SPIE Eco-Photonics

Energy, Engineering, Education, and the Environment

Technical Summaries

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Contents

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8065-100, Plenary Session I

Energy saving through LED in signaling functions for automotive exterior lighting (Invited Paper) (Plenary)

Alexis G. Bony, Khaled Hamami, Frank Tebbe, Jens Mertens, Daimler AG (Germany)

In this work, taking as an example the new Mercedes-Benz roadster SLK (R172), we present the first single LED day-time-running lamp, with a total power consumption below 5W per vehicle. After reviewing legal requirements, the optical and electronic concepts are discussed, as well as possible future evolutions towards design freedom or power consumption reduction.

Details on the tail lamp LED functions are also discussed, and particularly the advantages from the realization of fog lamp with LEDs.

8065-01, Session 1

Monitoring the energy systems of sustainable buildings

E. Bollin, Univ. of Applied Sciences Offenburg (Germany)

Today energy supply of residential and non-residential buildings become more and more sustainable. So-called Green Buildings use solar thermal systems to provide heat for heating and cooling purposes. Stand-alone or grid connected photovoltaic systems provide power for sustainable power supply. Green Buildings operate heat pumps for heating and cooling or cogeneration systems to provide heat, power and cooling in parallel. To temper the buildings inertia, they make use of natural sources in the buildings ambient like the chill of the night or the ground below the building.

These innovative sustainable technologies require additional investments which need a pay back over the live span of these systems. The pay back results from substitution of fossil energy sources and electric power, which are necessary to run the buildings conventional back-up energy systems. The buildings occupant point of view is to have a high building comfort at low costs: but how to check if this comfort is sustainable.

Monitoring systems assist the building management and progressive occupants to check buildings sustainability in daily operation. Linked to intelligent building automation systems and internet services they provide data to evaluate system operation in short term. By providing benchmarks for solar systems operation the daily energy production can be corrected with reference weather data and correlated to comparable systems. By checking the prognosis for the next days weather, advanced monitoring systems assist the building management to check building energy needs and building energy storages to operate building systems predictively with a maximum of sustainable energy fraction.

This paper will present results of long-term monitoring project on large-scale solar thermal systems and Green Building operation in the frame of the net research group Offenburg.

8065-02, Session 1

Design a linear irregular Fresnel lens to reduce the cost and thickness of an LED-based direct-type backlight module and improve the illuminance and uniformity of LCD plate

W. Chen, Yung-Ta Insitute of Technology and Commerce (Taiwan)

We propose a Linear Irregular Fresnel Lens (denoted as LIFL below) to replace the diffusion sheet and prism sheet in a rectangular LED-based Direct-type Backlight Module. The aim is to improve the illuminance and uniformity of LCD plate, as well as to reduce the cost and thickness of Backlight Module. In our previous works [1-5], we designed small, medium, and large irregular Fresnel lenses to efficiently guide and distribute the light rays of a reading light system with multiple LED sources. Here “irregular” means that groove angles are not gradually increasing or decreasing. In those works, we developed Genetic Algorithms to evolve a set of irregular groove angles to optimize the illuminance and uniformity performances of a reading light system using light rays emitted from all LEDs. The idea of designing irregular groove angles can be applied to develop an LIFL for the rectangular LCD-based Direct-type Backlight Module. The so-called “linear” means the grooves of a Fresnel lens are arranged linearly. To authors’ best of knowledge, an LIFL has not been addressed previously. To let the designed LIFL possess good effects of light ray guiding, we design two-layer linear irregular Fresnel lenses. The first layer of the designed LIFL consists of x-axis grooves, whereas the second layer of the designed LIFL consists of y-axis grooves to guide all light rays guided by the first layer LIFL. In this paper, we will simulate a simple fifteen-LED Direct-type Backlight Module to demonstrate the performances on illuminance and uniformity of our designed LIFL.

8065-03, Session 1

Simulation of silicon thin-film solar cells for oblique incident waves

C. Jandl, K. Hertel, C. Pflaum, Friedrich-Alexander-Univ. Erlangen-Nürnberg (Germany); H. Stiebig, Malibu GmbH & Co. KG (Germany)

To optimize the conversion efficiency of amorphous (a-Si:H) and microcrystalline (µc-Si:H) silicon thin-film solar cells, one has to study absorption and reflection of sunlight in these solar cells. Simulations are an adequate and economic method to analyze the optical properties of light in thin-film solar cells. A suitable simulation tool has to satisfy several requirements. These include simulations of oblique incident light to take into account outdoor conditions. The efficiency of a solar cell for different incident angles is mainly influenced by the wave polarization. Therefore, it is fundamental to study incoming waves with E-, H-, and circular polarizations over the whole solar spectrum. Furthermore, the efficiency of a silicon thin-film solar cell is influenced by the topology of nano-textured interfaces. It is well-known that a rough transparent conductive oxide (TCO) layer increases the efficiency of solar cells. Therefore, it is indispensable that various roughness profiles at the interfaces of the solar cell layers can be modeled in such a way that both atomic force microscope (AFM) scan data and imitated structures can be incorporated. Since available software packages do not satisfy all these requirement, we developed a simulation tool which meets the demands. Numerical calculations of Maxwell’s equations based on the finite integration technique (FIT) are performed in parallel on high performance computers (HPC). The simulations show that the light propagation in thin-film solar cells is based on partial reflection, resonant and plasmon effects, influenced by the structure of the interfaces, and the polarization and incident angle of the incoming light.

8065-04, Session 1

Monitoring applications of power generators for the increase of energy efficiency using novel fiber optical sensors

M. Villnow, M. Willsch, T. Bosselmann, Siemens AG (Germany); B. Schmauss, Friedrich-Alexander-Univ. Erlangen-Nürnberg (Germany)

Due to the increase in energy demand and the concept of sustainable engineering, modernizations of electric power plant installations become more and more important to improve the efficiency of energy and to save costs and materials. However, the operating point of electric machines like generators gets closer to its physical limit. To prevent damages and to verify optimization measures, sensors and monitoring systems are particularly essential. Therefore special fiber-optical sensors have been developed and proposed.

A fiber-optical hot wire anemometer was invented to measure the flow distribution along the cooling ducts of stator core. Based on the thermal effect of Fiber Bragg Gratings the thermal balance of the heated wire and the air flow can be measured and transformed to a flow velocity. Several sensing points could be realized by only one single sensor probe.

A further sensor concept using the strain effect of FBGs is the fiber-optical magnetic field sensor. The sensing part of the fiber is glued to a magnetostrictive metallic glass, which changes its shape while being exposed to a magnetic field. Fifty 2-axes sensors have been mounted to conductive bars of a hydro powered generator to measure the magnetic field distribution at the end windings.

To avoid damages of the insulation due to vibrations, novel fiber optical acceleration sensors were mounted to end winding connectors to monitor vibrations and determine natural resonances. These sensors are based on the light modulation caused by relative motion of optical components. In this paper the functionality of each sensor is described and real life measurement results are shown and discussed.

8065-05, Session 1

Study of spectrum-splitting solar photovoltaic system

L. Chen, Y. Zhao, M. Shen, Y. Zheng, Fudan Univ. (China)

The photoelectrical responsibility of single photo-electronic devices makes it difficult to achieve high efficiency of photoelectric conversion in the full solar spectrum range. The key to overcome the physical limits is to develop the system consisting of a set of solar cells in which the photo-electronic conversion of each cell will match to the sub-spectrum of the solar radiation with high conversion efficiency. In this work, we have used the spectrum splitting method to divide the solar spectrum into four sub-ranges of 400-630nm, 630-800nm, 800-900nm and 900-1800nm, respectively. Four high performance single-junction photo diodes are used, and each of them has high quantum-efficiency of photo-electronic conversion matching to the sub-ranges of solar spectrum. Under the 0.5-6.0 SUN radiation condition, the photo-electrical conversion efficiency of the system with four solar cells has been measured with the result to show that the photo-electric conversion efficiency of 37.7% is achieved under the typical 2.8 SUN radiation condition. The results given in this work will provide a way to show the potencial to realize a high photo-electric conversion efficiency (> 40%) of the solar system in application.

8065-06, Session 2

Current collection from different Si devices based on nanoscale Si-layered systems containing a new metamaterial for photovoltaics

Nanoscale Si-layered systems represent an attractive way to enlarge optical and electrical functions in Si optoelectronic, photonic and PV technology. Physical interactions transform the initial Si material to a new Si-based metamaterial. The device architecture also plays a role in specific nonlinear features. The seemingly paradoxical behavior requires a better insight into understanding the mechanisms determining the macroscopic performance. We report here some specific electrical properties resulting from the complexity of the electron transport in different test structures designed and manufactured by us. One of the most important parameters concerns the features of the state of the device surface. The measurements have been carried out in different conditions including illuminating light (composition of the spectrum, incident intensity, with or without an optical bias), the acquisition mode (duration of controlled acquisition), device polarization mode (photodiode, photovoltaic). Time-resolved current collection made with stabilized voltages, as well as time-resolved voltage variation under stabilized currents, both made under light excitation allowed distinguishing of extremely long time constants. We conclude that the behaviour of test devices is determined by a super capacity of tenths of F appearing at the nanocale.

8065-07, Session 2

Optimising optical efficiency in diamond turned Fresnel mould masters

J. L. Allsop, P. R. Shore, A. Mateboer, Cranfield Univ. (United Kingdom)

Radial and Linear Fresnel Lenses are used extensively in solar concentrators for Concentrated Photovoltaic and Concentrated Solar Thermal power applications. The efficiency of the lenses directly affects the yield of such systems. Peaks and valleys of the optical facets of the Fresnel lens must be sharp in order to prevent diffusion and transmission loss due to rounding. For diamond turned mould masters, optical facet sharpness is affected by machining accuracy, tool-path and tool wear/mileage. Strategies to optimise optical facet sharpness are presented which enable production of large lenses with minimal degradation of optical quality. Radial Fresnel produced with diameters over 500mm and Linear Fresnel over 1m long are discussed with data on structure fidelity and tool wear.

8065-08, Session 2

Enhanced light trapping in realistic thin film solar cells using one-dimensional gratings

A. Naqavi, K. Söderström, F. Haug, V. Paeder, T. Scharf, H. P. Herzig, C. Ballif, Ecole Polytechnique Fédérale de Lausanne (Switzerland)

Finding the optimal structure to enhance light trapping in thin film silicon solar cells has attracted much attention in the previous decades. However, because of problems in integrating theory and experiment, there are only few comprehensive contributions that provide guidelines for the optimal design of such structures. In this work, a realistic thin film solar cell with almost conformal layers based on a one-dimensional metallic grating back-reflector is investigated through experiment and theory. The external quantum efficiency of the cell is obtained with the aid of both theory and experiment for different angles of incidence and in both polarizations to validate the computational method and to show the impact of guided mode excitation. Different substrate shapes that are compatible with solar cell fabrication are then considered and the effect of geometrical parameters on the short circuit current density of the device is investigated. Calculations show that, among the investigated shapes, sawtooth gratings with a very sharp slope in one side, so called blazed gratings, are the most promising one-dimensional grating for light trapping. Furthermore, the role of material property is discussed specifically in the back-reflector by simulating aluminum and silver back-reflectors. It is shown that the blue response of the solar cells is similar almost regardless of the back-reflector material but their red response is viable to change due to variation in resonant properties of the structure.

8065-09, Session 2

Transparent conductive oxides for nano-SIS solar cells

K. Füchsel, Fraunhofer-Institut für Angewandte Optik und Feinmechanik (Germany) and Friedrich-Schiller-Univ. Jena (Germany); A. Bingel, Friedrich-Schiller-Univ. Jena (Germany); N. Kaiser, A. Tünnermann, Fraunhofer-Institut für Angewandte Optik und Feinmechanik (Germany)

As a reason of their electrical conductivity and transparency in the visible spectral range transparent conductive oxides (TCOs) are well known as electrodes for OLEDs or LCD displays. Another promising

application is a semiconductor-insulator-semiconductor (SIS) solar cell, in which the TCO induces the pn juntion and realises a low cost solar cell on crystalline silicon.

By using nanostructured silicon interfaces broadband antireflection properties with effective light coupling into the silicon can be achieved. Combined with the SIS concept it is possible to fabricate a low cost and high efficient PV device.

For the deposition of thin films of indium tin oxide (ITO) and aluminium doped zinc oxide (AZO) pulsed dc magnetron sputtering is used. The paper presents the surface modification of silicon by inductive coupled plasma (ICP) etching technology, discusses the influence of different TCO materials to the device, and analyses the optical and structural properties of the cells. Furthermore, the solar cell performance under AM1.5G illumination will be shown.

8065-10, Session 2

Microalgae photonics

T. Floume, Imperial College London (United Kingdom); J. Sylvestre, PhotoFuel SAS (France)

Due to their metabolic flexibility and fast growth rate, microalgae have a potential to become industrial photochemical converters. Microalgae photosynthesis could enable the large scale production of clean and renewable liquid fuels with major environmental, economical and societal benefits.

Capital and operational costs are the main issue to adress. A variety of photonic approaches have been proposed - we introduce them here and describe their potential, limitations and compatibility with separate biotechnology and engineering progress. We show that if the goal is ultimately to substitute biofuels for a significant fraction of petroleum, only autotrophic approaches are realistic.

We present AlgoSunTM, a solar spectrum modulation technique inspired by developments in the field of third-generation photovoltaics with luminescent down-shifting (LDS) and luminescent solar concentrators (LSCs). AlgoSunTM uses carefully selected combinations of luminescent compounds embedded in a polymer matrix to spectrally modulate sunlight. The material is specified for given {algea, product} couple, to match its measurable photosynthetic action spectrum.

We investigate quantitatively the effect of this technique on surfacic biomass productivity, the main factor determining biorefinery profitability, hence showing how photonics can directly benefit bioenergy production.

8065-11, Session 2

A silicon based metamaterial for the light-to-electricity conversion

Z. T. Kuznicki, Ecole Nationale Supérieure de Physique de Strasbourg (France)

One of the most challenging topic of today's research and development concerns the efficiency of the PV conversion on Si-derived devices. This aim seems to be achievable due to a new multistage conversion cycle that becomes possible due to a new Si metamaterial that allows low-energy carrier generation and multiplication. Combined with other conversion mechanisms regrouped on dedicated multifunction platforms this solution has interesting possibilities for solar energy conversion. I will describe several potential approaches to the use of such a metamaterial in future photovoltaics.

First, I will discuss use of a single-layer metamaterial with its elementary constituents allowing a tunable conversion. Metamaterial-based solar cells can work with small semiconductor volumes relative to conventional photovoltaics. I will also describe the use of such a structure in converter design and manufacturing. Finally I will explore the design and efficiency considerations for several levels of the light-to-electricity conversion, where the energy flow starts by the incoming light and is transformed by different superposed systems managing photons (photonic and optical platforms) and electrons (all-silicon platforms assuming a multistage cycle). The multistage cycle starts in individual generators called tectons. Tectons form generator lines due to metamaterial substructures (network of tectons). The final architecture of the convertion platform allows the function of a nano power station where different flows of photons and electrons may be managed.

8065-101, Plenary Session II

Photonics research in Europe (Plenary)

Stefan Kaierle, European Laser Institute (Germany)

A couple of years ago it had been recognized that a systematic approach to clustering research topics in the field of photonics would be required. As a result, the European Technology Platform "Photonics21" had been founded. Today, the platform serves as advisor for the European Commission and develops Strategic Research Agendas on a regular. The talk will cover the approach and demonstrate the future hot topics in European Photonics research.

8065-102, Plenary Session II

Examples of green laser applications (Plenary)

Michael Lang, TRUMPF Laser- und Systemtechnik GmbH (Germany); Klaus Löffler, TRUMPF GmbH & Co. KG (Germany)

Advances in Laser Technology have enabled implementation of various technology improvements that contribute to saving resources.

Reduction in carbon footprint is reached through effective manufacturing technologies, contributions to energy efficient products, and enabling access to new energy sources.

On a macroscopic scale high power lasers have enabled efficient, high speed welding. On a microscopic scale, lasers are used for various applications supporting eMobility and the manufacturing of solar cells.

Advantages of lasers are contact free manufacturing and highest precision. These properties are in demand for future production processes to achieve high product quality and throughput, at reasonable energy consumption. As a consequence the number of laser applications across various industries will continue to grow.

8065-105, Plenary Session II

Laser welding for weight saving in BIW design at PSA Peugeot Citroën (Plenary)

Author(s): Mathieu Kielwasser, PSA Peugeot Citroen (France)

No abstract available.

8065-104, Plenary Session II

Photonics-enabled manufacturing: ICT+sensors+lasers = sustainable growth for manufacturing in Europe (Plenary)

Thomas P. Pearsall, European Photonics Industry Consortium (France)

Photonics-powered production - the combination of lasers, sensors and ICT - is the key component of agile, lean and green manufacturing. The introduction of laser technologies in manufacturing is highly disruptive, creating competitive opportunities for European manufacturing, because programmable and controllable laser processing implements a flexible, fast and reactive manufacturing platform .

Photonics-powered production unites three sectors that account for more than 30 billion euros of economic activity per year in Europe, according to statistics published by Photonics-21 and SEMI: Lasers, Sensors and Machine Vision. In addition, this creates synergies among European Technology platforms: Photonics, Manufuture and Eniac. It leverages Key Enabling Technologies of Photonics and Advanced Manufacturing.

Diode lasers are a core technology of this vision. With slope efficiencies greater than 90 percent, and steadily improving output powers, direct diode laser processing could be developed for laser processing systems that deliver up to a kilowatt of continuous machining power. For higher powers, such diode laser systems can pump fiber laser or disc laser systems. Diode laser pumping is additionally the basis for ultra-short pulse length, high peak-power lasers that can be used to manufacture glass and ceramic based products: LCD displays and thin-film solar cells, for example.

The diode-pumped laser, and in particular the fiber laser, has been developed from optical amplifiers used for optical fiber telecommunications. There are a number of small companies making such lasers all over Europe. This technology is by nature easy to scale. Thus, high performance fiber lasers can be made to fit in the hollow of your hand, while the same technology is being used to make lasers the size of football fields for nuclear fusion. This is exciting technology with a brilliant future.

8065-12, Session 3

Carbon dioxide a raw material for sustainable development

J. Amouroux, Ecole Nationale Supérieure de Chimie de Paris (France); P. Siffert, European Materials Research Society (France); K. Hashimoto, Tohoku Univ. (Japan); P. G. Rutberg, Institute of Electrophysics (Russian Federation)

The continuous increase of the concentration of CO2 in the atmosphere (from 250 ppm to 380 ppm), and the related consequences, have pushed the European Parliament and the European Commission to launch a program for CO2 sequestration in the ground in agreement with the Kyoto protocol.

The European set plan have decided to capture and storage 20% of the European emission until 2020. (We have to remember that the world total emission of CO2 is close to 30 gigatons in 2010.)

To do that ten industrial units are programmed, with a unit price of approx 1.2 EUR for an adsorption capacity of 5 millions tons per year for each. The foreseen CCS model foresees essentially three steps: collect the CO2 as close as possible to the source, transfer it by pipeline to adequate locations and pump it in the soil.

The model we are proposing consists in considering CO2 as a RAW MATERIAL which can be recycled in a CHEMICAL FUEL, which can be used as energy source, generating a COMPLETELY NEW INDUSTRY in Europe.

In a first step CO2 has to be collected, exactly like in the present day model of the commission. Many works are starting in an industrial scale to qualify the efficiency, the cost and the liability of these processes using amine, ammonia or zeolithes for the adsorption step.

In a second step this RAW MATERIAL CO2 (a gas or a liquid) has to be chemically reduced by Hydrogen to rebuilt synfuel we can call that Redox processes of CO2 or carbon recycling.

8065-13, Session 3

Minimum energy per bit in high bit rate optical communications and quantum communications

P. B. Gallion, Telecom ParisTech (France)

Optical direct detection usually operates far above the quantum limit, thanks to high thermal noise level of PIN photodiodes. For signal energy at the quantum level, the thermal effects in photon counters are also a strong limitation. The optical amplification or the heterodyne detection of the 2 quadratures of the field, widely used in high bit rate and long haul optical systems, overcome this limitation at the expense of a minimum 3db noise figure. By allowing a noise free mixing gain, as well as single quadrature measurements, the balanced homodyne receiver is allowed to reach quantum noise limited operation.

The aim of this paper is to review the different quantum receiver implementations and to compare the minimum signal energy required to achieve a given bit error rate, or a given bit erasure rate, in high bit rate communication and quantum communication. Application to quantum cryptography will be also addressed.

8065-15, Session 3

Enhancement of spectral response of visible light absorption of TiO_2 synthesis by femtosecond laser ablation

A. S. N. Mahmood, Ryerson Univ. (Canada)

In this study, we report for the first time, formation of web like fibrous nanoparticle with nanosphere Ti-oxide aggregate due to irradiation of bulk titanium samples using femtosecond laser radiation at MHz pulse repetition frequency in air at atmospheric pressure. Instead of doping or sputtering deposited, truile (TiO2) nanosphere has been synthesized by irradiated bulk Ti using femtosecond laser at ambient condition. The formation of fibrous nanostructure layer figure 1, on the treated surface leads to a significant decrease in the reflection of visible radiation figure 2. For the visible wavelength, the decreased reflection is a result of the nature of the nanostructure. Electron microscopy analysis revealed that the nanostructure is formed due to aggregation of polycrystalline nanoparticles of the respective constituent materials. The nanoparticle diameter varies between 30 and 90 nm and they are mixed with a nanosphere oxide of a few nanometers thick. Micro-Raman analysis revealed metallic and oxide phases in the nanostructure. The x-ray diffraction test confirmed of retiles TiO2. An optimal performance of a dye-sensitized solar-cell (DSSC) is possible only when the TiO2 film has a huge surface-area-to-volume ratio, which, in turn, is determined by the morphology of the TiO2 film.

The optical properties of metal nanoparticles have long been of interest in physical chemistry, starting with the Ag and Au systems, because of the favorable bulk dielectric properties of these metals. Since 1969, TiO2 has been recognized as a fascinating material that shows photoelectron-chemical solar-energy conversion, and is known to be an important element for improving the strength and radiation resistance of oxides, production of waveguide layers and optical filters, formation of buried Ohmic contacts in oxides for fabricating micro sensors, and the modification of optical properties of glass window materials for space and industrial applications

8065-16, Session 3

Optical properties of crystalline and amorphous Si:P for device fabrication and structural modeling

M. Basta, Univ. de Strasbourg (France); Z. T. Kuznicki, Ecole Nationale Supérieure de Physique de Strasbourg (France)

Analytic representation of optical function is necessary for the device and structural modeling. Nowadays optoelectronic devices consist of complex materials combined together therefore accurate representation of each part is even more important and results in prediction of overall structure properties. The complete model for amorphous and crystallineSi:P dielectric function is presented. Range of accuracy, known problems and model parameters studied and described. New interesting features of Si:P dielectric functions are discussed. The influence of dopants and free-carriers is taken into account and studied separately and their overlap is also analysed. The influence of Drude damping time on the optical response of heavily doped Si:P is studied. All results are then compared with experimental data.

8065-55, Session 3

Solar trough system based on microstructured reflective Mylar sheets incorporating both photovoltaic and thermal conversions

V. Hejmadi, USI Photonics Inc. (United States); A. Giliberto, USI Photonics Inc. (United Arab Emirates); M. Shin, B. Kress, USI

Photonics Inc. (United States)

Hybrid Photovoltaic /Thermal (PV/T) conversion systems provide a good alternative to traditional concentrating photovoltaics (CPV) or thermal trough architectures. One type of PV/T system operates using concentration principles. However, the conventional PV/T concentrator systems have poor photovoltaic efficiency due to the very achromatic nature of their trough architecture.

We propose a novel technique to implement a PV/T concentrator which relies on commercially available trough concentrators / trackers based on reflective Mylar sheets. Here the Mylar is embossed with binary microstructures that act only on the visible portion of the sunlight, leaving the infrared part of the solar spectrum unperturbed.

This architecture has many advantages over existing PV/T concentrators, such as:

- The existing Mylar-based thermal trough architecture is left intact for optimal thermal conversion, with linear strips of PV cells located a few inches away from the central water pipe.

- The infrared radiation is focused on the central pipe, away from the PV cells, which remain relatively cool compared to conventional designs. Only visible light (the PV convertible part of the solar spectrum) is diffracted onto the PV cell strips.

- The Mylar sheets can be easily embossed by conventional roll-to-roll processes, with a one dimensional symmetric microstructured pattern.

We show how the positive master elements are designed and fabricated over a small area (a traditional IC wafer), and how the Mylar sheets are embossed by a recombined negative nickel shim.

We also show that such a hybrid system can have a hgih visible spectrum throughput over the linear strips of PV cells, while leaving unperturbed the infrared part of the spectrum, heating up the water pipe, as if the PV part of the system were not present. The tracking accuracy requirements of such a system remains within 0.5 degree.

8065-23, Session 4

Photonics education for a green future: connecting the dots of the Arizona STEM education experiment

S. M. Pompea, National Optical Astronomy Observatory (United States); L. W. Fine, Science Foundation Arizona (United States); P. Meystre, College of Optical Sciences, The Univ. of Arizona (United States)

The National Optical Astronomy Observatory, Science Foundation Arizona, and the University of Arizona are teamed on a long-term multi-pronged approach to photonics education in Arizona that is congruent with a “green” future. This approach involves education around renewable energy sources, laser-based communication and laser-assisted manufacturing, photovoltaics, solid-state lighting and displays, nanotechnology, and other recent technology developments.

Our Arizona efforts are also concerned with the process of transforming K-12 schools and universities to make them more effective in their teaching of the science, technology, engineering, and math (STEM) areas. Simply training the worker of yesterday in new technologies will not work. To transform the schools we apply lessons learned from key education projects in Arizona in the areas of professional development for teachers, teacher-scientist research experiences, teacher-scientists educational partnerships, and instructional materials development. Our programs also stress systems thinking, collaborative, long-range problem-solving, cultural understanding, and diversity. It also requires an understanding of the educational dissemination and change process, and a sense of which problems lend themselves to current cost-effective strategic interventions.

The Arizona approach also focuses on informal science education at museums, hands-on science centers, and planetariums. It utilizes star parties and after-school programs that provide “free-choice” learning for individuals and families.

A third component of the Arizona experiment is the use of research organizations and industry associations to provide innovative educational programs and to initiate risky initiatives in public private partnerships to achieve a bold approach to the reform of science education using optics as an exemplar.

8065-24, Session 4

The outreach activities to promote photonics education for school students

F. Zhou, Indiana Univ. of Pennsylvania (United States); D. M. Hull, OP-TEC National Ctr. for Optics and Photonics Education (United States)

We will present the results of a recent photonics technician job needs assessment and highlight some green energy related photonics jobs. In order to attract students for photonics education, several outreach activities are conducted for high school students and teachers. The presentation will also include several eco-photonics related lab activities that have been developed for high school students.

8065-25, Session 4

Enabling virtual reality on mobile devices: enhancing students learning experience

M. Feisst, The Univ. of Nottingham (United Kingdom)

Nowadays, mobile devices are more and more powerful concerning processing power, main memory and storage as well as graphical output capability and the support for 3D mostly via OpenGL ES. Therefore modern devices allows it to enable Virtual Reality (VR) on them. Most students own (or will own in future) one of these more powerful mobile device. The students owning such a mobile device already using it to communicate (SMS, twitter, etc) and/or to listen to podcasts. Taking this knowledge into account, it makes sense to improve the students learning experience by enabling mobile devices to display VR content.

The system discussed in this paper gives student the ability to access learning content, enriched with (interactive) VR content. There are two ways of visualising the VR content on the mobile devices. Either as a non interactive streamed video embedded in a HTML page or as interactive (animated) VR presented with the help of an additional program. The formate used to describe the VR content is the well known web standard X3D. The X3D viewer, currently working on Java enabled or Android base phones gives the students the possibility to view and examine VR content. For example in case the VR content shows the interconnection of a physical experiment, the student can zoom in/out and/or rotate the scene in order to gain a better understanding of the interconnection.

8065-26, Session 4

National education program for energy efficient illumination engineering

C. E. Walker, S. M. Pompea, National Optical Astronomy Observatory (United States)

The International Dark-Sky Association estimates that one-third of outdoor lighting escapes unused into space, causing light pollution. Such over-illumination can incur substantial costs. With the increasing number of streetlights, big box stores and billboards, outdoor lighting is a critical component of energy use today. Several strategies to minimize energy requirements and achieve an energy-responsive design can be considered by illumination engineers. To introduce students in grades 5 through 12 to the energy-responsive design principles, staff at the National Optical Astronomy Observatory have carefully crafted a focused, sequential, and cumulative set of 3 learning experiences. The first of the three learning experiences is the light shielding demonstration. It provides a visual illustration of the causes of light pollution and the main vocabulary that relates to illumination engineering. The second learning experience is the school outdoor lighting audit, which has students perform an audit and produce a revised master plan by retrofitting with compliant lighting. They then report on their results to a school board or city council. The solutions rely on an understanding of illumination engineering principles. The third learning experience is an introduction to the GLOBE at Night light pollution assessment campaign. GLOBE at Night provides an opportunity for more global awareness of the importance of remedying

light pollution issues, using illumination engineering as a main solution. The three learning experiences can standalone educationally, but together they provide an integrated learning unit.

8065-27, Session 4

New aspects of using eyetracking in education of optics and photonics

U. Rohbock, M. Jagoda, Univ. of Applied Sciences Offenburg (Germany)

Eyetracking is an empirical research method and one of the observation methods. The term “eyetracking”, in German “Blickregisterierung”, involves technical procedures which can register the course of a person´s gaze while looking at a document (e.g. picture, text, film) and can record it. This can be done for example with a specially developed video camera which records the eyes of the test person and which can determine the position of the eye movements using complex algorithms.

8065-28, Session 4

Interactive lecture demonstrations, active learning and the ALOP Project

V. Lakshminarayan, Univ. of Waterloo (Canada)

There is considerable evidence from physics education literature that traditional approaches (e.g., lecture) are ineffective in teaching physics concepts. Traditional methods exist in a passive learning environment and do not completely engage the student, if at all. A better teaching method is to create an active learning environment. Such an environment can be created using the Interactive lecture Demonstrations. These pedagogical techniques were developed in the late 1980s and 1990s primarily at the University of Oregon and at Tufts University. A formalized procedure has been developed and is designed to engage students in the learning process and therefore convert the usually passive lecture environment into an active learning environment. A key concept in the ILD methodology is that the instructor should avoid lecturing to the students. In a given physics situation (a demonstration to the class), the students make a prediction, test the prediction, analyze the results and discuss them and arrive at the conclusion that illustrates the physics concept that explains the situation.

The instructor acts mainly as a facilitator in this process and has a definite “agenda” and must often guide the discussion toward the important points raised by the ILD.

Based on the active learning methodology, and within the framework of the UNESCO mandate in physics education promoting active learning in introductory physics, the ALOP project (Active Learning in Optics and Photonics), provides a focus on an experimental area that has been relevant and adaptable to research and educational conditions in many developing countries. The project was started in 2004 with a workshop in Ghana and has continued to the present with at least two workshops per year in different countries. The project has developed a training curriculum based on the following themes: geometric optics, physical optics (interference, diffraction and spectroscopy), optics of the eye, environmental optics and optical communications. Modules with activities and appropriate instrumentation have been developed.

These aspects and results from the workshops will be discussed in the talk.

8065-17, Session 5

Eco efficiency of laser welding applications

S. Kaierle, Fraunhofer-Institut für Lasertechnik (Germany)

As widely known laser materials processing has some advantages regarding local heat input and controllability. In many fields applications were developed which are not accessible for conventional thermal processing. In other fields laser-supported manufacturing techniques are a valuable alternative. On the one hand laser techniques enable increased processing speed and less post-processing, leading to an increased productivity. On the other hand low efficiencies in the energy conversion seem to by a major drawback and apparently limit the range of applications. In the frame of conventional processing schemes laser beam welding requires a high utilisation in order to run economically. Main advantages lie in the reduced consumption of material and the reduced efforts in post processing. Because of the locally concentrated heat input process emissions are lower which reduces energy and material consumption in the auxiliary chain.

To make full use of the often-conjured flexibility a multitude of manufacturing schemes had been developed and adapted. In order to appraise the versatility of laser driven processing techniques a cost and benefit analysis based on a life-cycle approach is conducted including both, economics and ecology. Eco-efficiency is rated by a variation of the BASF method. Taking into account the reduced consumption of consumables, reduced effort for preparation and post-processing, and focussing on specific application ranges a positive environmental impact can be proven.

8065-18, Session 5

Glue-free assembly of glass fiber reinforced thermoplastics using laser light

W. Knapp, Cooperation Laser Franco-Allemande (France)

The use of laser light for bonding of long fiber reinforced thermoplastic composites (LFTPC) offers new possibilities to overcome the constraints of conventional joining technologies. Laser bonding is environmentally friendly as no chemical additive or glue is necessary. Accuracy and flexibility of the laser process as well as the quality of the weld seams provide benefits which are already used in many industrial applications. Laser transmission welding has already been introduced in manufacturing of short fiber thermoplastic composites. Laser replaces hot air in tape-laying systems for pre-preg carbon fiber placement. This presentation will provide an overview concerning the technical basics of the joining process and outline some material inherent characteristics to be considered when using long glass fiber reinforced composites The technical feasibility and the mechanical characterization of laser bonded LFTPC are demonstrated. The influence of the different layer configurations on the laser interaction with the material is investigated and the dependency on the mechanical strength of the weld seem is analyzed. The results show that the laser provides an alternative joining technique and offers new perspectives to assemble structural components emerging in automotive or aeronautical manufacturing. It overcomes the environmental and technical difficulties related to existing gluing processes.

8065-19, Session 5

Improvement of mechanical properties and life extension of high reliability structural components by laser shock processing

J. L. Ocaña, Univ. Politécnica de Madrid (Spain)

No abstract available

8065-20, Session 5

Wavefront analysis and optimization from conventional liquid crystal displays for low-cost holographic optical tweezers and digital holographic microscopy

A. Weber, V. Ortega Clavero, W. W. Schröder, Univ. of Applied Sciences Offenburg (Germany)

In different study fields the manipulation and imaging of micro-sized particles is essential. The use of holographic optical tweezers (HOT) and digital holographic microscopy (DHM) facilitates this task in a non-mechanical way by providing the proper computer generated hologram and the required amount of light. Electrically addressed spatial light

modulators (EASLM) found in holographic optical tweezers are typically of the reflective liquid crystal on silicon (LCoS) type which can achieve a phase shift of more than 2π but they are expensive. Similar components like transmissive twisted nematic liquid crystal displays

(TN-LCD) are produced in large quantities, their optical characteristics improve rapidly and they are inexpensive.

Under certain circumstances these devices can be used instead of expensive spatial light modulators.

Consumer grade objectives are not always well corrected for spherical aberration. In that case conventional liquid crystal displays can also compensate these undesired optical effects. For this purpose software-corrected computer generated holograms are calculated. Procedures to analyze and compensate different parameters of a conventional low-cost liquid crystal display, e.g. phase shift evaluation and aberration correction of objectives by Zernike polynomials approximation are explained. The applied software compensation of the computer generated hologram has shown significant improvement of the focus quality. An important price reduction of holographic devices could be achieved by replacing special optical elements if correction algorithms for conventional liquid crystal displays are provided.

8065-21, Session 5

Spot welding of highly reflective materials used for electrical contacts

C. Rüttimann, LASAG AG (Switzerland)

No abstract available

8065-30, Session 6

Robust, precise, high resolution Fourier transform Raman spectrometer

V. Ortega Clavero, Univ. of Applied Sciences Offenburg (Germany) and Univ. of Strasbourg (France); W. W. Schröder, Univ. of Applied Sciences Offenburg (Germany); P. P. Meyrueis, Univ. of Strasbourg (France); A. Weber, Univ. of Applied Sciences Offenburg (Germany)

A robust, flexible Fourier transform Raman spectrometer (FT-Raman) based on a Michelson interferometer and a self-made photon counter is presented. The proposed inexpensive setup has no complex hardware or control systems for optical path compensation. The mechanical and thermal induced errors are mathematically compensated by extracting the optical path information from the generated interference pattern of a = 632.8 nm Helium-Neon laser (HeNe laser). This information also permits high frequency precision of the calculated Raman spectrum. This system is flexible and allows the user having complete access to hardware and software. It enables a variety of experimental changes in the system, which are difficult to achieve with commercial devices. Precise, high resolution Raman spectra of cyclohexane with a resolution of 1.66 cm−1 to 5.0 cm−1 have been measured with this device. Higher resolution values can be achieved since longer scanning distances at the Michelson interferometer are possible and its calculated ´etendue (throughput) does not substantially corrupt the obtained interferograms. Other chemical compounds have been also monitored. Additionally, a detailed spectral analysis of different precision optical components and light sources has been performed.

8065-31, Session 6

Optical glass and the EU directive RoHS

P. Hartmann, SCHOTT AG (Germany)

Optical glass is part of optical systems, being subject to the EU directive RoHS, restricting the use of certain hazardous substances in electric and electronic equipment. Some special optical and filter glasses contain lead or cadmium, since these elements are essential for some special glass properties needed by high end optical systems. Most lead containing glass for consumer optics has been replaced by lead free versions. A lot of effort has been spent searching for substitute glass types. But for some remaining applications a set of lead or cadmium containing glass types have revealed to be irreplaceable. Even though they are used only in small amounts and are of negligible environmental influence, long and tedious effort was necessary to obtain an exemption from the directive. The optics community has to stay alert to prevent vast damages due to possible non-availability of glass types crucial for very important applications such as fluorescence microscopy. There are tendencies to restrict the use of even more elements, which could endanger the existence of most optical and filter glass types. These materials are key enabling factors of technical civilization as a whole because they are used in all industries and many research fields. They must be taken out of the scope of RoHS in total since exemption procedures will lead to periods of secured availability too short to be acceptable for the design of optical systems, which usually takes years and in high end optics must be valid also for long term deliveries. New regulations improving ecological aspects should assess the consequences on other important goals of society.

8065-32, Session 6

Communication of the multi laser tracker system used as position feedback sensor

T. T. Nguyen, T. Q. Nguyen, A. Amthor, C. Ament, Technische Univ. Ilmenau (Germany)

This paper presents a communication as well as localization algorithm of a multi laser tracker system (MLTS), which enables the possibility to find a retro-reflector, which is mounted on the Tool Center Point (TCP) of a positioning stage. The MLTS consists of four laser trackers and is used as a high precision feedback sensor in order to provide a contactless measurement of the position. A single laser tracker consists of a homodyne laser interferometer as well as a galvanometer scanner, and tracks the retro-reflector by utilization of a model-based PID controller. Using the Archimedean spiral a mathematical localization algorithm of the retro-reflector is designed. This approach was chosen due to the fact, that it allows the laser beam to search the retro-reflector in the complete working range of the laser tracker. The algorithm is derived in polar coordinates and then transformed in an angle coordinates of the galvanometer scanners. In the second part of the presented study, a communication channel between the laser trackers is designed. This enables the possibility to speed up the localization of the retro-reflector, because the position of the TCP is determined by triangulation and hence only two laser trackers are required for the first localization. This information is used to support the residual laser trackers of the MLTS, which are still in the search modus. At the end it is shown by experimental results, that the communication of the multi laser tracker system is effective in order to localize the retro-reflector as fast as possible.

8065-33, Session 6

Holographic microscope using conventional low-cost liquid crystal in transmissive setup

A. Weber, W. W. Schröder, V. Ortega Clavero, Univ. of Applied Sciences Offenburg (Germany)

The microscopic three-dimensional imaging of cells is a key method in biological and medical research. Con- ventional high-resolution scanning methods e.g. laser scanning microscopes are limited or require some form of compensation in monitoring of living cells. The proposed method uses a low-cost twisted nematic liquid crystal display (TN-LCD) which is used as phase modulating electrically addressed spatial light modulator (EASLM) to holographically generate a reference wave which can be translated and shift in phase. Wavefront distortions caused by aberrations are determined by scanning the system with the EASLM, approximating them with Zernike polynomials and calculating a phase correction function which can be superposed with the hologram. The inter- ference pattern of the object and shifted reference wave is captured with a CMOS camera and subsequently the object wave is reconstructed from the taken images. With this procedure it was already possible to reconstruct a diatom in different layers.

8065-34, Session 6

Energy efficiency in thermal joining processes

J. Wilden, Technische Univ. Berlin (Germany)

Rising energy costs make energy efficiency a key topic of the future for different industrial production processes. Thermal joining is widely used in the production process and causes a lot of energy lost.

Both weld seam and filler material have to be heated to temperatures higher than the melting point. During the process a high amount of heat conducts into the work piece.

Process efficiency and decrease of the energy consumption can be achieved through increasing of process temperature and decreasing of the weld metal volume, respectively. To achieve these goals, material and process developments have to be carried out. These can result energy savings up to 40% are established in laser and arc welding processes.

Nanotechnology is an innovative means to reduce required energy for joining processes. High energy which is necessary in the joining area can be generated in milliseconds only by using nanostructured reactive foils. Furthermore, the process velocity can reach several m/s. Due to the size effect the melting temperature of nanoparticles decreases inversely proportional to the radius. Therefore Ag nanoparticles with a diameter of 10 nm melt at about 200°C which has to be compared to micro, meso or macro sized Ag particles melting at 960 °C. Filler material manufacture based on this effect allows producing metallurgical joints at very low temperatures. After the joining process the size effect disappears. This means that the reflow temperature is equal to the macroscopic melting temperature.

Material and process developments offer a wide variety of opportunities to reduce the energy consumption in thermal joining processes. Especially taking advantage of nano effects to decrease the process temperature and increase the process velocity has great potential for future applications.

8065-54, Session 6

Virtual reality to simulate large lighting with high efficiency LED

T. Blandet, Ecole Nationale Supérieure de Physique de Strasbourg (France); G. Coutelier, Pixium (France)

LED provide a specific light structure. When a large number of led are used to lighten a monument, a building, a facility, a landscape it is very difficult to have an idea of the lighting effect just out of optical CAD CAM systems before realizing physically the lighting. It is necessary for making lighting decision with many LED to use new simulation tools. This is what we propose by using virtual reality hardware and software providing realistic and rigorous 3D interactive displays of LED lighting through which relevant choices can be made.

The virtual reality tools that we provide can concern companies involved in lighting engineering and wishing to have for their customers interactive 3D LED lighting simulation presentations that will be very close of the perceived scene once realized.

By changing the light engineering options virtually it is possible to offer a large range of lighting choice adapted to the surrounding condition, the weather, the cost, etc.

We explain our method and we illustrate it by some overviews of interactive examples selected among effective uses of our method from Abu Dhabi to St Petersburg.

We conclude by introducing some of our work in progress and the perspective of new developments expected for the years to come.

The authors thanks the Region Alsace for its contribution to the progress reported in this paper.

8065-46, Poster Session

Organic photovoltaic device characterized by high open circuit voltage with aluminum doped zinc oxide as transparent electrode

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We fabricated organic photovoltaic cells with improved photogeneration characteristics such as open circuit voltage. ZnO:Al/SubPc/C60/TCz1/Al heterostructure was studied, obtained by atomic layer deposition (ALD) of transparent and conductive aluminum doped zinc oxide (ZnO:Al) films and vacuum deposition of boron subphthalocyanine chloride (SubPc), fullerene (C60), 3,6-di(9-carbazolyl)-9-(2-ethylhexyl)carbazole (TCz1) on glass substrates.

ZnO:Al films obtained by the ALD posses very low resistivity (~10-4 Ωcm) and high optical transmission (~90%) in the visible range. They are, therefore, a very prospective candidate to replace so far widely used indium tin oxide (ITO) layers as transparent electrodes in organic electronic devices.

The open circuit voltage was increased (1.2 V) by using SubPc/C60 heterostructure. Moreover, we suggest using TCz1 in organic photovoltaic cell with an aim of transport electrons to the cathode (Al) from the acceptor layer (C60) and effectively blocking hole and exciton transport.

The effect of the heterostructure's formation conditions on their spectral photosensitivity and photovoltaic properties is studied. The interface characteristics for fabricated devices are obtained using impedance spectroscopy.

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8065-47, Poster Session

Zinc oxide films grown by atomic layer deposition for reflective coating applications

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Zinc oxide (ZnO) is widely studied for energy saving (smart solar reflective coatings of windows) applications. Its wider use was limited by sensitivity to humidity due to reaction of water vapor with oxygen vacancies. Thus, reduction of vacancies concentration is highly required.

For energy saving applications, ZnO should be highly transparent (above 85%) in spectral range of solar emission (0.25 μm < λ < 2 μm) and should efficiently reflect (due to metallic properties) radiation at longer wavelength (thermal radiation: 3 μm < λ < 50 μm).

In the present work we report on advantageous properties of ZnO films grown by atomic layer deposition (ALD) for energy saving applications. Growth parameters and properties of such the ALD grown films are described.

By controlling growth conditions, films with the required free electron concentration (in the range of 1020 cm-3) were grown. The films show ~90% transparency in the range of visible light, metallic conductivity, and relatively high electron mobility (in the range of 20 cm2/Vs). Plasma edge is observed in the near infrared, which means that a thermal emission is efficiently reflected. Even though grown at relatively low temperature, the ALD-grown ZnO films often show only the band edge photoluminescence (PL) and weak (or even any) deep level related PL, indicating a very reduced concentration of defects such as vacancies. The latter indicates the reduced sensitivity to water vapor.

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8065-48, Poster Session

Optimization of Pd surface plasmon resonance sensor for hydrogen detection

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A concept design to optimize a fiber optic Surface Plasmon Resonance (SPR) sensor using Palladium as a sensitive layer for hydrogen detection is presented. In this approach, the sensitive layer is deposited on the outside of a multimode fiber, after removing the optical cladding. The light is injected in the fiber with a given wavelength in the range of 450 nm to 900nm and excites equally all bunch modes of the optical fiber. The intensity modulation at the fiber output is measured to estimate the presence of hydrogen absorbed by the Pd, and consequently the Hydrogen concentration in the environment. The sensor response depends on both the Transverse Magnetic (TM) polarization (magnetic field perpendicular to incidence plane) and the Transverse electric (TE) polarization (electric field perpendicular to incidence plane). The response for the TE polarization is opposite to the TM polarization and depends on the wavelength. Fiber impurities, torsion or stress apply on the fiber may lead to the conversion of TE and TM polarization along the fiber, which may cause false alarms. The objective here is to optimize the Pd-SPR hydrogen sensor design in order to increase its sensitivity and limit the effects of the TE polarization on the sensor response. We introduce an analysis of the sensor response as a function of the Pd thickness showing the effects of both polarizations on the response. A new concept design based on a multilayer system (Ag/SiO2/Pd) is proposed to obtain an efficient SPR sensor.

8065-49, Poster Session

The design of a wireless battery-less bi-flash installation with high power leds

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Adding flashlights at crosswalks may make these weak traffic points safer. Unfortunately plugging in traffic lights into the electrical grid is expensive and complex. This paper reports about the electrical, the electronic and the light design of a wireless and battery-less bi-flash installation in the framework of a Flemish SME supporting program. The energy is supplied by a small solar panel and is buffered by supercapacitors instead of batteries. This has the advantage of being almost maintenance free: the number of charge-discharge cycles is almost unlimited because there is no chemical reaction involved in the storage mechanism. On the other hand the limited energy storage capacity of supercapacitors requires a new approach for the system design. Based on the EN-12352 standard for warning light devices, all design choices were filled in to be as energy efficient as possible. The duty cycle and the light output of the high power LED flashlights are minimized. The components for the electronic circuits for the LED driver, the control and the RF communication are selected based on their energy consumption and power management techniques are implemented. A lot of energy is saved by making the bi-flash system active. The LEDs are only flashing on demand or at preprogrammed moments. A bi-flash installation is typically installed at both sides of a crosswalk. A call at one of the sides should result in flashing at both sides. To maintain the drag and drop principle, a wireless RF communication system is designed.

8065-50, Poster Session

Perfection of sustainable processes of grinding and polishing of optical details

Y. D. Filatov, V. Bakul Institute for Superhard Materials NASU (Ukraine); O. Y. Filatov, National Academy of Sciences of Ukraine (Ukraine); G. Monteil, Ecole Nationale Supérieure Mécanique et des Microtechniques de Besancon (France); U. Heisel, M. G. Storchak, Univ. Stuttgart (Germany)

Machining of detail's surfaces from optical glass, quartz, optical ceramics and semi-conductor crystals is made at diamond grinding and polishing. Toxic technological liquids are applied to increase productivity and stability of grinding process and chemical influence on a working surface of the tool and a detail surface layer. At machining toxic polishing powders in a free condition are used and various chemical additives are entered into suspension for an exception of deposit formation. For perfection of sustainable processes we develop the diamond grinding tool on metallic-polymeric binding which provides stable removal of a processed material. Powders of metals with positive (copper) and negative (magnesium) in the normal electrochemical potentials, galvanic steams forming in the water environment are used. At change of the volume maintenance of metals the parity between mechanical and corrosion deterioration changes, loss of cutting properties of the tool is excluded and stable effective processing is provided. At polishing of optical materials application of toxic polishing powders is completely excluded. Powders on a basis cerium oxide are applied in for a bound-abrasive polishing tools. Quantum-mechanical calculations have defined probability of a deposit formation from slime particles on a surface of the tool and have designated zones of localisation of a deposit fragments. Deposit exception on flat and spherical polishing tools is provided without use of special chemical compounds at the expense of a design which does not contain elements in the field of deposit localization.

8065-35, Session 7

The role of photonics in sustainable product design

B. Wessler, OSRAM Opto Semiconductors GmbH (Germany)

Light has a fundamental effect on life given the first photosynthetic organisms evolving about 3,500 million years ago laying the fundamentals of more complex life on earth. Eco - or better Sustainability - and Photonics therefore have an eternal association.

Modern photonic technologies utilize the generation, the emission, transmission, modulation, sensing, amplification, detection and signal processing of light to enable eco-friendly and sustainable solutions for many applications and production processes.

Photonic technologies have a major impact on sustainability and contribute to the solution of major economic, ecologic and societal challenges - whether we look into the field of: energy generation, where photovoltaic panels substitute fossil energy sources and thus reducing CO2; energy consumption in the use phase - e.g. increased the energy efficiency with reduced electricity consumption using modern lighting solutions - or - meeting future communication requirements with reduced power consumption per bit by optical next generation networks; enabling energy reductions in the manufacturing processes - e.g. with lasers producing light-weight structures in transportation meeting modern mobility needs by lower green house gas emissions per kilometer - or - control, monitor and optimize energy consumption and hazardous substances.

However - as photonic technologies are expected to contribute to massive energy savings from 30 up to 90% - the danger of a "reverse-back" effect from human behaviors and technician's ambition to continuously increase functions and with this new energy consumers may lead into a "The tortoise and the hare" type of story.

8065-36, Session 7

Improving the energy efficiency of telecommunication networks

C. Lange, Deutsche Telekom AG (Germany); A. Gladisch, Deutsche Telekom Labs. (Germany)

Throughout the recent past, power and energy consumption of telecommunication networks have attracted high attention in the telecommunications industry since the energy-related costs contribute significantly to the network operator's operational expenditures. Furthermore, the sustainability of networks has become an important societal and economic factor.

Since the traffic volume is forecasted to be increasing rapidly during the forthcoming years, the energy consumption of telecommunication networks is expected to rise, too, if networks are deployed and extended accordingly using current paradigms of network architecture and system technologies.

Opportunities for limiting the energy consumption of networks are discussed emphasizing techniques for load-adaptive network operation as a very promising approach to increase the network's energy efficiency. The energy saving potential of related techniques is discussed as well as challenges for their usage in operator networks.

8065-37, Session 8

Fully controlled helicopter for 3D-reconstruction of buildings and survey applications

R. Lehmann, S. Staiger, W. W. Schröder, Hochschule Offenburg (Germany)

When aerial monitoring work must be performed, certain tasks can result complicated. The resources required for inspection through helicopter or airplane are by far expensive and not always the best option. In recent years the flight modeling branch has grown considerably. Different modeling devices can be found on the market at reasonable prices. Nevertheless the operation of a model helicopter is still a determinant factor for performing an aerial monitoring task, since a experimented pilot is required. At the institute for applied research at the University of Applied Sciences Offenburg an attitude and heading reference system (AHRS) for small helicopters has been developed. It contains a GPS-augmented inertial navigator, a flight control system and a ground station. This system allows a smooth controlled flight while he performs the desired monitoring. This system has been successfully tested under several whether conditions. Including more than 50km/h wind load and ice-build-up on frame and blades. The following tables show the main technical parameters.

Platform main capabilities: The helicopter is able the fly in all-weather conditions including strong winds and low temperatures. The control system allows a easy flight for any user. The helicopter is fast and very maneuverable and can hold a load of up to 3 kg. It is designed for monitoring purposes or small package in small or long range transport. It allows carrying several monitoring devices, like cameras, thermal cameras, etc. The designed system can used for different modeling artifacts with relative small adaption. It is very quiet and has low radar and thermal signature.

Performed tasks and results: The described system is able to perform reliable controlled flight under severe weather conditions. Monitoring work has also been performed using this device. Figure 1 shows the helicopter flying near one tower of the cathedral in Freiburg, Germany. Figure 2 shows high resolution pictures obtained from this observation.

3D high resolution reconstruction of certain pieces of the tower has been performed. The same kind of exploration can be done with thermal camera for energy optimization purposes.

8065-38, Session 8

Mobile display backlight light guide plates based on slanted grating arrays

J. S. Kimmel, T. Levola, Nokia Research Ctr. (Finland)

Modern mobile communication devices have user interfaces that are dominated by high-quality displays. Increased multimedia use imposes high demands on the design of display modules, as the content available for mobile use becomes visually richer. Especially the power dissipation of the display can limit the amount of time available for multimedia consumption and interaction. In the mobile liquid-crystal display (LCD), the energy efficiency is determined by the backlight design. State-of-the-art backlights direct white light through a display subpixel array, with high uniformity and up to 90 % efficiency in white light output. Diffractive backlights have recently been proposed to reduce the power dissipation of the display module, and slanted grating arrays are the enabling optical features that allow for radical reduction in power dissipation beyond what is available in the state of the art. By the use of diffractive grating arrays, the required primary color (red, green, or blue) is directed through the LCD subpixel array with geometrical registration, instead of flooding the whole LCD with white light and filtering the primary colors through the subpixel color filter array. This paper presents grating structures based on slanted grating arrays fabricated in high refractive index materials. The grating design principles, display system design, and grating characterization results are provided. Emphasis is given on energy savings aspects on future display system design. The results show that significant savings in power consumption can be expected with advanced display system design based on slanted grating array backlight light guide plates.

8065-39, Session 8

Realtime implementation of square 16-QAM transmission system

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Combination of quadrature amplitude modulation with coherent detection is attractive for optical transmission systems, since it allows an increase of data rate without increasing the symbol rate or the required bandwidth. 16-point Quadrature Amplitude Modulation (16-QAM) is most interesting in this context. In-phase (I) and quadrature (Q) signals transmit 2 bit each. Together with polarization division multiplex this amounts to 8 bit/symbol.

In this article we present the implementation of a 16-QAM transmission system with feedforward realtime synchronous demodulation and data recovery, reaching a data throughput of 2.5 Gbit/s. A dual-parallel Mach-Zehnder modulator (DPMZM) is driven by 4x625 Mb/s pseudorandom binary sequence (PRBS) data in different lengths combined as 2x625 Mbaud quaternary data signals to generate 16-QAM data. I&Q data are Gray-encoded to form a quadrant number. All bit streams are analyzed in realtime. The transmission was error-free in a back-to-back electrical test for various PRBS lengths.

The 625 Mbaud (4x625 Mb/s) data is transmitted over 5.5 km of fiber, and is received in a realtime I&Q homodyne setup with standard external cavity laser. The resulting electrical signals are amplified, and sampled in 6-bit analog-to-digital converters (ADCs). The ADCs are connected to a Xilinx Virtex 4 FPGA that recovers carrier and data in realtime. The carrier recovery does not contain any feedback loop and is therefore highly tolerant against laser phase noise.

The bit-error-rate (BER) floors were at 4.47x10-4 and 6.25x10-4 for tested PRBS data lengths of 7 and 23, respectively.

8065-41, Session 8

Clean photonics for environmental monitoring: not only the wavelengths are green

H. Zappe, Albert-Ludwigs-Univ. Freiburg (Germany)

Photonic sensors are ideally suited for measurement and monitoring of a wide range of environmentally-relevant parameters: gasses, liquids, solids and complex systems such as plant and animal tissue can be optically analyzed. New fabrication techniques applicable to many types of photonic components, particularly those based on high-volume replication using polymers, will allow the manufacture of monitors at considerably lower environmental cost than established

semiconductor processes. We will discuss examples of how photonics can become greener while supporting novel approaches for environmental monitoring.

8065-42, Session 8

The european ICT-BOOM project: silicon photonic TB/s routers for improved energy efficiency in optical networks

A. Pagano, E. Riccardi, TelecomitaliaLAB (Italy); C. Stamatiadis, K. Vyrsokinos, National Technical Univ. of Athens (Greece); L. Stampoulidis, CONSTELEX Technology Enablers (Greece); H. Avramopoulos, National Technical Univ. of Athens (Greece)

Power consumption has recently emerged as a crucial problem due to increasing energy costs and to relevant environmental impacts. The turn towards photonic technology is an interesting option to achieve energy savings in optical networks. In particular, in mid term evolution, optical switching is a promising substitute for electrical switching at least inside high throughput core routers. In order to keep up with this emerging trend and allow for even smaller, faster, cheaper and “greener” optical routing chips, a photonic integration platform that will enable scalable, functional and cost effective integration is required. Even if a complete substitution of electronics with optics is far in time due to the strong potentiality of digital electronic devices (large scale integration and proven high volume costs models), some intermediate sub-functions could be efficiently realized with photonic integrated devices. This is accomplished by a reduction of the number of electro-optical discrete components and a simplification in interconnections layout. The Silicon-on-Insulator (SOI) integration technology to develop compact, cost-effective and power efficient silicon photonic components as well as flip-chip bonding and die-to-wafer integration methods to fabricate and mount the complete family of III-V components on SOI, can provide this new generation of functional and miniaturized photonic components. This opportunity has been carefully analyzed with the help of a developed model for the core switching platform and its integration in basic router architecture. A comparison in term of throughput, footprint, power consumption with a conventional electronic solution has been undertaken and reported with successful energy savings results.

8065-43, Session 8

D³-display: the ‘no power’ (green) electrowetting display

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Electrowetting displays were first reported in 1981 [1] and it lasts two decades until first prototypes were introduced by LIQUAVISTA [2] Several years later the authors of this paper presented a bistable electrowetting principle [3] and GAMMA DYNAMICS published their work on electrowetting in 2009 [4]. However, ADT’s so called D³-Displays (Droplet-Driven-Displays) is the only bistable one which makes them very attractive for energy-saving systems. That means that the power supply can completely shut off after changing the content and it will keep its information for years. But there are some more features that make the ADT approach very unique. It is the only display technology which shows a paper like white appearance in the powerless OFF-state. Most of the displays nowadays used are transmissive types, which mean they are using a backlight. The D³ is a reflective technology. So no backlight is needed during as long as ambient light is present. But compared to other E-Paper displays, that are mainly only reflective, the D³ can also be operated in transflective and transmissive mode. Through the assembling of the structures we achieve a high aperture ratio of 65% and a white state reflectance of about 70%. Other E-Paper technologies are in the range of 25-50%. The size of a pixel can vary in the range 0.3 up to 10mm. Compared to a standard LCD this very big but for a low content display with ambitions for large billboards this will be perfect.