LASER SCIENCE
Bringing Tomorrow's Technology Today

Tomorrow Today

- A Laser Science Newsletter

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LASER SCIENCE SERVICES (I) PVT. LTD.

Inside this issue:

Bringing Tomorrow's Technology to Indian Labs

In the last few months, Laser Science Services India Pvt. Ltd has installed a number of new and first-time systems across various labs in India. The most recent of these is the **ezHEMS from NanoMagnetics Instruments, UK** which was successfully installed at IIT Kharagpur on April 17, 2015.

ezHEMS at IIT Kharagpur

The company has recently installed the first ever **Laser Lift-Off (LLO) system in India, from Optec s.a, Belgium, based on the eximer laser from Coherent, Inc.** This system was placed at CEERI, Pilani.

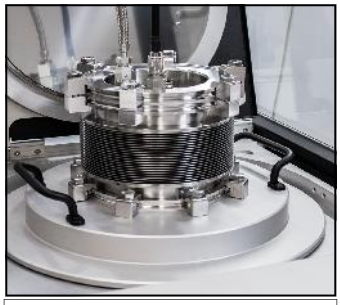
The first ever industrial micromachining system in India, the **Micromaster, from Optec s.a, Belgium, with CompexPro excimer laser of coherent, Inc,** was also installed by Laser Science at CMTI, Bangalore. This system will be used to develop many new, cutting edge applications for industries and scientific laboratories.


MicroMaster at CMTI Bangalore

The company also installed **Coherent Inc.'s Chameleon Ultra II laser**, with wavelengths ranging from 680nm to 1080nm and an output power >3.5 W with Zeiss microscope system, at IIT Kanpur & ACTREC Mumbai.

Other unique systems installed by Laser Science, in the first quarter of 2015 include **LT-AFM from NanoMagnetics Instruments,** which was installed at CGCRI, Kolkata; the **Tunable Diode laser from Sacher Lasertecnik, Germany,** installed at IPR, Ahmedabad, and the **4.6 micron Tunable Laser System from Daylight Solutions, USA,** installed at IIT, Gandhinagar.

Beneq unveils the complete range of upgrades and options for its TFS 200 Thin Film Systems for ALD


TFS 200 Premium with Plasma Option PO-200-LT

To give researchers new opportunities for exploration in Atomic Layer Deposition (ALD), Beneq has now unveiled a broad range of upgrades and options for its TFS 200 thin film system. Each of the options allows users to better match current research needs and stay at the forefront of ALD research.

Beneq's upgrades and options expand the capabilities of existing ALD tools by adding some of the most advanced features of the ALD process itself. The company's flexible and modular solutions are based on the world's best ALD know-how. The selection primarily enables researchers to get a quick alteration to their existing system configuration, create an application-specific configuration or upgrade stepwise.

Four of the top upgrades now provide the following research benefits:

- Plasma-Enhanced ALD
- Wide selection of reaction chambers
- Wide selection of source lines
- Substrate loaders

Daylight Solutions Achieves Over 1 Million Hours of Quantum Cascade Laser Operation

Daylight Solutions, Inc. recently announced that the company has reached two major milestones as part of its ongoing reliability characterization and growth program for quantum cascade laser (QCL) technology.

Over 1 million hours of QCL device operation, and over 250,000 hours of fully packaged QCL module operation have been accumulated as part of this program. All units under test were sampled from high-yield, commercial production. The units maintained optical power levels above specifications throughout the test, and continue to operate without failure.

Hong Kong University of Science and Technology demonstrated 10.8 % efficiency with 10 different mixtures

In a paper published in Nature Communications, a research team from Hong Kong University of Science and Technology led by He Yan and researchers from North Carolina State University demonstrated that temperature-controlled aggregation in a family of new semi-conducting polymers is the key to creating highly efficient organic solar cells that can be mass produced more cheaply. They also showed that record efficiencies of up to 10.8% - compared to the currently published 9.8% - are achievable with the substitution of numerous fullerenes.

Excimer Lasers for Machining Optical Components

In recent years, excimer laser mask projection techniques have been demonstrated to be suitable for the fabrication of highly smooth optical structures. This technique results in much smoother surfaces than those that can be realized using techniques such as focal point scanning with a picosecond laser. The typical set up for excimer laser assisted machining is shown in **Figure 1**.

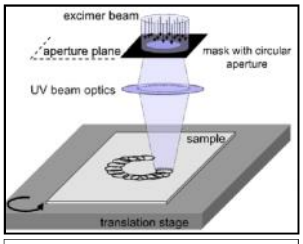


Figure 1

Several types of common polymers such as PMMA, can be machined efficiently and with a high degree of smoothness via photoablative decomposition using a 193nm(ArF) excimer laser while polycarbonate can be machined with similar results using a 248nm (KrF) laser beam. An example of a fiber coupling lens with a radius of curvature of 400 microns, machined into PMMA using this technique is shown in **Figure 2**. Another example is the fabrication of extraction mirrors for optical waveguides which can be done by using a dynamic mask that starts as a small vertical slit, gradually opening to the left in a programmed manner such that each part of the ramp accumulates the desired number of shots. Additionally, the same technique can be extended to small arrays of features machined in parallel by using a mask with an array of defining apertures.

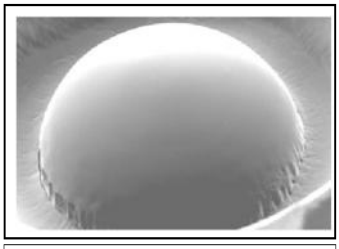


Figure 2

Arrays of features can also be patterned using synchronized image scanning, wherein the motifs in the set are on the same mask plate, and at constant pitch. A large laser beam is used to illuminate one or more lines containing the complete set of motifs, and the virgin part is translated at constant speed with pulse synchronized output firing of the laser ensuring that the images of successive motifs in the set fall on top on each other. In this way an indefinitely long line of finished motifs is produced in a single operation. Alternatively, this can be done via a technique called orthogonal grooving, wherein a linear array of simple motifs is used in combination with part motion to generate a 1D array of identical grooves.

In addition to the polymers mentioned previously, materials such as Si, Ge and ZnSe can also be machined using a 193 nm or 248 nm excimer laser. An example of a 'moth's eye' absorbing structure having a 6 micron pitch, machined in ZnSe using orthogonal grooving is shown in **Figure 3.** In summary, the use of excimer lasers for machining optical components is a highly effective technique for patterning individual features or small arrays into polymers and semiconductors alike, and can be extended to large area arrays when used in conjunction with an air bearing stage.

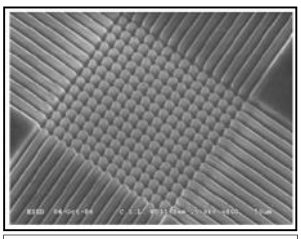


Figure 3

Research Article: Self-Powered Ion Sensors Based on Efficient Photovoltaic Conversion

Autonomous sensing of metal ions and biological species in remote environments with high reproducibility and sensitivity has the potential to enable many new applications. However, the large power draw of such devices typically limits their operational lifetime. Prior sensor demonstrations have attempted to alleviate this by incorporating a solar cell based power source as an additional component. However, this makes the assembly bulky and unsuitable for limited-space applications. Agrawal et. al demonstrate a sensing scheme in which the presence of ionic analytes disrupts the flow of electrical current between two electrodes, with the electromotive force provided by absorbed ambient light, thus eliminating the need for an external power source.

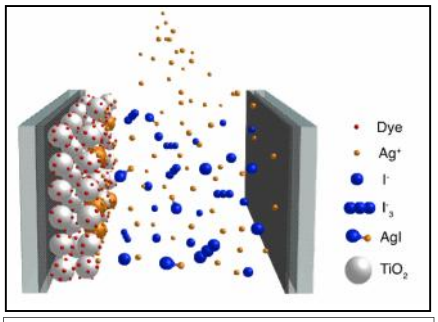


Figure 1: Schematic of a dye sensitized solar cell based silver ion sensor

This concept is implemented using the classical dye-sensitized solar cell (DSSC) structure consisting of a ruthenium based sensitizing dye (N3) and the iodide/triiodide redox shuttle. The authors found that the presence of Ag+ ions causes an appreciable change in the device characteristics. Ionic target species can also be generated using an auxiliary release mechanism so as to allow for indirect detection of biological analytes. As a result, this detection approach enables a new class of highly miniature, low cost sensors for continuous, environmental and health monitoring.

A schematic of the dye sensitized photovoltaic cell based sensor is shown in Figure 1. In a typical DSSC, charges are efficiently transported through a liquid electrolyte in the presence of sunlight. Introducing silver ions into the electrolyte of a normally operating DSSC results in the adsorption of these ions on the titania electrode which in turn, causes a shift in the electrical characteristics of the cell as seen in Figure 2.The practical utility of this scheme is manifested in the fact that the power conversion efficiency of the device never drops below 70% of its original value, thus ensuring that sufficient power is generated to modulate the intensity of an external circuit element even when a very high concentration of the analyte is present in the electrolyte.

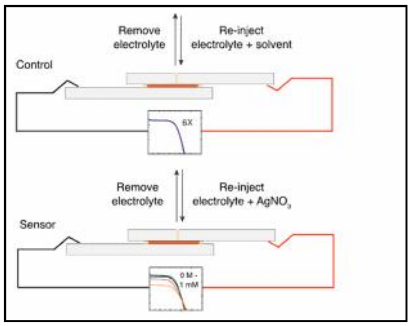


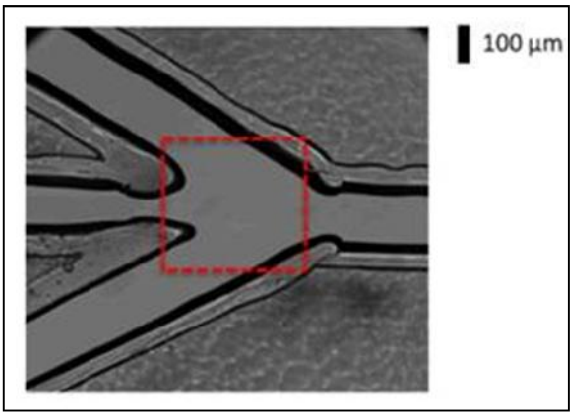
Figure 2: Schematic of the testing protocol for the control and sensor tests performed

In conclusion, this device achieves power generation while also providing the ability to reliably detect small concentrations of charged species in solution. Additionally, this technique is highly versatile and can be applied to the detection of a wide variety of metal ions with high sensitivity and selectivity simply by using different material systems to fabricate the cell. The authors believe that the concept demonstrated in their study represents an important step in realizing autonomous, ultra-compact sensing devices that may be integrated with wearable sensor technology.

Article Courtesy: Kanika L. Agrawal and Max Shtein, "Self-powered ion detectors based on dye-sensitized photovoltaics", Nanoscale 6, 11019 (2014).

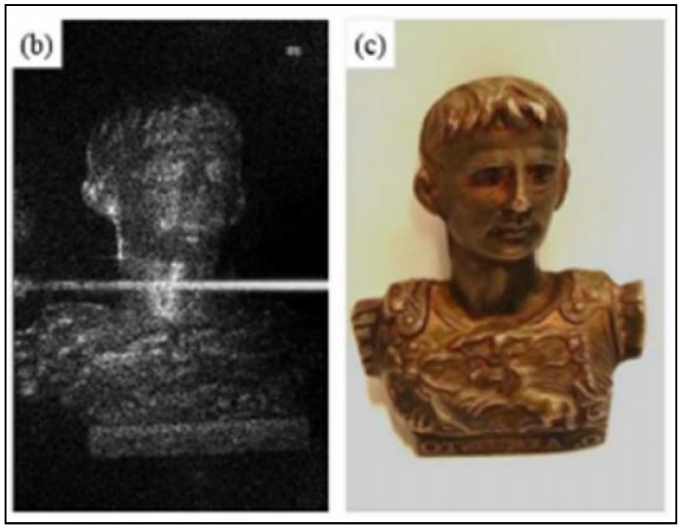
Mid-infrared lasers contribute to cutting-edge applications

Mid-infrared lasers continue to help push boundaries in many cutting-edge applications. One such example is that of intra-operative imaging of tumorous tissue via ATR spectroscopy using Quantum Cascade Lasers. An important goal during surgery is to remove malignant tissue completely, since partial tumor resection results in higher recurrence than full resection. A group from the University of Stuttgart and Siemens Corporate Research Group has demonstrated the feasibility of generating infrared spectra of undried tumorous tissue using single reflection ATR and a **Daylight Solutions' Uber-Tuner quantum cascade laser.** This compact and fast instrument can be used intraoperatively to provide both spatial and spectral information without the use of fluorescence markers to improve tissue resection and the evaluation of transitions between tumorous and non-tumorous tissue during cancer surgery.



Microfluidic mixer utilizing mid-infrared hyperspectral imaging detection

Another promising application is sub-millisecond mixing in a continuous-flow, microfluidic mixer utilizing mid-infrared hyperspectral imaging detection. Microfluidic mixing is a useful tool for studying fast kinetics of biomolecular reactions on the microsecond to millisecond timescale. A group led by Brian Dyer at Emory University has demonstrated such a microfluidic mixer that eliminates the need for fluorescence labeling of proteins because of the intrinsic IR absorbance of the molecules of interest. The study demonstrates the ability to follow a specific chemical reaction, in this case the protonation state of AMP using a **Daylight Solutions' CW tunable laser.** This approach can be widely applicable to other biological reactions such as protein folding and enzymatic reactions.



Mid IR digital holography

Mid-IR digital holography is an appealing tool for on-site nondestructive testing or for rescuing people during fires by visualizing through smoke and flames. Mid-IR digital holography has been demonstrated using CO_2 lasers and has proven to be a powerful coherent imaging technique due to reduced sensitivity to mechanical vibration, increased field of view and possible vision through scattering media such as smoke. Recently, InstitutoNazionale di Ottica-CNR (INO) in Italy, extended this work to using quantum cascade lasers (QCL), specifically the **Daylight Solutions 8 micron tunable laser.** This QCL allows a more compact holographic system and the tunability allows hologram acquisition at different wavelength to extract phase images.

PhaseTech Spectroscopy makes user-friendly, commercial two-dimensional infrared (2D IR) spectroscopy a reality

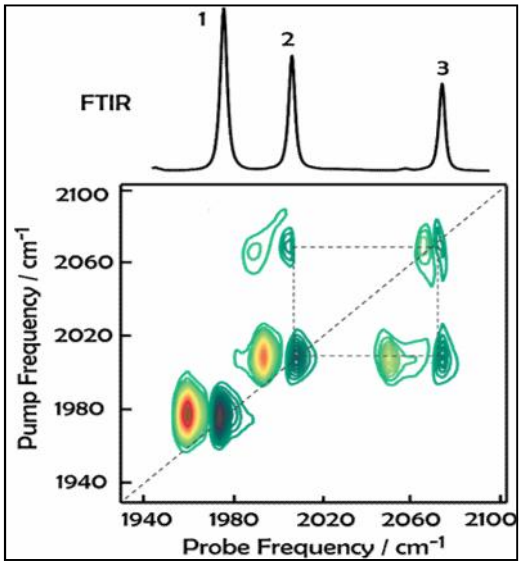


Figure 1: Experimental FT-IR and 2D IR spectra for a mixture of $W(CO)_6$ and a rhodium dicarbonyl (RDC). For each peak in the FT-IR spectrum, the 2D IR spectrum exhibits a pair of diagonal peaks. The cross peaks in the 2D IR spectrum reveal that the two higher frequency peaks are coupled to one another, which is because peaks 2 and 3 are from a rhodium dicarbonyl (RDC) whereas peak 1 is from $W(CO)_6$. $W(CO)_6$ and RDC do not have cross peaks between them because the mixture is too dilute.

Two-dimensional infrared (2D IR) spectroscopy, an extension of Fourier transform infrared (FTIR) spectroscopy, is one of the most exciting advances in the ultrafast sciences in the last 20 years. This technique correlates peaks to molecules in a sample and is gaining popularity in academic research laboratories across the world to study topics in the analytical, materials, chemical and biological sciences. Figure 1 illustrates its application as an analytical tool, which shows an FTIR and a 2D IR spectrum for a solution made from two molecules. This example comes from the research laboratory of Prof. Martin Zanni at the University of Wisconsin-Madison. Three peaks are observed in the FTIR spectrum, but one does not know *a priori* which peaks belong to which molecule. In the 2D IR spectrum, each peak from the FTIR creates a pair of peaks along the diagonal and in addition, also contains information on the connectivity of bonds in a molecule via the cross peaks that appear off of the diagonal. In this solution, cross peaks appear between peaks 2 and 3, indicating that these two modes come from the same molecule. Thus, peak 1 is from one molecule and peaks 2 and 3 from the second solute molecule. Thus, 2D IR spectroscopy provides the necessary connectivity information to unravel mixtures.

2D IR spectroscopy has also been used to study amyloid protein aggregation, dye-sensitized solar cells, the structures and dynamics of liquids, coherent control, and polymer structures. PhaseTech Spectroscopy has licensed a patented technology developed in the Zanni research group that has made user-friendly commercial 2D IR spectroscopy possible by offering spectrometers that are engineered for stability and ease of operation. It is no more complicated than a transient absorption spectrometer, but has much, much more functionality.

Newly Launched Products

Nanomagnetics Instruments , UK Launches ezSTM

The ezSTM is an all new Scanning Tunneling Microscope which features excellent performance while being remarkably affordable.

It's ideal for student laboratories, high schools, nanotechnology educations and basic research with its compact, high stability, user-friendly design.

PCO. AG Germany Launches Revolutionary Scientific CMOS Image Sensor Technology– Pco.edge 3.1 & Pco.edge 4.2LT

PCO, the pioneer in sCMOS technology released two new versions of its pco.edge family: the pco.edge 3.1 and the pco.edge 4.2LT.

The new pco.edge 3.1 provides a resolution of 3.1 MP and a global shutter readout mode. The second, called pco.edge 4.2LT, offers a resolution of 4.2 MP and a quantum efficiency of more than 70%.

Coherent Inc. introduces Chameleon Discovery Dual Wavelength Laser for MPE

Chameleon Discovery is an ultrafast tunable laser with performance that truly redefines possibilities for non-linear imaging. This new dual-wavelength laser from Coherent, Inc., combines the industry's widest tuning range, highest power and shortest pulsewidth to enable cutting edge fluorescence detection techniques in non-linear microscopy. The rugged testing demanded by Coherent's industrial design process ensures high system uptime and low maintenance.

PCO. AG Germany Launches Compact, Ruggedized, High-speed PCO.dimax CS

The new pco.dimax CS camera is specially designed for all applications centered around car safety testing involving onboard, off-board and sled testing. Leading high-speed image and color quality within a new camera body which is high-G resistant and with secure synchronization in multi-camera environments; it provides crisp, brilliant color images in any challenging car safety testing situation.

Litron Lasers Launches the Litron Aurora II Integra

The Aurora II Integra range of type II BBO OPOs has been designed with reliability, stability and ease of use in mind. This allows researchers to concentrate on their experiments, and gives industrial system integrators the peace of mind that their process will be consistent and robust. With a wide choice of integrated and optimized Nd: YAG pump lasers from 10Hz to 200Hz, these are truly flexible systems. The Aurora II Integra has a tuning range from 400 nm to 710 nm and from 710 nm to 2.3 µm, UV harmonic option for 205 nm to 419 nm and linewidth < $4cm^{-1}$.

Fianium Introduces the all New WhiteLase OEM Industrial Supercontinuum Fiber Laser

The WL-SC OEM is the first Supercontinuum laser designed specifically for industrial integration and is suitable for demanding applications including those requiring 24/7 operation. For the first time these unique white-light laser sources are more than laboratory tools and are now a serious alternative to multiple laser sources or traditional lamp-based illumination.