Conference on Applications of Lasers and Optics, 3-5 April 2006, Melbourne, Australia, <http://www.laserinstitute.org/conferences/picalo/>
- SPIE Europe International Symposium Photonics Europe, 3 - 7 April 2006 Strasbourg, France, <http://www.spie.org/conferences/calls/06/epe/>
- SPIE Defense and Security Symposium, 17 - 21 April 2006 Orlando (Kissimmee), Florida, USA
- AKL'06, Aachener Kolloquium für Lasertechnik, 3 - 5 May 2006, Eurogress Aachen, Germany <http://www.ilt.fraunhofer.de/ger/100547.html>
- SPIE International Symposium High-Power Laser Ablation, 7 - 11 May 2006, Taos, USA
- IPRM 2006 (Indium Phosphide & Related Materials), 7 - 11 May 2006 Princeton, USA, <http://www.ieee.org/organizations/society/leos/LEOSCONF/IPRM2006/index.html>
- Nanotechnology in Northern Europe, 16-18 May 2006 Helsinki Finland, [www.nano.fi](http://www.nano.fi)
- LAMP 2006, 4th International Congress on Laser Advanced Materials Processing, 16-19 May 2006, Kyoto, Japan, <http://www.jlps.gr.jp/lamp/lamp2006/>
- CLEO/QELS, 21-26 May 2006 Long Beach, USA, [www.cleoconference.org](http://www.cleoconference.org)
- IEEE-NANO 2006, 17-20 July 2006 Cincinnati, USA
- ICPS 2006, 28th International Conference on the Physics of Semiconductors, 23-28 July, Vienna, Austria, <http://www.icps2006.at/>
- ICSNN 2006 (The International Conference on Superlattices, Nano-Structures and Nano-Devices), July 30 - Aug 4, 2006 Istanbul, [www.essex.ac.uk/ese/icsnn2006](http://www.essex.ac.uk/ese/icsnn2006)
- CIRP 2006, 56th General Assembly of International Institution for Production Engineering Research, 20-26 August 2006, Kobe, Japan, <http://www.cirp.net/secretariat/forminfo.html>
- ISLC 2006, 20th IEEE International Semiconductor Laser Conference, 17-21 September 2006, Waikoloa Beach, Hawaii, <http://www.ieee.org/organizations/society/leos/LEOSCONF/ISLC2006/islc06.htm>
- IEEE LEOS'06, 29 October - 2 November 2006, Montreal, Quebec-Canada, <http://www.ieee.org/organizations/society/leos/LEOSCONF/LEOS2006/index.html>
- ICALEO 2006, 30 October - 2 November 2006, Scottsdale, Arizona USA, <http://www.icaleo.org>
- NanoKAP 2006 - The 5th International Conference "Nanoimprint Lithography Application in Nanosystems and Nanodevices", December 4 - 5, 2006 Miami Beach, USA, [www.knowledgefoundation.com](http://www.knowledgefoundation.com)



## Laser Competence Centre Finland

covers the whole development chain, which includes the technology-oriented basic research, end users' application development, system integration, and testing of lasers.

The wide know-how of the units of the Tampere University of Technology in the separate areas of the laser technology forms the foundation of the operation of the centre. The objective is to adapt laser technologies to the needs of the industry.