ORAL PRESENTATIONS

NOTE:

Each presentation is encoded with the Day of the conference (two first letter of the day), the session (A or B) and the time of the conference.

Example:
TH-A-15:40 is for Thursday, session A at 15:40 or 3:40 pm

Oral sessions A will takes place in the Carmen room.
Oral sessions B will takes place in the Wagner/Vivaldi room.
Plenary sessions will take place in the **Plaza I** room (emphasized in grey)

TUESDAY 17 JUNE

PLENARY SESSION

SESSION CHAIRS: I. MIYAMOTO, M. MEUNIER

TU-A-08:30

OPENING OF THE CONFERENCE

I. Miyamoto and M. Meunier

TU-A-09:00

LASER MATERIAL PROCESSING IN THE MICRO AND NANOMETER DOMAINS: PAST, PRESENT AND POSSIBLY THE FUTURE

H. Helvajian ; Physical Sciences Laboratories, The Aerospace Corporation, P.O. Box 92957, Los Angeles, CA 90009 USA

Laser material processing now supports a worldwide industry with sales measured in $B USD. A number of textbooks, spanning over 20 years, now document the research and technology developments in precision micro and nanofabrication. Over the same time duration there have been dramatic strides in laser technology with smaller footprint, pulse stability and reliability being the current hallmarks and the controllable delivery of a prescribed photon flux being a capability on the horizon. In view of all these developments, it is time to catalogue the accomplishments of the laser micro and nanofabrication community and to establish new research benchmarks to insure that future developments will lead to a sustained growth in the field.

TU-A-09:50

CELL TRANSFECTION USING NOVEL LASER TECHNIQUES

K. Dholakia, X. Tsampoula, V. Garcés-Chávez, D. J. Stevenson, C. T. A. Brown and F.J. Gunn-Moore ; University of St Andrews, Scottland

This paper will explore the use of specialist light beams for applications in femtosecond laser assisted transfection of cells. In particular we look at the use of "non-diffracting light fields that obviate the need for exact focussing for this multiphoton event. Progress towards visualising the cell pores, the dependency upon wavelength and the use of non-free space techniques for cell transfection will be described

LASER PROCESSING FOR BIOLOGICAL APPLICATIONS 1 (BIO 1)
SESSION CHAIRS: A. VOGEL, C. SCHAFFER

TU-A-10:50

LASER INDUCED NANOCAVITATION FOR TRANSIENT PERFORATION OF CELL MEMBRANES

N. Linz1, S. Freidank1, S. Eckert1, G. Paltauf2, A. Vogel1;

1- Institute of Biomedical Optics, University of Lübeck, Peter-Monnik Weg 4, D-23562 Lübeck, Germany

2- Physics Institute, Karl-Franzens-University Graz,Universitätsplatz 5, A-8010 Graz, Austria

Gentle optoperforation of cells for gene transfer using single pulses relies on the generation of minute cavitation bubbles that permeabilize the membrane without destroying the cell. To identify suitable laser parameters for optoperforation, we developed a probe beam scattering method in which the bubble size is inferred from the bubble oscillation time. We can detect bubbles as small as r = 150 nm. Minute bubbles are created by UV-, VIS-, and IR fs pulses, and also by UV- and VIS ns pulses with smooth pulse shape. The scattering technique was used to establish an online dosimetry integrated into a commercial microbeam system.

TU-A-11:10

WAVELENGTH DEPENDENCE OF FEMTOSECOND LASER ABLATION THRESHOLD OF CORNEAL STROMA

F. Vidal1, G. Olivié1, D. Giguère1, T. Ozaki1, J.-C. Kieffer1, O. Nada2, and I. Brunette3 ;

1-Institut National de la Recherche Scientifique – Énergie, Matériaux et Télécommunications,1650, boulevard Lionel-Boulet, Varennes, QC, J3X 1S2, Canada

2-Department of Ophthalmology, Ain Shams University, Abbassia 11566, Cairo, Egypt

3- Department of Ophthalmology, University of Montréal, Maisonneuve-Rosemont Hospital Research Center, 5415, L'Assomption boulevard, Montréal, QC, H1T 2M4, Canada

We have measured the surface ablation threshold fluence of porcine corneal stroma for 100 fs laser pulses, with wavelengths between 800 nm and 1450 nm, generated by a Ti:sapphire-pumped optical parametric amplifier. The ablation threshold was found to vary only slightly within this wavelength range, between 1.5 and 2.2 J/cm2. The data suggest a rapid increase of the ablation threshold for wavelengths up to about 1000 nm, followed by a plateau for longer wavelengths. This behavior is partly confirmed by a simple theoretical model of the ablation process.

TU-A-11:30

SELECTIVE DAMAGE OF FILAMENTOUS CYANOBACTERIA WITH FEMTOSECOND PULSES

J.R. Vázquez de Aldana1, J.B. Arellano2, C. Méndez1, S. González-Pérez2, P. Moreno1, L. Roso1 ;

1- Servicio Láser, Universidad de Salamanca, Pl. La Merced SN, 37008 Salamanca, Spain

2- Departamento de Estrés Abiótico, Instituto de Recursos Naturales y Agrobiología de Salamanca (IRNASA-CSIC), Apdo. 257, 37071, Salamanca, Spain

The interaction of femtosecond laser pulses with filamentous cyanobacteria has been investigated. It has been possible to selectively damage a single cell with no apparent damage of the neighbours. The two different kind of cells present in the bacteria, vegetative cells and heterocysts, are found to have very different photo-disruption thresholds. For certain range of laser parameters the fluorescence of vegetative cells was inhibited suggesting permanent damage in the thylakoid membrane.

TU-A-11:50

QUANTIFIED FEMTOSECOND LASER BASED OPTO-PERFORATION OF LIVING CELLS

J. Baumgart1, W. Bintig2, A. Ngezahayo2, S. Willenbrock3, H. Murua Escobar3, W. Ertmer4, H. Lubatschowski1, and A. Heisterkamp1 ;

1- Laser Zentrum Hannover e.V., Hollerithallee 8, Hannover, Germany

2- Institute of Biophysics, Leibniz University Hannover, Herrenhaeuserstr. 2, Hannover, Germany

3- Small Animal Clinic, University of Veterinary Medicine, Bischofsholer Damm 15, Hannover, Germany

3- Institute of Quantum Optics, Leibniz University Hannover, Welfengarten 1, Hannover, Germany

Opto-perforation is an interesting alternative to conventional techniques for gene transfer into living cells. The cell membrane is perforated by femtosecond (fs) laser pulses, in order to induce an uptake of macromolecules. In this study, we successfully transfected cells with GFP vector. Transfected cells were not showing any signs of apoptosis or necrosis after 48 h. Based on simultaneously measured membrane potential changes, we calculated and experimentally verified that the relative volume exchanged is 0.4 times the total cell volume. Thus, for first time quantitative predication of the amount of uptaken molecules and therefore a quantification of transfection is possible.

TU-A-12:10

HIGH-THROUGHPUT ON-CHIP SMALL-ANIMAL SCREENING USING FEMTOSECOND LASER NEURO-SURGERY AND MICROFLUIDICS.

C. Rohde, F. Zeng, C. Gilleland, M. Angel, M. F. Yanik ; Massachusetts Institute of Technology, Department of Electrical Engineering and Computer Science

We demonstrate on-chip in vivo small-animal genetic and drug screening technologies for high-throughput neural degeneration and regeneration studies. Our high-throughput microfluidic platform allows real-time immobilization of animals without use of anesthesia, and sub-cellular resolution multi-photon imaging on physiologically active animals. Using femtosecond laser micro/nano-surgery and pattern recognition algorithms, we can perform sub-cellular precision neuro-surgery on awake but immobilized animals in our microfluidic chips with minimum collateral damage within seconds. We also show technologies for interfacing with drug/RNAi libraries. These technologies can allow for the first time in vivo high-throughput genetic/drug screens for neural degeneration and regeneration following injury.

LASER PROCESSING FOR BIOLOGICAL APPLICATIONS 2 (BIO 2)
SESSION CHAIRS: K. DHOLAKIA, S. LAZARE

TU-A-14:00

NONLINEAR OPTICS IN VIVO: USING LIGHT TO INDUCE AND STUDY CEREBROVASCULAR DISEASE IN RODENTS

N. Nishimura1, J. Nguyen1, N. L. Rosidi1, J. Zhou1, F. A.Medina1, C.o Iadecola2, and C. B. Schaffer1;
1. Department of Biomedical Engineering, Cornell University, Ithaca, NY, USA
2. Department of Neurology and Neuroscience, Weill Cornell Medical College, New York, NY, USA

Tightly-focused femtosecond laser pulses provide a unique tool that allows the three-dimensionally localized disruption of specifically targeted biological structures, in vivo. Here, we use this capability to injure individual blood vessels in the brain of an anesthetized rodent in order to mimic cerebrovascular diseases found in humans that are linked to the development of dementia. Using this novel animal model of small stroke, we study the blood flow changes and loss of cell health and function that results from microvascular lesions.

TU-A-14:30

PRINCIPLES OF LASER-INDUCED DISSECTION AND TRANSPORT OF HISTOLOGIC SPECIMENS AND LIVE CELLS

A. Vogel1, K. Lorenz1, V. Horneffer1, G. Hüttmann1, D. von Smolinsky2, A. Gebert2;
1- Institute. of Biomedical Optics, University of Lübeck, Peter-Monnik Weg 4, 23562 Lübeck, Germany
2- Institute of Anatomy, University of Lübeck, Ratzeburger Allee 160, 23538 Lübeck, Germany

Laser microdissection (LMD) and laser catapulting (LC) at 337 nm were investigated by time-resolved photography, and side effects assessed by thermal calculations, real-time RT-PCR, and recultivation studies. LMD relies on plasma formation, and LC on plasma formation or explosive ablation, depending on laser spot size. Pressures up to 700 MPa accelerate histologic specimens to up to 300 m/s, and cells to 50-60 m/s. Catapulting with tightly focused or strongly defocused pulses results in little collateral damage, while slight defocusing involves significant heat and UV exposure. Optimum strategies for transporting live cells adherent to a polymer membrane were identified.

TU-A-14:50

SECOND HARMONIC DIAGNOSTICS FOR LASER WELDING AND ABLATION OF SOFT BIOTISSUE

A. Lalayan; Yerevan State University, Physics Department, 1A.Manoogian St.r ,Yerevan, 375025, Armenia

Nonlinear optical phenomenon of the second harmonic generation (SHG) was used to monitor the photothermal processes induced during CW laser irradiation. A picosecond YAG:Nd beam with 1064nm and the pulse duration of timp=33ps was used for probing. The second harmonic response from welded and ablated area of the skin samples has been measured. After the laser welding of chicken skin sample, the SHG radiation decreased by a factor of 1.7 times in area of the irradiation. As a result of the laser ablation of the same sample the SHG nonlinear signal increased by a factor of 2.

TU-A-15:10

THICK FILM LASER INDUCED FORWARD TRANSFER OF GENETICALLY ENGINEERED MAMMALIAN CELLS FOR TISSUE ENGINEERING APPLICATIONS

N. Kattamis1, D. Cohen1, P. Purnick2, R. Weiss2, Cr. Arnold1,2;
1-Department of Mechanical and Aerospace Engineering, Princeton University

2- Department of Electrical Engineering, Princeton University, Princeton, NJ, 08544, USA

Laser forward transfer processes incorporating thin absorbing films can be used to deposit robust organic materials, but the deposition of more delicate materials has remained elusive due to contamination and stress induced during the transfer process. Here, we present the approach to high resolution patterning of sensitive materials by incorporating a thick-film polymer absorbing layer that is able to dissipate shock energy through mechanical deformation. Deformation of the polyimide film is modeled, showing good agreement with experimental measurements. Using this technique we show viable and contamination free deposition of genetically-engineered mammalian embryonic stem cells with the appropriate biochemical response.

TU-A-15:30

OPTICAL TWEEZERS AND INTEGRATED WAVEGUIDE SYSTEM FOR CELL SELECTION AND TRANSPORT IN POLYMER MICROFLUIDIC DEVICES.

L.Charron, D. Shah, C. L.Lilge ; University of Toronto, Princess Margaret Hospital/Ontario Cancer Institute, 610 University Avenue,7th floor, room 306, M5G 2M9, Toronto, Ontario

A laser-based optical system for cell selection and passive transportation inside polymer microfluidic device is presented. The combination of optical tweezers and integrated polymer waveguides are used to select, manipulate and transport multiple cells in a network of channels. The devices were fabricated using a cost effective master-based replication technique using laser micromachining. The combined optical tweezers and integrated waveguides system provides a very attractive fast, semi-automated and minimally invasive method to manipulate cell motion in microfluidic devices

TU-A-15:50

LASER MICROPRINTING ON CHEMICAL AND BIOSENSORS

I. Zergioti1, C. Boutopoulos1, P. Andreakou1, D. Goustouridis2, V. Tsouti2, S. Chantzandroulis2, D. Kafetzopoulos3 ;
1-National Technical University of Athens, Physics Department, Iroon Polytehneiou 9, 15780
Zografou, Athens, Greece
2 -NCSR Demokritos, Instute Microelecronics, Aghia Paraskevi 15310, Greece
3-Foundation for Research & Technology – Hellas, Institute of Molecular Biology and
Biotechnology, P. O. Box 1527, Heraklion 71110, Greece.

We describe highly sensitive, label free, multiplexed electrical detection of bio and chemical reactions using capacitive sensors array. We have used liquid phase Laser Induced Forward Transfer process (LIFT) of biomaterials and chemical compounds on capacitive sensors

FUNDAMENTALS OF LASER-MATERIALS INTERACTION (FUNDAMENTALS)

SESSION CHAIRS: H. HELVAJIAN, H. NINO

TU-B-10:50

NANOSTRUCTURE FORMATION UPON FEMTOSECOND LASER ABLATION: THE ROLE OF PULSE REPETITION RATE

O. Varlamova, G. Jia, R. P. Schmid, J. Reif; Brandenb. Tech. Univ. Cottbus and Cottbus JointLab, Kónrad-Wachsmann-Allee 1; 03046 Cottbus; Germany

The long-time dynamics of nanostructure formation upon fs laser ablation is investigated by varying the pulse-to-pulse separation time. It is found that for high repetition rates transient surface modifications are important while for a large pulse-to-pulse separation permanent damage plays a crucial role via, e.g., local field enhancement

TU-B-11:10

ABLATION OF DIELECTRIC MATERIALS BY FEMTOSECOND LASERS : FROM ELEMENTARY PROCESSES TO CRATER'S DEPTH

S. Guizard, G. Geoffroy, G. Petite; Laboratoire des Solides Irradiés, CEA/CNRS/Ecole Polytechnique/CNRS/Ecole Polytechnique, 91128 Palaiseau, France.

Our research concerns the fundamental mechanisms occurring during the interaction of intense femtosecond laser pulse with dielectric materials. A key parameter is the energy balance of the interaction. We have measured both the density of excited carriers, with a time resolved pump-probe interferometric set-up, and their energy distribution, by photoelectron spectroscopy. Thus we can estimate the amount of energy transferred from the light pulse to the solid. Knowing this, we can simulate the interaction and calculate the crater's depth. We will discuss the influence of laser parameters (wavelength, pulse duration and energy) on the ultimate machining precision.

TU-B-11:30

INVESTIGATION OF PLASMA AND SHOCK-WAVE DYNAMICS AND PROPERTIES INSIDE HOLES DURING LASER DRILLING OF METALS

M. Brajdic, M. Hermans, A. Horn, I. Kelbassa; Lehrstuhl für Lasertechnik der RWTH-Aachen, Steinbachstrasse 15, 52074 Aachen, Germany

A novel method for investigating in-situ plasma and shock-wave dynamics inside a confined space like a laser drilled hole in metals is presented. A specific sample preparation with prepared mock-up holes including a transparent material as window is used. By use of high speed imaging and spectroscopy a time and spatially resolved monitoring of the optical emissions of plasma and shock-waves is realized during drilling stainless steel and aluminum with ns-pulsed laser radiation. Spatial intensity distributions and the velocities of the shock-waves and the plasma and the electron densities and temperatures are measured inside the holes with a temporal resolution of 1 ns and a spatial resolution of < 1 µm.

TU-B-11:50

CONTROLLABLE LIQUID-BUBBLES JET DRIVEN BY FEMTOSECOND LASER INDUCED BREAKDOWN IN LIQUID

S. Oshemkov1, L. Dvorkin2, V. Dmitriev1;

1-Pixer Technology, Maale Camon 44 Karmiel 21613 Israel

2-Lasermax Engineering, Harimon 11/3, Akko, Israel

The peculiarities of liquid-bubbles flow formation in liquid driven by ultrafast high repetition rate laser induced breakdown initiated in the vicinity of a flat or curved liquid – gas boundary are investigated. It is shown that under certain experimental conditions a liquid-bubbles jet directed away from the boundary is created. The jet originates in the breakdown zone and is directed along the perpendicular to the boundary. The length of the jet depends on the kind of liquid, laser pulse parameters and the distance between the beam focus point and the liquid – gas boundary and may reach several centimeters.

TU-B-12:10

FABRICATIONS OF UV LIGHT EMITTING DIODES USING ZNO NANOWIRES SYNTHESIZED BY NANOPARTICLE-ASSISTED PULSED LASER DEPOSITION

R. Guo1 J. Nishimura2 M. Matsumoto2, M. Higashihata2 and T. Okada2;

1- Laboratory of Advanced Materials, Fudan University, Shanghai 200433, China

2- Graduate School of Information Science and Electrical Engineering, Kyushu University, Fukuoka 819-0395, Japan

I am going to present our recent progresses in the synthesis of ZnO nanowires by nanoparticle-assisted pulsed-laser deposition and their applications to UV light emitting diodes.

LASER 3-D MICROFABRICATION (3-D MICROFAB)
SESSION CHAIRS: A. PIQUE, E. OHMURA

TU-B-14:00

LASER–INDUCED OXIDATION OF THIN METALLIC FILMS: SUPERRESOLUTION IN THEORY AND IN PRACTICE

V.P.Veiko, A.G. Poleshchuk, V. P. Korolkov, E.A. Shakhno;

St.Petersburg State University of Information Technologies, Mechanics and Optics, 49 Kronverksky pr., 197101, St.Petersburg, Russia; and Institute of Automation & Electrometry Siberian Branch of Russian Academy of Sciences, 1 Acad. Koptjug pr., 630090, Novosibirsk, Russia

Laser–induced oxidation on thin metallic films with following selective etching is a powerful method for micropatterning of different structures like photomasks, diffractive optical elements etc.

TU-B-14:20

FABRICATION OF PLASMONIC WAVEGUIDES BY NANO IMPRINT LITHOGRAPHIC REPLICATION

C. Ohrt, S. Passinger, A. Seidel, R. Kiyan, C. Reinhardt and B. Chichkov; Laser Zentrum Hannover e.V. , Nanotechnology-Department, Hollerithallee 8, D-30419 Hannover Germany

Using modern laser fabrication techniques such as Two-Photon polymerisation (2PP) resolutions of less then 300 nm could be achieved. Advantages of 2PP can be exploited by combining it with Nano Imprint Lithography (NIL). We report on the fabrication of plasmonic waveguides by NIL technique with Polydimethylsiloxan (PDMS). The fabrication process benefits in two ways from this combination of 2PP and NIL. First of all ones a PDMS stamp is generated, very reproducible replicas of the master can be created in fast and cheap process. Secondly, putting the mould under a tensile stress can make structures narrower in one dimension.

TU-B-14:40

GENERATION OF PHOTONIC CRYSTAL END FACES USING LASER MICROFABRICATION

T. Schweizer1, A. Neumeister1, Q. Guo1, W. Wohlleben2, R.J. Leyrer2, R. Kling1, A. Ostendorf1;

1- Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover, Germany

2- BASF Aktiengesellschaft, 67056 Ludwigshafen, Germany

In this paper, we present a number of laser microfabrication methods to generate high quality end faces of photonic crystal templates. We have produced opal templates of 1 µm polystyrene spheres with 20-30 µm thickness on 20x20 mm cover glasses using the self-assembly technique. In order to gain access to the useable area in the centre of the polystyrene opals we modified the cover glass substrates and the opals with pulsed ns and ps

UV lasers. By writing micro grooves into the substrate and by fabricating polymer microstructures on top of the substrates we generated crystal end faces accessible for direct fibre coupling.

TU-B-15:00

LASER FABRICATION AND MANIPULATION OF OPTICAL ROTATOR EMBEDDED INSIDE A TRANSPARENT SOLID MATERIAL

S. Kiyama, T. Tomita, S. Matsuo, S. Hashimoto; Department of Ecosystem Engineering, The University of Tokushima,2-1 Minamijosanjima-cho, Tokushima, 770-8506, Japan

An optical rotator was fabricated inside a vitreous quartz substrate by femtosecond laser-assisted etching process. A mirocavity was fomed inside the substrate with leaving the optical rotator region unetched. Thus a movable rotator with the material is identical to that of the host substrate was fabricated. The laser manipulation technique was applied to rotate the object with dissymmetrical shape in the cavity filled with water. The rotation speed observed was 98 rpm at a laser power of 4 W. This type rotator may act as a micro pump and mixer.

TU-B-15:20

3D PHOTOFABRICATION BY FEMTOSECOND LASER PULSES AND ITS APPLICATIONS IN BIOMEDICINE

A. Ovsianikov, and B. Chichkov; Laser Zentrum Hannover e.V., Hollerithalee 8, 30419 Hannover, Germany

In this contribution, we will present our recent results on three-dimensional microstructuring of photosensitive materials by multiphoton illumination technique. Recently, we studied possible applications of multiphoton illumination technique in biomedicine. The reproducibility, speed of fabrication, and precision of manufacturing, show a great potential of this technology for applications in this area. Investigations on the mechanical and chemical properties of the fabricated structures, as well as biocompatibility will be presented. Numerous examples of fabricated structures for applications in biomedicine will be demonstrated.

TU-B-15:40

PLASMONIC METAMATERIALS PRODUCED BY TWO-PHOTONINDUCED PHOTO REDUCTION TECHNIQUE

T. Tanaka; RIKEN, Metamaterials laboratory, 2-1 Hirosawa, Wako, Saitama 351-0198, JST PRESTO

Plasmonic metamaterials are artificially designed materials. By engineering such materials, we can control the magnetic permeability even in the optical frequency region in which all materials in nature lose magnetic response. In this paper, as a fabrication technique of plasmonic metamaterials, we report a technique that enables fabrication of three-dimensional (3D) metallic microstructures with a resolution of nano-scale by means of two-photon-induced metal-ion reduction. We demonstrate fabrications of continuous and electrically conductive silver or gold 3D structures self-standing on the substrates. In the presentation, the magnetic response of the plasmonic metamaterial fabricated by this technique is also discussed.

WEDNESDAY 18 JUNE

LASER PROCESSING FOR BIOLOGICAL APPLICATIONS 3 (BIO 3)

SESSION CHAIRS: A. DUNCAN, I. ZERGOTI

WE-A-08:30

LASER-INDUCED CATAPULTING AND MICRODISSECTION OF BIOMATERIALS AND LIVE CELLS

R. Gangnus; Carl Zeiss MicroImaging, Germany

Laser as a tool to manipulate and dissect in a microscopic scale to generate pure samples for biomedical research and guarantee contamination-free analysis.

WE-A-09:00

PLASMONIC LASER NANOSURGERY OF CELLS USING FEMTOSECOND LASER ABLATION IN THE NEAR-FELD OF GOLD NANOPARTICLES

D. Eversole, N. Durr, and A. Ben-Yakar ; Mechanical and Biomedical Engineering Departments, University of Texas at Austin, Austin, TX, 78712, USA

We will present our studies on plasmonic laser nanosurgery (PLN) of biomaterials. This technique takes advantage of surface-enhanced plasmonic scattering of ultrashort pulses in gold nanoparticles to ablate subcellular structures in atto-litter volumes. While the use of fs-laser pulses ensures non-thermal tissue ablation, the use of nanoparticles acting as “nano-lenses” improves the precision and selectivity of the ablation/surgery process. This technique can be used as a high precision noninvasive tool for manipulation of nano structures inside living cells and organisms as well as a removal tool for the treatment of diseases where minimal collateral damage of surrounding tissue is vital.

WE-A-09:20

ULTRAFAST LASER INDUCED HEATING OF NANOPLASMONIC STRUCTURES ON BIOLOGICAL TISSUES

E. Boulais, M. Meunier ; Laser Processing Laboratory, Ecole Polytechnique de Montreal, Department of Engineering Physics, Succursale CentreVille, PO Box 6079, Montreal, PQ, Canada , H3C 3AY

Interest in hyperthermia therapy for tumor destruction is stimulated by recent advances in plasmonic nanostructures synthesis. Structures such as nanorods exhibit plasmon resonance in the near infrared portion of the spectrum, enabling treatment in deep tissues. However, there is a lack of a quantitative description of the temperature profile induced in the tumor and its surrounding by the process. In the present study, 3D electromagnetic field distribution and tissue transient temperature distribution is calculated for embedded gold nanoplasmonic structures after an interaction with an ultrafast laser pulse. Using this model, temperature profile induced is calculated for different types of nanostructure.

WE-A-09:40

SILICON NANOPARTICLES PRODUCED BY FEMTOSECOND LASER ABLATION AS PHOTOSENSITIZERS IN PHOTODYNAMIC THERAPY

D. Rioux1, M. Laferrière1, D. Shah2, S. Douplik2, L. Lilge2, A. V. Kabashin1 and M. Meunier1;

1- Laser Processing Laboratory, Department of Engineering Physics, École Polytechnique de Montréal, Case Postale 6079, Succ. Centre-ville, Montréal, Québec, Canada, H3C3A7

2- Ontario Cancer Institute, University of Toronto, Princess Margaret Hospital, 610 University avenue, Toronto, Ontario, Canada, M5G 2M9

We propose a femtosecond laser-assisted method for the synthesis of small and low-dispersed silicon colloidal NP at room temperature in non-aggressive liquids such as deionized water, rendering this process very environment friendly. This method can produce ultrasmall nanoparticles (~ 2.4 nm) at low laser fluence. Such nanoparticles are of great interest as photosensitizers in photodynamic therapy since they induce production of singlet oxygen that kills cancer cells. Indeed, early experiments have shown that our silicon nanoparticles can kill cancer cells upon illumination. Furthermore, we do not observe any photobleaching of the nanoparticles, a limitation of actual photosensitizers.

WE-A-10:00

CELL AND PROTEIN INACTIVATION WITH OPTICAL ABSORBERS

R. Rahmanzadeh1, T. Scholzen2, J. Gerdes2, G. Hüttmann1;

1-Institute of Biomedical Optics, University of Lübeck, Peter-Monnik-Weg 4, D-23562 Lübeck, Germany

2-Research Center Borstel, Dept. of Immunology and Cell Biology, Div. of Tumour Biology, Parkallee 22, D-23845 Borstel, Germany

Optical absorbers in combination with light irradiation are valuable tools for cell and protein inactivation with high spatiotemporal precision. In vitro studies on protein inactivation using strongly absorbing gold particle-antibody-conjugates showed a fragmentation of the target protein upon irradiation (nanoparticle-assisted laser inactivation, NALI), while irradiation of fluorescent dye labeled antibodies led to specific crosslinking (chromophore-assisted laser inactivation, CALI). Selective cell killing could be observed with NALI. With CALI, a successful inactivation of the cell proliferation associated Ki-67 protein was found in living cells on sub-nuclear level. The resulting inhibition of rRNA-synthesis inside the nucleoli represents the first functional evidence for the physiological role of pKi-67 in living cells.

LASER PROCESSING FOR BIOLOGICAL APPLICATIONS 4 (BIO 4)

SESSION CHAIRS: R. GANGNUS, A. VOGEL

WE-A-10:50

IN-SITU BIOCONJUGATION –TAILORED NANOPARTICLE BIOCONJUGATES BY LASER ABLATION IN BIOACTIVE MEDIA

S. Petersen, J. Jakobi, S. Barcikowski; Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover, Germany

Ultra short pulsed laser ablation in liquids has evolved as a powerful tool for nanoparticle generation showing advantages in the nearly unlimited material variety and purity. We perform the ablation in solutions containing bioactive reagents, realizing an in-situ bioconjugation of the nanoparticles. This novel method enables the generation of diverse nanoparticle bioconjugates, demonstrated at the example of DNA and peptides. A novel route to the development of nanomaterials with added value for biomedical applications is presented.

WE-A-11:10

PRODUCTION OF BIOACTIVE NANOMATERIAL USING LASER GENERATED NANOPARTICLES

A. Hahn, S. Barcikowski; Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover, Germany

In recent years the use of nanotechnology is one of the most promising fields to enhance material properties for instance for biomedical applications. In our study we present a route to design bioactive materials using laser

generated nanoparticles in different media addressing two effects: nanocomposites (drug release) and nanosurfaces. The nanoparticle size, stability and generation rates are investigated in different media. First results on the ion release which causes the bioactive properties of the nanocomposite are shown. Overall, we present a laser-based access to two types of bioactive nanomaterials.

WE-A-11:30

SELECTIVE LASER SINTERING OF CALCIUM-POLYPHOSPHATE: EXPERIMENTAL AND FINITE ELEMENT ANALYSES ON TEMPERATURE AND DENSITY DISTRIBUTIONS

Y. Shanjani1, E. Toyserkani1, R. M. Pilliar2;

1- Rapid Prototyping Laboratory, Department of Mechanical and Mechatronics Engineering, University of Waterloo,Waterloo, ON, Canada

2- Department of Dentistry, University of Toronto, Toronto, Canada

In this work, the selective laser sintering process of a bio-composite blend comprising of biodegradable Calcium Polyphosphate (CPP) and Polyvinyl Alcohol (PVA), as a polymeric binder, was investigated. A multi-physics finite element model which includes both thermal analysis and viscous sintering phenomenon was developed and simulated for different process conditions. An increase of the temperature and a decrease of the porosity in the heat affected zone were observed in the finite element results. The thickness of the fabricated CPP layer using the experimental setup demonstrated a close agreement with the simulation.

WE-A-11:50

PICOSECOND AND FEMTOSECOND LASER MACHINING MAY CAUSE HEALTH RISKS RELATED TO NANOPARTICLE EMISSION

S. Barcikowski, A. Hahn, J. Walter; Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover, Germany

It is well known that nanoparticles are generated as by-products during ultrashort-pulsed laser ablation. Although nanoparticles are well known as potential health risk there is still a lack of data to be compared with regulatory limits of ultrafine dust workplace concentration and related toxicity thresholds. In order to provide safety-related statements on nanoparticles generated during laser micromachining in air, we studied the particle size distribution during picosecond (ps) and femtosecond (fs) laser ablation. We present for the first time a comparison and risk assessment of ps versus fs generated airborne nanoparticles.

WE-A-12:10

LASER ABLATION AND CELL BIOLOGY

A. Duncan ; Université de Rouen, France

The recent introduction of microelectronics technology in the area of biological sciences has brought forth previously unforeseeable applications such as DNA and protein biochips or scaffolds for controlled cell growth. We have developed and investigated a new method using “cold” excimer laser beam in order to delineate critical microscopic surface features effects on cell-material interaction. These results are promising in that they provide a new conceptual model and tool for the study of cell biology and cell response to surface 3-D and 2-D features on the same size scale as the cell. Potential applications cover the fields of biosensor, biomedical, biomaterial and pharmaceutical engineering sciences.

LASER MICROMACHINING 1 (MICROMACHINING-1)

SESSION CHAIRS: K. SUGIOKA, X. LIU

WE-A-14:00

LASER BASED RAPID FABRICATION OF SiO2-PHASE MASKS FOR EFFICIENT UV-LASER MICROMACHINING

J. Ihlemann, R. Weichenhain-Schriever; Laser-Laboratorium Göttingen, Hans-Adolf-Krebs-Weg 1, 37077 Göttingen, Germany

Laser based rapid fabrication of SiO2-phase masks for efficient UV-laser micromachining J. Ihlemann, R. Weichenhain-Schriever The laser based fabrication of surface relief SiO2 phase masks is demonstrated: First, a UV-absorbing coating of silicon monoxide (SiO) is deposited on a fused silica substrate. Second, the SiO-coating is patterned by excimer laser ablation to form the desired phase structure. Third, the SiO-material is oxidized to UV-transparent silicon dioxide (SiO2). Applications of these phase masks in combination with suitable imaging optics for efficient laser micro machining are demonstrated.

WE-A-14:30

SURFACE MICRO-STRUCTURING OF SILICA GLASS BY LASER-INDUCED BACKSIDE WET ETCHING

H. Niino, Y. Kawaguchi, T. Sato, A. Narazaki, and R. Kurosaki ; Photonics Research Institute (PRI), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba Central 5, 1-1-1 Higashi, Tsukuba, Ibaraki 305-8565, Japan

(Please put my presentation into Monday to Wednesday sessions. I prefer Oral but Poster is OK.) We have investigated a one-step method to fabricate a microstructure on a silica glass plate by using laser-induced backside wet etching (LIBWE) that consists of diode-pumped solid state (DPSS) laser beam scanning system. Well-defined deep microtrenches without crack formations on a fused silica glass plate were fabricated by LIBWE method with the UV lasers. In the LIBWE technique, protection layer, that is indispensable in conventional lithography processing, is unnecessary on the material surface. The new system allows us to use rapid prototyping of high precision surface microfabrication of silica glass as laser direct-write processing.

WE-A-14:50

HELICAL DRILLING WITH ULTRASHORT LASER PULSES

Th. Hoeche 1,2, M. Lasch1, B. Keiper1, T. Petsch1;

1- 3D-Micromac AG, Annaberger Straße 240, D – 09125 Chemnitz, Germany

2- also with: Leibniz Institute for Surface Modification, Permoser Straße 15, D – 04318 Leipzig, Germany

Helical drilling with a picosecond laser is applied to machine micro holes in various materials. Cross-sections are used to demonstrate the performance in terms of inner wall smoothness, extension of the heat affected zone and overall shape of the hole's directrix. Pros and cons of the technology are discussed as well as further developments beyond drilling of individual holes.

WE-A-15:10

FABRICATION OF MICRO MOULDS AND DIES USING PRECISION LASER MICROMACHINING AND MICROMILLING TECHNOLOGIES

E. Bordatchev and S. Nikumb; Industrial Materials Institute, National Research Council of Canada, 800 Collip Circle, London, Ontario, Canada N6G 4X8

This paper presents results obtained from studies on the laser micromachining and micromilling technologies. Specific examples of micro mould and dies, fabricated using these techniques, are presented. The process parameters using laser micromachining technique were investigated for 2D and 2½D features and results on several micro dies fabricated with a surface roughness > 70 nm and with contour geometric errors within +/-2 µm are reported. Case studies on three micro dies fabricated from different materials and with different geometries using laser micromachining and micromilling technologies, challenges met during microfabrication and results on geometric quality are presented.

WE-A-15:30

EXCIMER LASER MICROMACHINING OF LINBO3 FOR OPTICAL AND MICROWAVE APPLICATIONS

E. Mortazy1, K. Wu1, M. Meunier2;

1- Poly-Grames Research Center, École Polytechnique de Montreal, Montreal, H3T 1J4, Canada

2- Laser Processing Laboratory, École Polytechnique de Montreal, Montreal, H3T 1J4, Canada

In this paper, cutting the LiNbO3 wafer, creating a ridge optical waveguide and fabricating a specific pattern of holes for microwave applications by 248nm Excimer laser are presented.

WE-A-15:50

CO2 LASER AND MECHANICAL CLEAVING OF OPTICAL FIBERS FOR MECHANICAL SPLICING: A COMPARATIVE STUDY

M. Levesque1, R. Beaulieu1, E. Weynant2, M. Bergeron2, N. Tovmasyan2;

1 – INO, 2740 Einstein Street, Sainte-Foy, Québec, G1P 4S4, Canada

2 – PhasOptx Inc., Lab & Production Facility, 2740 Einstein Street, Suite 1013, Québec, QC, G1P 4S4, Canada

An experimental setup has been realized to cleave optical fibers using a liquid-cooled slab waveguide CO2 laser (DEOS LC-100NV). In a comparative study, experimental results related to laser cleaved fiber-to-fiber and mechanically cleaved fiber-to-fiber connection losses will be presented. Mechanical splices for single-mode and multimode fibers have been realized and insertion losses have been measured using computer-controlled fusion-splicing apparatus to align the optical fibers. Also, mechanical splices for two fibers with different tip shapes have been tested. Insertion losses of mechanical splices and "Shape memory alloy" mechanical splices have been compared.

LASER MICROMACHINING 2 (MICROMACHINING-2)

SESSION CHAIRS: J. IHLEMANN, T. TANAKA

WE-A-16:40

OBSERVATION OF THIN FILM REMOVAL BY "GI-LDE" (GRAZING INCIDENCE METHOD WITH LASER-DRY-ETCHING)

N. Fukuda, Y. Kunishio, S. Nakayama;

Hitachi Zosen Corporation, 2-11, Funamachi 2-Chome, Taisho-ku, Osaka, 551-0022, Japan

Laser-dry-etching method has attracted a great deal of interest in industry because it has many potential benefits. However, the laser-dry-etching method takes a long time to process a large area due to the high energy needed to concentrate on a small area. The authors have developed a new etching method so called “grazing incidence method with laser-dry-etching (GI-LDE)”. This system tries to balance between processing speed to processing quality. The authors have used high speed camera to observe thin film removal by GI-LDE due to understanding this phenomena. In this paper, observation results of thin film removal are discussed.

WE-A-17:00

ADAPTIVE CONTROL FOR FULL PENETRATION IN MICRO LAP SEAM WELDING WITH FIBER LASER

Y. Kawahito1, T. Ohnishi1, S. Gouriki2, H. Nakamura3 and S. Katayama1;

1- Joining and Welding Research Institute, Osaka University, 11-1 Mihogaoka, Ibaraki, Osaka, 567-0047, Japan

2- Industrial Technology Center of Fukui Prefecture, 16-10 Washizukacho, Fukui, Fukui, 910-0102, Japan

3- Horikawa Inc., 6-8 Kawasaricho, Sabae, Fukui, 916-0088, Japan

A fiber laser is supposed to be one of desirable heat sources for adaptive control of laser power as well as its excellent beam quality enough to be applied for micro welding.

WE-A-17:20

IMPROVEMENT OF PRODUCTIVITY AT MICRODRILLING IN STEEL WITH ULTRASHORT PULSED LASER RADIATION

M. Kraus1, S. Collmer2, S. Sommer1, F. Dausinger1;

1- FGSW Forschungsgesellschaft für Strahlwerkzeuge mbH, Pfaffenwaldring 43, 70569 Stuttgart, Germany

2- TGSW Technologiegesellschaft für Strahlwerkzeuge mbH, Rotebühlstraße 87, 70178 Stuttgart, Germany

The fabrication of high-precision microholes in metals is required in various industrial applications, for example in the field of dosing or injection technology. It has been shown in a variety of publications that the use of picosecond laser pulses enables the production of microholes of high quality and contour accuracy without post processing. Limiting the pulse energy with the objective of melt reduction and precision enhancement, however, leads to insufficient process efficiency. The investigations presented in this article are focused on improving productivity at helical drilling in austenitic steel using modern picosecond laser sources combined with adequate processing technology.

WE-A-17:40

EXTENSIVE MICRO-STRUCTURING OF METALS USING PICOSECOND PULSES – ABLATION BEHAVIOUR AND INDUSTRIAL RELEVANCE

A. Ostendorf, R. Kling, U. Klug, F. Siegel; Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover, Germany

The micro-structuring of technical surfaces is an effective technique to change their characteristics. Therefore, laser-based generation of defined micro-structures on extensive metallic surfaces for fluidic purposes is under development. Micro-machining of metals using a ps-Nd:YVO4-laser source has been investigated. To get a general understanding about the ablation behaviour, eight different metals have been analysed. Based on these results, the presented paper shows an approach for Riblet generation, where the metallic surface is direct-structured. The machined compressor blades are tested in a cascade wind tunnel. The achieved results for reducing skin friction as well as an efficiency-consideration regarding industrial applications will be discussed.

WE-A-18:00

INFLUENCE OF THICKNESS IN LASER SCRIBING OF GLASS AND CRACK PROPAGATION BY LASER IRRADIATION ALONG LASER SCRIBED LINE

K. Yamamoto1, N. Hasaka2, H. MoritaA2 and E. Ohmura1;

1- Graduate School of Engineering, Osaka University 2-1 Yamadaoka, Suita, Osaka, Japan

2- Mitsuboshi Diamond Industrial Co., Ltd. 2-12-12 Minami-kaneden, Suita, Osaka, Japan

In the laser scribing of glass, thermal stress is induced by a CO2 laser and a water jet. In this study, influence of the thickness of the glass substrate, and crack propagation by laser irradiation along the laser scribed line are discussed by two-dimensional thermal-elasticity analysis. As a result, the scribing condition can be estimated by maximum surface tensile stress and maximum temperature in any thickness. And compressive stress is generated on the glass surface due to laser irradiation, and tensile stress generated inside concentrates at the crack tip and the crack penetrates in the depth direction.

WE-A-18:20

LASER MICROJET FOR HIGH PRECISION DRILLING OF MECHANICAL DEVICES SUCH AS FUEL INJECTION NOZZLES

A. Brulé 1, J-B. Deschamps 1, B. Richerzhagen 1, H. H. Levine 2 ;

1- Synova SA, Ch. de la Dent d'Oche, 1024 Ecublens, Switzerland

2- Synova Inc USA, 48521 Warm Springs Blvd., suite 314, Fremont CA 94539, USA

Laser MicroJet for High Precision Drilling of Mechanical Devices such as Fuel Injection Nozzles. Manufacturing of injection nozzles necessitates a drilling precision of ± 2 µm. Cut quality is also a critical requirement. Presently, the main process used is EDM, a method known for its cut quality, but implying a long processing time. Water jet-guided laser has proven to be even more suited to the micromachining of these parts. Due to the cooling effect provided by the water jet between laser pulses, the cut edges are immediately cooled and the material does not suffer from thermal effects nor mechanical damage. Tool replacements and post-processing are also avoided.

FEMTOSECOND LASER PROCESSING 1 (FEMTO-1)

SESSION CHAIRS: J. SOLIS, K. ITOH

WE-B-08:30

MICROMACHINING WITH A HIGH REPETITION RATE FEMTOSECOND FIBER LASER

F. Yoshino1, L. Shah2, M. Fermann2, A. Arai1, Y. Uehara2;

1- IMRA America, Inc., Applications Research Laboratory, 48834 Kato Road, Suite 106A, Fremont, CA 94538 U.S.A.

2- IMRA America, Inc., 1044 Woodridge Avenue, Ann Arbor, MI 48105 U.S.A.

Industrial micromachining applications with ultrashort pulse lasers are often difficult to make practical due to the lack of robustness of the laser and the slow processing speed resulting from the low repetition rate. The FCPA µJewel D-1000 has a flexible performance range that includes 10-µJ pulses at 100 kHz and 1-µJ pulses at 1 MHz. The µJ pulses at 100 kHz or higher repetition rates enable some interesting micromachining processes, particularly with transparent dielectric materials. This paper expands our previously reported work on micromachining of transparent materials using a high repetition rate, femtosecond fiber laser.

WE-B-08:50

SINGLE-SHOT NANOMILLING OF COPPER SURFACES USING FEMTOSECOND NEAR-INFRARED LASER PULSES

C. K. Wen, S. E. Kirkwood, Y. Y. Tsui, R. Fedosejevs ; Laser Plasma Applications Laboratory, Department of Electrical and Computer Engineering, University of Alberta, Edmonton, Canada T6G 2V4

We have demonstrated near-infrared femtosecond laser pulse nanomilling of copper thin film surfaces to depths smaller than the optical penetration depth. To further our investigation into the mechanism of nanomilling, a time-of-flight (TOF) technique was used as a real time monitor of ablated ions in conjunction with photomultiplier tube (PMT) measurements of the copper emission line at 326 nm. The single-shot results showed two distinct ablation

regimes when measured by optical interferometric profilometry: nanometer depth ablation at very low fluences and tens of nanometer depth ablation at higher fluences.

WE-B-09:10

USE OF HIGH REPETITION RATE AND HIGH POWER LASERS IN MICROFABRICATION: HOW TO KEEP THE EFFICIENCY HIGH?

G. Račiukaitis, M. Brikas, P. Gečys, B. Voisiat, M. Gedvilas ; Laboratory for Applied Research, Institute of Physics, Savanoriu Ave. 231, LT-02300 Vilnius, Lithuania

Numeric simulation and experiments were performed to find out conditions of the efficient use of laser energy in ablation of metals and silicon. Accumulation of defects lowered the ablation threshold when a high pulse-repetition rate was applied. The volumetric ablation rate was affected by the pulse energy. An optimum beam waist existed for certain pulse energy to maximize the ablation but the waist did not allow achieving a high accuracy. Energy efficiency of the laser processing fell down at higher pulse energies. The limiting factor in the energyc ablation efficiency of the picosecond laser was plasma formation at the specimen surface.

WE-B-09:30

MICRO AND NANO FABRICATION OF GAN BY WET CHEMICALS-ASSISTED FEMTOSECOND LASER ABLATION

S. Nakashima, K. Sugioka, K. Midorikawa; RIKEN:The Institute of Physical and Chemical Research

We have investigated 3D micro and nano fabrication of wide-bandgap semiconductor GaN using femtosecond laser. Nanometer scale crater is successfully formed by wet chemicals-assisted fs laser ablation, in which the laser beam is focused on single-crystal GaN substrates in an HCl acid solution. This method can efficiently remove the ablation debris due to chemical reaction, resulting in high quality ablation. The wet chemicals-assisted fs laser ablation method achieves the resolution as small as approximately 500 nm by using high NA (0.73) objective lens. We have also demonstrated formation of 140-μm-long straight and hollow channels embedded single-crystal GaN using this method.

WE-B-09:50

ELEMENTAL ANALYSIS USING FEMTOSECOND LASER ABLATION-ICPMASS SPECTROSCOPY IN EARTH'S SCIENCE

T. Hirata and Y. Kon; Laboratory for Planetary Sciences (LPS),Tokyo Institute of Technology, O-okayama 2-12-1, Meguro, Tokyo 152-8551, Japan

Femtosecond laser is also applied to the chemical and isotopic analysis of the samples. Many analytical advantages such as elemental sensitivity, better analytical precision or smaller elemental fractionation during the laser ablation can be achieved by the fs-laser. In this presentation, I would like to talk about the principles of the mass spectrometry technique and the application of the laser ablation-mass spectrometry technique using a TiS femtosecond laser to the Earth sciences.

FEMTOSECOND LASER PROCESSING 2 (FEMTO-2)

SESSION CHAIRS: J. REIF, Y. NAKATA

WE-B-10:50

OPTIMIZATION OF PROCESSING PARAMETERS FOR WAVEGUIDE WRITING IN ER:YB CO-DOPED PHOSPHATE GLASS WITH FS LASER PULSES.

A. Ferrer, A. Ruiz de la Cruz, D. Puerto, W. Gawelda, J. Siegel and J. Solis ; Laser Processing Group, Instituto de Optica, C.S.I.C., Serrano 121, 28006 Madrid, Spain

In this work we have analyzed the role of several processing parameters (pulse energy/duration, polarization and writing depth) in the production of waveguides in Er:Yb phosphate glass. Slit beam-shaping has been used to shape the focal volume, in order to obtain circularly shaped guided modes at ?=1550 nm. From our results it can be concluded that circular polarization produces better waveguides. Pulse duration control allows strongly improving the efficiency of energy deposition at the focal region, allowing minimizing the negative effects associated to non-linear propagation which deplete the energy available at the focus to induce the desired structural transformations.

WE-B-11:10

MODIFICATION OF THE OPTICAL PERFORMANCE OF FIBER BRAGG GRATINGS USING FEMTOSECOND LASER MICROMACHINING

H. Alemohammad; University of Waterloo

The present paper is concerned with the use of femtosecond laser for micromachining of fiber Bragg gratings to modify their filtering performance. In this research work, a Ti:Sopphire regenerative amplifier was effectively used to micromachine the cladding layer of FBGs. Periodic corrugated structures with specific pitch lengths were fabricated by moving the fiber against the femtosecond laser beam. The captured reflectivity spectrums of the FBGs showed that by tuning the process parameters (e.g., laser power and laser speed) the optical performance such as Bragg wavelength and filtering bandwidth of the FBG can be selectively modified.

WE-B-11:30

BRAGG GRATING RECORDING IN FLUORINE DOPED ALL-SILICA FIBRES USING 248NM, FEMTOSECOND AND PICOSECOND RADIATION

S. Pissadakis, M.Livitziis; Institute of Electronic Structure and Laser, Foundation for Research and Technology – Hellas, P.O. Box 1527, 71110, Heraklion, Greece

We present results on the inscription of Bragg reflectors in fluorine-depressed cladding and microstructured silicate glass fibres, using 120fs, 500fs and 5ps 248nm laser radiation. The results presented refer to grating exposures in pristine and hydrogenated all-silica fibres, and the investigation of the grating recording process by means of average and modulated refractive index changes; and the thermal durability of the inscribed structures. Maximum refractive index changes of the order of 5x10-4 were inscribed in both pristine and hydrogenated fluorine doped fibres. The gratings recorded in pristine fibres demarcated at high temperatures, reaching levels of 850oC.

WE-B-11:50

FABRICATION OF MICROELECTRODES EMBEDDED IN GLASS CHIPS USING A FEMTOSECOND LASER

J. Xu, Y. Liao, Y. Cheng, Z. Xu, K. Sugioka and K. Midorikawa; Shanghai Institute of Optics , Shangai, CHINA

We demonstrate the fabrication of the microelectrodes embedded in glass chips using femtosecond laser direct writing followed by successive electroless copper plating. The features of these microelectrodes can be well controlled by varying the parameters of the laser direct writing and the electroless plating process. The formation mechanism of microelectrodes and their application for integrated microdevices are also discussed. This technique will provide great potential for rapid and cost-effective fabrication of monolithic three-dimensional micro-electro-opto-fluidic devices.

WE-B-12:10

MOBILITY OF NANOPARTICLES GENERATED BY FEMTOSECOND LASER ABLATION IN LIQUIDS AND ITS APPLICATION TO SURFACE COATINGS

A. Menéndez-Manjón, A. Hahn, N. Baersch, S. Barcikowski; Laser Zentrum Hannover, Hollerithallee 8, D-30419 Hannover, Germany

Nanoparticles generated in liquids by femtosecond laser ablation were investigated. Avoiding beam disturbance by introducing a liquid flow, the productivity was increased up to three orders of magnitude. Particle velocimetry allowed on-line studies of the generation process dynamics. Electrophoretic mobilities of the laser-based nanoparticles were measured by tracking analysis and electrophoretic deposition of nanoparticles on electrode surfaces was demonstrated. Using this technique, medical devices, such as implants, are superficially nanostructured in order to improve their function.

FEMTOSECOND LASER PROCESSING 3 (FEMTO-3)

SESSION CHAIRS: E. AUDOUARD, A. BEN-YAKAR

WE-B-14:00

MICRO-SELECTIVE FEMTOSECOND LASER ON-LINE EXTRACTION OF QUARTZ-HOSTED PETROLEUM INCLUSIONS

A. Fuerbach, C. Miese, H. Volk, D. Fuentes, W. Koehler, N. Baersch, S. Barcikowski ; Macquarie University, MQ Photonics Research Centre D, North Ryde, NSW, 2119, AUSTRALIA

Fluid inclusions are tiny sized vacuoles filled with petroleum. The oil in these perfectly sealed vessels provides a snap-shot of the fluid composition in the geological past, and is shielded from contamination and alteration that usually affects hydrocarbons. Coupling a compact high-energy femtosecond oscillator with a gas chromatograph – mass-spectrometer has enabled us to analyse the organic content of a single fluid inclusion hosted in quartz and filled with petroleum. This geological application of laser technology demonstrates, for the first time, that individual fluid inclusions can be selectively opened and analysed on-line. This capability will certainly be useful in petroleum exploration.

WE-B-14:20

NANOSECOND LASER-INDUCED LOW-DENSITY PLASMAS – A NEW REGIME FOR NANOMORPHING IN BULK DIELECTRICS

A. Vogel, N. Linz, S. Freidank, J. Noack; Institute of Biomedical Optics, University of Lübeck, Germany

We compared ns breakdown in water at large NA using single-longitudinal mode and regular Nd:YAG laser pulses. For UV and VIS pulses with a smooth pulse shape (including those from a microchip laser) we discovered a low-density plasma regime in which nano-bubbles are created, with sizes similar to femtosecond breakdown. 10-30 times above the bubble threshold, the plasma suddenly assumes a larger size, luminesces brightly, and much larger bubbles of 200 µm radius are produced. Nanoeffects could not be produced with regular pulses, and at IR wavelengths. The two-step process was successfully modeled considering thermal ionization besides multiphoton and avalanche processes.

WE-B-14:40

SURFACE NANOSTRUCTURING MEDIATED BY GOLD NANOPARTICLE ARRAY AND A SINGLE PARTICLE EXCITED BY FEMTOSECOND LASER

T. Miyanishi1, N. Nedyalkov2, T. Saiki1, M. Obara1;

1- Department of Electronics and Electrical Engineering, Faculty of Science and Technology, Keio University, 3-14-1 Hiyoshi, Kohoku-ku, Yokohama, 223-8522, Japan
2- Institute of Electronics, Bulgarian Academy of Sciences, Tzarigradsko shousse 72, Sofia 1784, Bulgaria
We present theoretical and experimental results on the near field distribution in the vicinity of metal nanoparticle array and compare it to the single nanoparticle. Using this localized and enhanced near-field the surface nanostructuring is demonstrated. It is found that the field enhancement factor increases with the increase of the inter-particle distance and at the distances longer than the incident wavelength it approaches that of a single particle. The near field distribution is also found to be governed by the polarization of the incident radiation. This study can be a novel method for precise nanostructuring of different surfaces.

WE-B-15:00

FABRICATION OF TWO-DIMENSIONAL PERIODIC NANOSTRUCTURES BY TWO-BEAM INTERFERENCE OF FEMTOSECOND PULSES

T. Jia, M. Baba, M. Suzuki, R. A. Ganeev and Hiroto Kuroda, J. Qiu, X. Wang, R. Li and Z. Xu ; State Key Laboratory of Precise Spectroscopy, East China Normal University, Shanghai 200062, P.R. , CHINA
Two-dimensional periodic nanostructures on ZnO crystal surface were fabricated by two-beam interference of 790 nm femtosecond laser,The long period is, as usually reported, determined by the interference pattern of two laser beams. Surprisingly, there is another short periodic nanostructures with periods of 220-270 nm embedding in the long periodic structures. We studied the periods, orientation, and the evolution of the short periodic nanostructures, and found them analogous to the self-organized nanostructures induced by single fs laser beam.

WE-B-15:20

TIME RESOLVED SPECTROSCOPY DURING FS-LASER DIRECT WRITING OF COHERENT SUB WAVELENGTH RIPPLES ON SIO2 AND SAPPHIRE

M. Hörstmann-Jungemann, J. Gottmann, D. Wortmann; Lehrstuhl für Lasertechnik Aa, Steinbachstr. 15, Aachen, Nordrhein-Westfalen, 52074, Germany
Sub wavelength ripples perpendicular to the polarisation of the laser radiation are obtained by scanning a tightly focused beam (~1µm) of femtosecond laser radiation over the surface of various materials. The ripple patterns extend coherently over many overlapping laser pulses and scanning tracks. The cross-sections and the surface of the ripples are investigated using electron microscopy Additionally the time resolved dielectric function of transparent materials is calculated by the measured reflection and transmission in a pump-probe set-up during and up to 1ns after the laser pulse.

WE-B-15:40

ULTRAFAST LASER PROCESSING AND PROSPECT OF INDUSTRIAL APPLICATIONS

X. Liu; Panasonic Boston Laboratory, USA

FEMTOSECOND LASER PROCESSING 4 (FEMTO-4)

SESSION CHAIRS: T. HIRATA, S. SOMMER

WE-B-16:40

MODELING NONLINEAR PLASMA FORMATION FOR FEMTOSECOND PROCESSING OF TRANSPARENT MATERIALS AND BIOLOGICAL CELLS AT HIGH NA FOCUSING

C. Arnold, A. Heisterkamp, W. Ertmer, H. Lubatschowski; Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover, Germany

Nonlinear plasma formation is generally accompanied by a number of additional nonlinear effects such as self-focusing, filamentation and plasma-defocusing. These parasitic effects limit the achievable precision and reproducibility of applications based on the controlled generation of optical breakdown. To reduce pulse energy, enhance precision, and limit nonlinear side effects, applications of ultrashort pulses recently evolved towards tight focusing using high NA microscope objectives. However, from the theoretical point of view, generation of optical breakdown at high NA was barely studied. A comprehensive model is derived to numerically simulate the generation of optical breakdown at high NA and to estimate undesired side-effects.

WE-B-17:00

FUSION WELDING OF FUSED SILICA BY ULTRASHORT PULSE LASER

I. Miyamoto1, T. Herrmann2;

1- Osaka University,1-12, Yamada-Oka, Suita, Osaka 565-0871, Japan.

2-Lumera Laser GmbH, Opelstrasse 10, 67655 Kaiserslautern, Germany.

Novel fusion welding technique of borosilicate glass was developed using ultrashort laser pulses with fs and ps durations, and melt dimensions calculated from thermal conduction equation was shown to agree well with experimental ones [1.2]. In this paper, local melting process of fused silica due to ultrasrashort pulse laser is studied by characterizing the size and shape of the molten region at different pulse energies, pulse repetition rates and translation velocities. The intensity distribution of laser energy absorbed by nonlinear process is evaluated along the optical axis based on the thermal conduction analysis.

WE-B-17:20

DIRECT WELDING BETWEEN COPPER AND GLASS SUBSTRATES BY USING FOCUSED FEMTOSECOND LASER PULSES

Y. Ozeki1, T. Inoue1, T. Tamaki 1, 2, H. Yamaguchi1, T. Sano3, S. Nishiuchi3, A. Hirose3, and K. Itoh1;

1- Department of Material and Life Science, Graduate School of Engineering, Osaka University

2- Department of Control Engineering, Nara National College of Technology

3- Division of Materials and Manufacturing Science, Graduate School of Engineering, Osaka University

The technique of ultrafast laser microwelding allows us to directly join dissimilar transparent materials. In this paper, we show that this technique can be applied to a metal material by successfully demonstrating the direct joining of copper and non-alkali glass substrates. The joint strength is higher than 16 MPa and is almost independent of the energy of laser pulse. A scanning electron microscopy image of the morphology of the interface proves successful joining without vacancy or crack.

WE-B-17:40

MICRO STRUCTURING WITH HIGHLY REPETITIVE ULTRA SHORT LASER PULSES

J. Schille, R. Ebert, H. Exner, U. Loeschner, T. Suess; Hochschule Mittweida – University of Applied Sciences Technikumplatz 17 in 09648 Mittweida, Germany

Micro structuring with highly repetitive ultra short laser pulses J. Schille, R. Ebert, H. Exner, U. Loeschner, T. Suess Hochschule Mittweida – University of Applied Sciences For the first time a laser source with pulse lengths less then 250fs, high beam quality, high pulse energies up to 8µJ, and repetition rates up to 25MHz (IMPULSE, Clark-MXR, Inc.) is applied for micro material processing. First results are shown to demonstrate the possibilities and limits of the machining process with highly repetitive laser pulses for applications in rapid micro tooling. Because of high pulse energies at high pulse repetition rates completely new effects of laser material interaction are expected. Principle mechanisms of the existing interaction processes are derived from experimental results and models are discussed.

WE-B-18:00

ULTRAFAST LASER TEXTURING OF METALLIC SURFACES

B. K. Nayak and M. C. Gupta; Department of Electrical and Computer Engineering, University of Virginia, Charlottesville, Virginia 22904

Results of ultrafast-laser-induced surface texturing of metals (titanium and stainless steel) are presented. Nearly regular arrays of self-assembled conical micro/nano structures are formed on these metal surfaces whose shape, size, and aspect ratios could be controlled by varying experimental parameters such as laser fluence, pulse repetition rate, number of scans and gaseous environments. The microstructures of different heights (few hundred nanometers to 10's of microns) with few hundred nanometers of tip can be fabricated. Nano-ridges of period of the order of the wavelength of the laser are observed on the microstructures. The textured surfaces look complete black in color compared to the original shiny silver-grayish color of these metals.

WE-B-18:20

RIPPLES FORMATION UNDER FEMTOSECOND LASER IRRADIATION: MONO AND MULTI PULSES STUDIES AND INTERPRETATION

M. Guillermin, B. Dusser, J.-P. Colombier, A.S. Loir, F. Garrelie, R ; Stoian, E., Audouard, A. Tishchenko, O. Parriaux, and F. Pigeon. ; Laboratoire Hubert Curien, CNRS UMR 5516,

Université Jean Monnet,18, rue du Pr Benoit Lauras, 42000 Saint Etienne, France

Ripples formation under femtosecond laser irradiation : mono and multi pulses studies and interpretation Femtosecond surface structure modifications are investigated under irradiation with laser pulses of 150 fs at 800 nm. We report sub-wavelength periodic structures formation (ripples) perpendicular to the laser polarization that can be obtained with only one pulse. Sub wavelength ripples can be obtained both on metallic or dielectric samples, and such periodic nano structures can be used for surface functionalization and "smart" marking. The control of sample marking requires a good understanding of laser matter interaction mechanism. For femtosecond regime, the standard surface scattered wave model is not well suited and has to be refined using Maxwell equation boundaries taking into account the induced polarisation and resonant surface excitation calculation, using also a suited model to describe matter optical absorption.

THURSDAY 19 JUNE

LASER PULSE SHAPING 1 (PULSE SHAPING-1)
SESSION CHAIRS: R. STOIAN, W. WARREN

TH-A-08:30

SURFACE NANOSTRUCTURING BY ULTRAFAST SHAPED LASER PULSES

M.Wollenhaupt, L.Englert, C.Sarpe-Tudoran, L.Haag and T.Baumert; Institut fuer Physik and CINSaT, Universitaet Kassel, Heinrich-Plett-Str. 40,D-34132 Kassel, Germany

We report on an experimental demonstration of laser control of two basic ionization processes in dielectrics, i.e. photo ionization and electron-electron impact ionization. We generate temporally asymmetric pulse trains on the femtosecond time scale and show that the timing of the intense photo ionizing sub-pulse turns on or off electron-electron impact ionization. This is observed via different thresholds for surface material modification. Thresholds are determined by Scanning Electron Microscopy and Atomic Force Microscopy. We create robust structures up to one order below the diffraction limit. Our strategy opens the route to tailored pulse shaping for controlled nanoscale material processing of dielectrics.

TH-A-09:00

SPATIO-TEMPORAL PROPERTIES OF TRANSIENT ELECTRONIC PLASMAS PRODUCED IN CONDITIONS OF FS WAVEGUIDE WRITING IN DIELECTRICS

W. Gawelda, D. Puerto, J. Siegel, A. Ruiz de la Cruz, A. Ferrer, J. Solis ; Laser Processing Group, Instituto de Óptica "Daza de Valdés", C.S.I.C., 28006 Madrid, Spain

Our study focuses on spatial and temporal optimization of fs laser pulse induced transient plasmas in bulk dielectrics under waveguide writing conditions by means of fs pump-probe microscopy. The spatial plasma distribution is tailored by means of elliptical beam shaping, leading to a focal volume cross sections with an aspect ratio close to unity by expanding the focus transversely to the beam propagation axis. Temporal shaping is achieved by pulse chirping, which substantially improves the spatial distribution of the deposited energy by effectively reducing the deleterious influence of filamentation through changing the self-focussing conditions in the material.

TH-A-09:20

CORRECTING WAVEFRONT DISTORTIONS DURING ULTRAFAST LASER INDUCED REFRACTIVE INDEX CHANGES IN BULK TRANSPARENT

MATERIALS

C. Mauclair1,2, A. Mermillod-Blondin1, V. Diez-Blanco3, N. Huot1, J. Bonse2, A. Rosenfeld2, J. Solis3, I. V. Hertel2, E. Audouard1, and R. Stoian1 ;

1- Laboratoire Hubert Curien (UMR 5516 CNRS), Université Jean Monnet, 42000 Saint Etienne, France

2- Max-Born -Institut für Nichtlineare Optik und Kurzzeitspektroskopie, 12489 Berlin, Germany

3- Instituto de Optica Consejo Superior de Investigaciones Científicas, 28006 Madrid

We present strategies for correcting wavefront distortions which appear during ultrafast laser-induced changes of refractive index in bulk optical materials. The physical nature and the spatial distribution of refractive index changes depend critically on the spatial and temporal scale of laser energy deposition. This, in turn, may affect the quality and efficiency of the photoinscription process with consequences in waveguide writing. The proposed

strategies are based on programmable spatio-temporal pulse shaping and have the objective of concentrating the laser energy on minimal spatial scales.

TH-A-09:40

TWO-DIMENSIONAL PERIODIC NANOSTRUCTURES INDUCED BY THE INTERFERENCE OF TWO-BEAM OF FEMTOSECOND LASER PULSES

T.Q. Jia1 Z.R. Sun1 H. Koruda2 Z.Z. Xu3;

1- State Key Laboratory of Precise Spectroscopy, East China Normal University, Shanghai 200062, P.R. China

2- The Institute for Solid State Physics, The University of Tokyo, Chiba 2778581, Japan

3- State Key Laboratory of High Field Laser Physics, Shanghai Institute of Optics and Fine Mechanics, Shanghai 800-211, P.R. China

Two-dimensional periodic nanostructures on ZnO crystal surface were fabricated by two-beam interference of 790 nm femtosecond laser. The long period is, as usually reported, determined by the interference pattern of two laser beams. Surprisingly, there is another short periodic nanostructures with periods of 220-270 nm embedding in the long periodic structures. We studied the periods, orientation, and the evolution of the short periodic nanostructures, and found them analogous to the self-organized nanostructures induced by single fs laser beam.

TH-A-10:00

ULTRAFAST PHASE TRANSFORMATIONS INDUCED BY TEMPORALLY SHAPED FEMTOSECOND PULSES

C. M. Liebig1, E. Audouard1, J. Solis2, and R. Stoian1;

1- Université Jean Monnet, Laboratoire Hubert Curien,CNRS UMR 5516, 18 rue Benoit Lauras, 42000 Saint Etienne, France

2- Instituto De Optica, CSIC, Serrano 121, 28006 Madrid, Spain

We investigated the effects of shaped ultrashort laser pulses on the phase transformations of semiconductor materials. We determined optimal pulse shapes to initiate the desired phase changes. Finally, the pulse shapes were analyzed in order to gain a greater understanding of the dynamics of the phase transitions.

LASER PULSE SHAPING 2 (PULSE SHAPING-2)

SESSION CHAIRS: M. WOLLENHAUPT, CR. ARNOLD

TH-A-10:50

HIGH RESOLUTION, DEEP TISSUE IMAGING AND MANIPULATION USING FEMTOSECOND LASER PULSE SHAPING

W. S. Warren; Center for Molecular and Biomolecular Imaging, Duke University, Box 90346, Durham, NC 27708

Advances in laser technology make it possible to surmount many of the limitations of conventional imaging methods. We use rapidly updatable, femtosecond pulse shaping and multidimensional spectroscopy to make new targets accessible by nonlinear optical imaging, including many endogenous targets. For example, we observe two-photon absorption (TPA), sum frequency absorption (SFA) and self phase modulation (SPM)), all using less power than a typical laser pointer. Detection of TPA and related effects, such as the local quantum yield (fluorescence/absorption) permits direct observation of important endogenous molecular markers which are invisible in multiphoton fluorescence microscopy; it also permits excitation in the long-wavelength water windows which have significantly reduced scattering, but little endogenous two-photon fluorescence.

TH-A-11:20

HIGH SPEED MODULATION OF SPATIALLY SHAPED BEAMS FOR MATERIAL PROCESSING APPLICATIONS

A. Mermillod-Blondin, M. Brown, E. McLeod and Cr. Arnold ; Mechanical & Aerospace Engineering, Princeton University, Engineering Quad, Princeton, NJ 08540, USA

Rapid shaping of an incident Gaussian laser beam enables spot-to-spot control over local material properties in pulsed and CW applications. In this study, we present a novel approach to adaptive beam shaping using a Tunable Acoustic Gradient Index of Refraction (TAG) lens. An amplified ultrasonic signal is used to establish a density fluctuation within a liquid causing an oscillatory variation in local index of refraction. The theory behind the lens operation, its speed, degrees of control, experimental results, and applicability to laser-materials processing and imaging will be presented.

TH-A-11:40

LASER INDUCED FORWARD TRANSFER OF METALS USING SHAPED FEMTOSECOND LASER PULSES

A. Klini, P.A. Loukakos, D. Gray, C. Fotakis ; Institute of Electronic Structure and Laser (IESL), FOundation for Research and Technology-Hellas (FORTH), N. Plastira 100, Vassilika, Vouton, 70 013, Heraklion, Crete, Greece

Temporally shaped, femtosecond laser pulses have been used to controllably remove a metallic thin film from a transparent carrier target and transfer it in the form of micron-sized dots onto a receiver substrate using Laser Induced Forward Transfer. We report a study on the morphology of the deposited dots as a function of the separation time (ranging from 0.1 to 10 ps) of double pulses with equal intensity generated in a liquid crystal spatial light modulator (SLM). The interaction of the double pulses compared to a single pulse of the same total energy is presented and discussed.

TH-A-12:00

OPTIMIZATION OF NANOPARTICLE PRODUCTION BY LASER ABLATION WITH TAILORED ULTRASHORT PULSES

V. Hommes , M. Miclea, R. Hergenröder; ISAS – Institute of Analytical Sciences, Bunsen-Kirchhoff-Str. 11, D-44139 Dortmund, Germany

Many industrial applications of “tailored” nanoparticles have been identified in recent years: selective catalyst or membranes, electronic/ magnetic information storage, additives for the control of rheological or thermophysical properties, etc. Nanoparticle size must be tightly controlled to take full advantage of quantum size effects in such applications. Laser ablation is a convenient way of generating nanoparticles and their aggregates. However, controlling the size and chemical composition is difficult. Short (picosecond and femtosecond) pulse laser irradiation has the ability to bring materials to highly non-equilibrium transient states even close to the spinodal and to induce a transformation pathway leading to the formation of metastable phases and structures not accessible with conventional materials processing technique. If the ability to reach non-equilibrium states is combined with adaptive femtosecond laser pulse shaping techniques that allow the optimization and control of the temporal energy flux to the surface, then non-equilibrium thermodynamic pathway control on an ultrashort timescale (fs - ps) is possible and due to the enhanced controllability tailoring particle distribution is feasible. Here we show the feasibility of the concept by shifting the maximum of the size distribution of semiconductor nanoparticles to smaller diameters. The response of semiconductor materials to short laser pulses is well characterized, and therefore Si and Ge provide a basis for a qualitative description of the light-matter interaction under the influence of an optimized laser pulse.

LASER NANOFABRICATION(NANO)

SESSION CHAIRS: J. DUBOWSKI, R. HERGENRODER

TH-A-14:00

SELF-ORGANIZING LASER INDUCED AU NANOCRYSTALL FORMATION IN CONDITIONS OF SURFACE PLASMON RESONANS

L. Fedorenko, B. Snopok, M. Yusupov V. Lashkaryov; Institute of the Semiconductor Physics, NAS of Ukraine

A novel laser assisted method of Au nanoparticles formation in conditions of surface plasmon resonance in the Au/glass system is presented

TH-A-14:20

ALLOYING AND SIZE CONTROL OF NANOPARTICLES USING FEMTOSECOND LASER-INDUCED SUPERCONTINUUM GENERATION

S. Besner1, A.V. Kabashin1, F.M. Winnik2 and M. Meunier1;

1-Laser Processing Laboratory, Department of Engineering Physics, École Polytechnique de Montréal, CP 6079, succ. Centre-ville, Montréal (Québec), Canada, H3C 3A7

2-Département de Chimie et Faculté de Pharmacie Université de Montréal Pavillon J. A. Bompardier CP 6128 succ. Centre-ville Montréal (Québec), Canada, H3C 3J7

A femtosecond laser-based method has been developed for the size control of colloidal solution and metal alloys formation. This technique employs the self-transformation of the femtosecond laser irradiation into a broad white-light pulse which expands from ~365 to 1050nm and arises under high localization of the radiation in space and time. The final size and composition of the particles could also be tuned by simply varying the white-light pulse energy and the relative concentration of the metallic colloidal mixture and of the stabilizer in the solution. Such nanoparticles might be of good interest for Surface Enhanced Raman Scattering and bio-sensing applications.

TH-A-14:40

FABRICATION OF AU NANOPARTICLES BY PULSED LASER ABLATION IN AQUEOUS MEDIA

D. Yang, S. Lee, B. Chen and S. Nikumb; Industrial Materials Institute, National Research Council Canada, 800 Collip Circle, London, Ontario, N6G 4X8, Canada

We have carried out a systematic investigation of the growth of Au nanoparticles by pulsed laser ablation of an Au target using three different laser wavelengths in surfactant-free and alkanethiols or sodium alkyl sulfates containing aqueous solutions and studied the morphology of Au nanoparticles characterized with respect to laser wavelength, pulsed duration, pulse energy, repetition rate, and other laser process parameters in order to understand the nanoparticle formation process during laser ablation. The parameters controlling the morphology and properties of Au nanoparticles during laser ablation in surfactant-free and surfactant-containing aqueous media are discussed.

TH-A-15:00

INFLUENCE OF TRANSVERSE MODE STRUCTURE OF LASER BEAM ON SPECTRAL PROPERTIES OF COLLOIDAL GAAS QUANTUM DOTS FABRICATED BY LASER ABLATION IN LIQUID MEDIA

A. Lalayan; Yerevan State University, Physics Facultyt, 1A.Manoogian St.r ,Yerevan, 375025, Armenia

In this work we describe the luminescence properties of colloidal GaAs QDs fabricated in ethanol by laser ablation. Picosecond YAG:Nd laser with 1064nm wavelength, which operated in two switchable transverse electromagnetic modes (TEM00 and TEM11) was used. The luminescence of the colloidal QDs was excited by irradiation at 355nm,

the third harmonic of the same YAG:Nd laser. The blue and white photoluminescence of colloidal nanoparticles have been registered under 355nm laser irradiation.

TH-A-15:20

MAGNETIC NANOPARTICLES FABRICATED BY FEMTOSECOND LASER ABLATION IN LIQUIDS

P. Boyer, D. Ménard, M. Meunier ; Laser Processing Laboratory, École Polytechnique de Montréal, Département de génie Physique

Metallic nanoparticles have been synthesized by laser ablation and fragmentation in liquids. A clear tendency is seen for long ablation time between the polarity of the solvent and the average nanoparticle size suggesting interaction between the laser pulse and the colloids. Produced nanoparticles show a stronger superparamagnetic signal then expected, suggesting that the transition between from the superparamagnetic to ferromagnetic state occurs at a higher diameter. This is propably due by the quenching of the nanoparticle colliding with the solvent. Faraday effect is studied in diluted colloids for pulse laser devices : absorption, transmission and Verdet constant.

TH-A-15:40

PRODUCTIVITY OF NANOPARTICLE GENERATION DURING HIGH-POWER PICOSECOND LASER ABLATION IN LIQUIDS

J. Jakobi1, N. Bärsch1, S. Weiler2, S. Barcikowski; 1-Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover, Germany

2 -TRUMPF Laser GmbH & Co. KG, Aichhalder Str. 39, 78713 Schramberg, Germany

The generation of nanoparticles during ultra-short-pulsed laser ablation in liquids is known to offer a nearly unlimited material variety. Using a new generation of ultra-short-pulsed lasers with higher output power, the productivity of nanoparticle generation can be increased significantly even for ablation in combustible solvents. This study introduces ablation results in acetone and in water using an ultra-short-pulsed disk amplifying system emitting laser pulses of 6 ps at an average output power of 50 W. We have generated silver, magnesium, copper, and zirconia nanoparticles, achieving ablation rates of up to several milligrams per minute without igniting the surrounding acetone.

TH-A-16:00

IMPROVING LASER ABLATION OF ZIRCONIA BY LIQUID FILMS: MULTIPLE INFLUENCE OF LIQUIDS ON SURFACE MACHINING AND NANOPARTICLE GENERATION

N. Bärsch1, A. Gatti2, R. Sattari1, S. Barcikowski1; 1- Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover, Germany

2- Università di Modena e Reggio Emilia, via Campi 213 /A, 41100 Modena, Italy

Laser ablation of tetragonal zirconia is the key to highly interesting new applications. On the one hand, short-pulsed laser structuring is the only wear-free method to shape fully sintered substrates. On the other hand, particles that are laser-ablated from the surface of zirconia substrates can be embedded into other products to increase their surface strength. Both fields can be combined by one processing approach, involving the use of liquid films on the ablated surfaces. Remarkably, the liquid layer does not only allow to collect nanoparticulate matter and improve the quality of micromachining, but can also enhance the productivity.

LASER MICROPROCESSING (MICROPROCESSING)
SESSION CHAIRS: E. FOGARASSY, T. OKADA

TH-B-08:30

LASER DICING OF SILICON : COMPARISON OF ABLATION MECHANISMS WITH A NOVEL TECHNOLOGY OF THERMALLY INDUCED STRESS

O. Haupt1, F. Siegel1, L. Richter1, R. Kling1, A. Ostendorf; Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover, Germany

Laser Dicing of Silicon: Comparison of Ablation Mechanisms with a Novel Technology of Thermally Induced Stress In silicon dicing with laser radiation different mechanisms have a big influence on the effective cutting speed and edge quality. All current dicing techniques use a single beam and cut layer-by-layer in several cycles. For ultra-short pulses many more repetitions must be performed than for nano- or microsecond laser pulses. Melting is the main mechanism for micro- and nanosecond pulses while for ultra-short pulses evaporation is dominant. We compared the influence of pulse duration and cutting speed with the corresponding edge quality by using a three-point bending test. As a result the bending strength of the cut samples directly correlates with edge defects. In contrast to the laser dicing technologies using ablation we investigated a novel mechanism of thermally induced stress cutting of silicon wafers. This process does not produce any debris or other edge defects and uses continuous wave laser radiation. One-step cutting for wafers is possible up to a thickness of a several hundred microns if laser radiation with photon energy near the indirect band gap of silicon is used. The results of ablation rates, bending strength, and effective cutting speed will be presented from picosecond to continuous wave laser dicing. The mechanism of the novel dicing technology will be explained in more detail.

TH-B-08:50

DEVELOPMENT OF INTENSE VACUUM ULTRAVIOLET LASER SYSTEM FOR PRECISE AND MICROSCOPIC PROCESSING

M. Katto1, A. Yokotani2, M. Kaku2, K. Oda2, S. Kubodera2, N. Miyanaga3 and K. Mima;
1- Cooperative Research Center, University of Miyazaki, 1-1 Gakuen-Kibanadai-Nishi, Miyazaki 889-2192, Japan
2- Dept. of Electrical and Electronic Eng., Univ. of Miyazaki, 1-1 Gakuen-Kibanadai-Nishi, Miyazaki 889-2192, Japan
3- Institute of Laser Engineering, Osaka University, 2-6 Yamada-Oka, Suita, Osaka 565-0871, Japan

We have been developing intense vacuum ultraviolet (VUV) radiations for the advanced applications such as precise and microscopic processing and photochemical reactions. Now, we are constructing a new VUV laser system to generate an output at wavelength of 126 nm with energy of sub mJ and pulse width of sub-ps at the repetition rate above 10 Hz. The system is consist of three parts; (1) seed pulse generated by the 7th harmonics of 882 nm Ti:Sapphire laser, (2) the Ar2 excimer medium generated by the optical-field-ionization plasma pumped by 800 nm Ti:Sapphire laser and (3) discharge pumped Ar2 excimer amplifier system. We successfully obtained 7th harmonic in the Xe gas. The Ar2 excimer generated by the OFI plasma produced a gain of gl=6. Now, the discharge pumped main amplifier is designing and developing.

TH-B-09:10

IMAGING DIAGNOSTICS OF DEBRIS FROM LAS-PRODUCED TIN PLASMA WITH DROPLET TARGET FOR EUV LIGHT SOURCE

D. Nakamura1, A. Akiyama1, K. Tamaru1, A. Takahashi2, T. Okada2;
1- Graduate School of Information Science and Electrical Engineering, Kyushu University
2- School of Medicine, Kyushu University

The dynamics of debris from the laser-produced tin (Sn) plasma with a Sn droplet target was investigated using imaging methods in order to establish the guideline for the optimum design of the EUV lithography system. The behaviors of the Sn atoms from the droplet target irradiated by the Nd:YAG laser were investigated using the laser-induced fluorescence (LIF) imaging method. Sn atoms were observed from a droplet target of 30um in a diameter and emitted in all directions. Furthermore, the ablation dynamics of the irradiated droplet was observed by a high-speed imaging camera simultaneously with the LIF imaging.

TH-B-09:30

NANOSTRUCTURING OF THIN GOLD FILMS BY FEMTOSECOND LASERS

A.I. Kuznetsov, J. Koch, and B.N. Chichkov; Laser Zentrum Hannover e.V., Hollerithalle 8, 30419 Hannover, Germany

New results on nanostructuring of thin gold films by femtosecond laser pulses are presented. Different micro- laser field distributions on the sample surface are created by 50×-demagnified image transfer. It is shown that gold tends to concentrate in the centre of the irradiated region. Material modifications by different laser field distributions are investigated.

TH-B-09:50

NANOSCALE JUNCTION FABRICATION BY LASER DOPING PROCESS

J. Venturini ; Excico, France

LASER FILM DEPOSITION (FILM)

SESSION CHAIRS: N. MATSUSHITA, J. VENTURINI

TH-B-10:50

RESONANT INFRARED MATRIX ASSISTED PULSED LASER DEPOSITION OF POLYMERS: IMPROVING THE MORPHOLOGY OF AS-DEPOSITED FILMS

Brian Collins, Ullas Gurudas, Michael Papantonakis, and Daniel M. Bubb;
1 -Rutgers University – Camden, Department of Physics, 227 Penn Street, Camden, NJ,08102, USA
2-Naval Research Laboratory, 4555 Overlook Ave, SW, Washington, DC, 20375, USA

Thin PMMA films are deposited by resonant matrix assisted pulsed laser deposition. The surface roughness of the deposited films is strongly dependent on both the laser energy and the solubility parameters of the solution. The ejection mechanism will be discussed along with the implications for depositing smooth, high quality thin films.

TH-B-11:10

GROWTH OF PR : ZBLAN THIN FILMS BY PULSED LASER DEPOSITION FOR GREEN INTEGRATED WAVEGUIDE LASERS

D. Ganser, S. Kruppe, M. Hermans, J. Gottmann; RWTH Aachen University, Steinbachstr. 15 , Aachen, NRW, 52074, Germany

Praseodymium doped ZBLAN (a fluoride glass consisting of ZrF4, BaF2, LaF3, AlF3 and NaF) thin films are grown by pulsed laser deposition using excimer laser radiation. Optical microscopy, scanning electron microscopy, electron dispersive X-ray spectroscopy and optical reflection spectroscopy are used to characterize the morphology, composition and the thickness of the grown films. By coupling the radiation of a GaN diode laser into the polished

edge of the film the optical properties (e.g. emission spectra and life-time of the green emission) of the deposited films are determined.

TH-B-11:30

QUANTUM CONFINEMENT EFFECT IN NANOCRYSTALLS ON SIC SURFACE, GROWN BY UV LASER RADIATION

L. Fedorenko1, A.Medvid'2, P.Onufrievs2, M.Yusupov1;

1- V.Lashkaryov Institute of Semiconductor Physics, 03028 Kyiv, 45 Prospekt Nauky, Ukraine

2- Riga Technical University, 14 Azenes Str., 1048 Riga, Latvia

The results of Nitrogen laser assisted nanocrystall fabrication on the SiC:6H surface is presented. The photoluminescence (PL) spectra data of SiC surface has shown the some shift of the PL band maximum to high energy of PL transition. This effect correlate with the nanocrystalls appearance on the irradiated surface that is evident from AFM images. The established correlation between these two processes and numerical calculations allow to assume that changes of PL spectra originate from quantum confienment effect.

TH-B-11:50

THE ORIGIN, GROWTH AND APPLICATION OF SELF ORGANIZING RIPPLE PATTERNS

M.N.W. Groenendijk, A.J. Huis in 't Veld ; University of Twente, Chair of Applied Laser Technology, P.O. Box 217, 7500 AE Enschede, The Netherlands

In this paper we report on self organizing ripple patterns. Experiments are presented that identify the influence of different parameters on ripple spacing. We also focuss on the starting mechanism. The observations are correlated to the theory describing ripple formation after ion-suttering. Furthermore an application of ripples is presented in the form of super hydrophobic surfaces, prepared by femtosecond laser pulses.

TH-B-12:10

LASER SPOT HEATING SYSTEM FOR CONTROLLING MICROSTRUCTURES

T. Yamashita1, M. Tsukamoto2, T. Shibayanagi2, H. Nakano3 and N. Abe ; 1- Graduate school of engineering, Osaka University, 1-1 Yamadaoka, Suita, Osaka 565-0871, Japan

2- Joining and Welding Research Institute, Osaka University, 11-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan

3- School of Science and Engineering, Kinki University, 3-4-1 Kowakae, Higashi-Osaka, Osaka 577-8502, Japan

We designed the laser spot heating system for controlling microstructures including the grain boundary observation system. Two kinds of lasers were employed in this system. They were a CW laser and a short pulse laser. The CW laser was a fiber laser. The short pulse laser was a nanosecond laser. The sample was a stainless steal (SUS 304) plate. Grain boundaries of the sample appeared after the irradiation of the nanosecond laser in the grain boundary observation system. Then, the grain could be selected for the spot heating with the fiber laser.

LASER-BASED DIRECT WRITING (DIRECT WRITE)
SESSION CHAIRS: M. SCHMIDT, S. NAKAHARA

TH-B-14:00

LASER DECAL TRANSFER OF ELECTRONIC MATERIALS

Alberto Piqué1, Raymond C.Y. Auyeung1, Kristin M. Metkus1, Heungsoo Kim1, Scott Mathews, Thomas Bailey2, Xianhai Chen2 and Lydia J. Young2;

1- Naval Research Laboratory, 4555 Overlook Ave. SW, Washington, DC 20375, USA

2- Photon Dynamics, Inc., San Jose, CA 95138, USA

Laser decal transfer is a novel technique for direct writing of thin film-like patterns of electronic inks on many substrates. It allows the direct printing of metallic nano-inks from a donor substrate to a receiving substrate while maintaining the size and shape of the laser transfer pulse. That is, the area of the donor substrate exposed to the laser pulse releases an identical area of nano-ink material which retains its shape once transferred. As a result, this technique does not exhibit the limited resolution, non-uniform thickness, irregular edge features and surrounding debris associated with earlier laser forward transfer techniques.

TH-B-14:20

MICRODROPLETS PRINTING THROUGH LASER-INDUCED FORWARD TRANSFER

M. Duocastella, J.M. Fernández-Pradas, P. Serra, J.L. Morenza; Universitat de Barcelona, Departament de Física Aplicada i Òptica, Martí i Franquès 1, E-08028, Barcelona, Catalunya, Spain

Laser-induced forward transfer (LIFT) is a direct-writing technique which uses laser pulses to transfer small portions of a material from a donor thin film to a receptor substrate. When LIFT is applied to liquid films, and under suitable conditions, the laser radiation can gently propel a tiny portion of the liquid towards the receptor substrate, which can be deposited in the form of a well-defined microdroplet. This can be successfully applied to deposit complex materials, which is required in micropatterning applications. In this work, the study of the transfer process through LIFT of biological solutions is reported.

TH-B-14:40

SELECTIVE LASER MELTING OF HONEYCOMBS WITH NEGATIVE POISSON'S RATIO

O. Rehme, C. Emmelmann; Hamburg University of Technology (TUHH), Institute of Laser and System Technologies, Denickestr. 17, 21073 Hamburg, Germany

Laser Freeform Fabrication processes, such as Selective Laser Melting (SLM), allow the manufacture of designs with negative Poisson's ration, i.e. structures which contract laterally under compressive forces or expand laterally under tensile forces vice versa. This feature can be useful in applications like crash impact energy absorbers or artificial intervertebral discs. This study reveals some new honeycomb structure designs and the experimental investigation of their lateral strain behaviour under elastic compression and derives some rules for successful design of honeycombs with negative Poisson's ratio.

TH-B-15:00

LOCAL-AREA INFRARED LASER ENGINEERING OF BANDGAP GRADIENT CONTROLLED QUANTUM WELL SEMICONDUCTOR WAFERS

R. Stanowski, M. Martin, J.J. Dubowski; Department of Electrical and Computer Engineering, Center of Excellence for Information Engineering, Université de Sherbrooke, Sherbrooke, Québec J1K 2R1, Canada,

We present here a novel quantum well intermixing technique based on infra-red laser rapid thermal annealing for local multibandgap engineering of quantum semiconductors. In previous work we have shown that this technique can induce very high photoluminescence shifts in AlGaAs/GaAs and InGaAsP/InP wafers. We however encountered overheating of the material at the sample edges. We demonstrate, via both modeling and experiments, that processing with a precisely controlled non-linear laser beam velocities allows for local writing of uniformly QWI patterns into the whole area of quantum semiconductor microstructure.

TH-B-15:20

FEMTOSECOND LASER DIRECT WRITING OF OPTICAL WAVEGUIDE IN UV TRANSPARENT POLYMER FOR BIOSENSING APPLICATIONS

Y. Hanada, K. Sugioka, K. Midorikawa; RIKEN The Institute of Physical and Chemical Research, 2-1 Hirosaw, wako, Satama 351-0198 Japan

Much attention has been paid to UV transparent polymers in the field of not only optoelectronics but also biophotonics, since such devices sometimes request transmission of UV light. However, few polymers can trnasmit in deep-UV region shorter than 300nm. Recently, Asashi glass Co. Ltd has produced fluoropolymer, called CYTOP, which has excellent properties of high-transmission in the wavelength range from 200 nm to 2 μm, high-electrical insulation, high-chemical stability. In addition, it has a refractiveindex of 1.34 which is comparable to that of water. Therefore, the CYTOP would be a good candidate for substrates of integrated optoelectronic, biophotonic and bioship devices. In this paper, we will demonstrate an optical waveguide fabrication in CYTOP for optical biosensing applications.

TH-B-15:40

LASER INDUCED FORWARD TRANSFER WITH PATTERNED DONOR SUBSTRATE

Q. Wang and Y.Y. Tsui; Department of Electrical and Computer Engineering, University of Alberta, Edmonton, Alberta T6G 2V4. Canada

The Laser Induced Forward Transfer (LIFT) process uses focused laser pulses to remove thin-film material from a transparent donor substrate as a micron sized dot and deposit it on an acceptor substrate nearby. Typically a continuous metal thin film are deposited on the donor substrate and the size of the transferred micro-dots are usually a few microns limited by the focal spot size of the laser and the mechanical properties of the metal film. In order to produce smaller micro-dots, Cr dots of 3μm diameter are fabricated on the donor substrate using photolithography, which are then transferred to the acceptor substrate.The results from this proof-of-concept experiment will be reported.

TH-B-16:00

LASER FIRED CONTACTS FOR PHOTOVOLTAICS AND INDUCED DEFECTS

C. Huang, M. Gupta; Department of Electrical & Computer Engineering, University of Virginia, Charlottesville, VA 22904, USA

The goal of this study is to develop reliable laser fired contact process for photovoltaic applications and examination of induced defects. Both single crystalline and multicrystalline silicon wafers were used as substrate. Laser fired contact area was examined using various analytical techniques such as scanning electron microscopy, secondary ion mass spectrometry, photoluminescence for examination of laser induced defects and their affect on solar cell efficiency. The mechanism of laser-induced defect formation and alloying is being analyzed.

FRIDAY 20 JUNE

INDUSTRIAL APPLICATIONS1 (INDUSTRIAL-1)
SESSION CHAIRS: A. GILLNER, T. HOULT

FR-A-08:30

PRECISION LASER MATERIALS PROCESSING WITH IPG FIBER LASERS

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Fiber laser technology and its applications have seen the largest growth in industrial laser power sources in the last 15 years. This presentation provides a review of fiber laser technology, it's applications and pulse generation techniques using IPG fiber lasers.

FR-A-08:50

HIGH AVERAGE POWER ULTRAFAST FIBER AMPLIFIERS FOR LASER MICRO-PROCESSING APPLICATIONS

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3- Amplitude Laser, One Broadway, Cambridge MA 02141, U.S.A.

High peak and average power femtosecond laser systems are required in a large number of industrial and scientific applications such as waveguide writing, frequency conversion ,micro-and nano- machining. Fiber lasers offer an attractive approach, due to their efficient heat dissipation and capability for high average power operation. However, power scaling of ultrafast single-mode fiber amplifiers has been restricted byi non-linearities induced phase distorsions. We report on a new generation of high average power fiber amplifiers, Average power range from 10 to 100W and pulse duration in the picosecond or femtosecond regime.

FR-A-09:10

DEVELOPMENT OF HIGH-SPEED & HIGH-ACCURACY ROLL & PITCH ANGLE ADJUSTMENT MACHINE FOR HDD SUSPENSION

T. Sanada, H. Watanabe, A. Ushimaru, M. Nomura; Fujitsu-automation Ltd.

Development of high-speed & high-accuracy roll & pitch angle adjustment machine for HDD suspension. We report on the outline because we developed high-speed and high-accuracy of roll & pitch angle adjustment machine using laser form technology for the magnetic head suspension of HDD.

FR-A-09:30

REFRACTIVE MICROOPTICS FOR MULTI-SPOT AND MULTI-LINE GENERATION

M. Zimmermann1, M. Schmidt, M. Rank1, A. Bich2;

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Multi-spot optics are applied for process parallelizing if the demand on throughput in mass production rises or large areas of material has to be processed. We investigate the usage of microlens arrays as multifunctional elements for forming an arbitrary laser beam into a spot-, a ring-spot- or a line-array pattern. It can be shown that the intensity distribution of each spot is equal to the intensity distribution of all other spots in the whole pattern. We demonstrate that beside other optical properties the output beam profile strongly depends on the Fresnel-Number and is influenced by diffraction and interference effects. We present important design rules which consider geometrical and physical optics. The properties of the spot arrays, like spot diameter, Rayleigh length and beam divergence in dependency of beam and system properties are investigated. Finally we will show some laser micro structuring and micro drilling results in different materials.

FR-A-09:50

MICROMACHINING OF SHAPE MEMORY ALLOYS USING HIGH POWER COPPER VAPOUR LASER

D. Antonov1, S. Klimentov2, V. Kubasov1, F. Leblanc1, A. Fraser1, E. Weynant1, M. Bergeron1 ;

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2- General Physics Institute of RAS, Vavilova St. 38, 119991 Moscow, Russia

Radiation of high power copper vapour laser (55 W) was applied for the first time to micromachining of shape memory alloys. Reported are results of optimisation of this technology, aiming at increased productivity of deep high precision drilling, known to be a clue point in manufacturing of a novel type of compact mechanical splices using super-elastic properties of this material for multiple connections of different kinds of optical fibers.

INDUSTRIAL APPLICATIONS2 (INDUSTRIAL-2)- PLENARY SESSION

SESSION CHAIRS: I. MIYAMOTO, K. WASHIO

FR-A-10:50

HIGH SPEED LASER PROCESSING IN SOLAR CELL MANUFACTURING

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For future solar cell concepts and an increase of manufacturing speed and efficiency new laser processes for structuring, drilling and interconnection are investigated. Using high power, high brilliance lasers, high speed laser drilling process is performed with drilling rates of up to 5.000 holes per second for EWT-backside contacting. For the interconnection of solar cells to solar modules like laser soldering is investigated. Using selective heating with fast scanning algorithms and optimized thermal management overheating of the ribbon connector and the solder, as well as the solar cell can be avoided.

FR-A-11:10

MICROMACHINING OF MACRO COMPONENTS WITH SHORT AND ULTRASHORT PULSED LASERS IN PRINTING AND AUTOMOTIVE INDUSTRY

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For the industrial use of short and ultrashort pulsed lasers, the pillars processing development and lasers systems progressed within the last years. This enables also a high precision machining of macroscopic parts for example in

automotive or printing industry. Depending on the system technology, that often has to be constructed by oneself, productive applications can be achieved.

FR-A-11:40

ADVANCED APPLICATIONS FOR PULSED AND CONTINUOUS WAVE FIBER LASERS WITH PARTICULAR REFERENCE TO THE PHOTOVOLTAIC INDUSTRY

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Advanced applications for pulsed and continuous wave fiber lasers with particular reference to the photovoltaic industry

SURFACE TREATMENT (SURFACE TREATMENT)

SESSION CHAIRS: M. C. GUPTA, Y. ITO

FR-B-08:30

NUMERICAL SIMULATION OF PLASMA DYNAMICS IN LASER SHOCK PROCESSING EXPERIMENTS

M. Morales, J.A. Porro, C. Molpeceres, A. García-Beltrán, J.L. Ocaña ; Centro Láser UPM, Universidad Politécnica de Madrid, Campus Sur UPM, Edificio La Arboleda Ctra. de Valencia, km. 7,300, 28031 Madrid, Spain

In the present paper, a review on the physical issues dominating the development of LSP processes from a high intensity laser-matter interaction point of view is presented along with the theoretical and computational methods developed by the authors for their predictive assessment

FR-B-08:50

SURFACE MODIFICATION OF TITANIUM DIOXIDE FILMS WITH SHORT PULSE LASER

M. Tsukamoto1, T. Yamashita2, T. Yoshioka2, M. Yoshida3, H. Nakano, M. Takahashi4, M. Fujita5 and N. Abe1 ;

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4- Osaka Municipal Technical Research Institute, 1-6-50 Morinomiya, Joto-ku, Osaka 536-8553, Japan

5- Institute for Laser Technology, 2-6 Yamadaoka, Suita, Osaka 565-0871, Japan

The objective of this study is to decrease the electrical resistance of the TiO2 films by short pulse laser irradiation without producing surface morphological changes. When the films were irradiated by the nanosecond laser in the range of 0.2 to 2.0 J/cm2, surfaces of the films were darkened and their electrical resistances were decreased. However, these surface morphologies were changed. For femtosecond laser irradiation, the laser fluence was varied in the range of 63 to 130 mJ/cm2. Darkening was generated without changing the morphology of the films. Then, as the laser fluence was increased, the electrical resistance was decreased.

FR-B-09:10

LASER DOPING FOR PHOTOVOLTAIC APPLICATIONS

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The feasibility of laser doping of crystalline and polycrystalline silicon for solar cell application was examined using spin-on-dopants. Such processes have been shown to demonstrate precise control over doping profile and simultaneous recrystallization and dopant diffusion for thin film applications on glass substrates. A diode pumped solid state laser of wavelength 940 nm was used in the CW and pulsed regime for n-type diffusion. The effect of various process parameters such as fluence, number of scans, scanning speed and gaseous environment on doping profile was examined. Doping profile was characterized by various analytical techniques and solar cell performance was evalauted.

FR-B-09:30

SEM OBSERVATION OF CROSS-SECTIONAL STRUCTURES OF LASER-INDUCED RIPPLES ON SEMICONDUCTORS AND HOPG

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We will report the cross-sectional profiles of ripples and discuss the formation mechanisms, especially the deformation process of initial flat surfaces. Inspection of SEM image reveals that the crosssection of coarse ripples on Si, and SiC have the plano-convex shapes, while that on HOPG has the plano-concave shape. We tentatively suppose that the difference of the crosssectional profiles, especially between semiconductors (Si and SiC) and a semimetal (HOPG) may arise from the difference in thermal conductivities involving the cooling process of laser irradiated surfaces. The detailed analysis and the results on fine ripple will be discussed in the presentation.

FR-B-09:50

LASER SHOCK MICROFORMING OF THIN METAL SHEETS

J.L. Ocaña, M. Morales, J.J. García-Ballesteros, J.A. Porro, O. García, C. Molpeceres ; Centro Láser UPM, Universidad Politécnica de Madrid, Campus Sur UPM, Edificio La Arboleda Ctra. de Valencia, km. 7,300, 28031 Madrid, Spain

In this paper, laser shock microforming of thin metal sheets is studied using both numerical and experimental methods. The numerical model [3] is integrated by two principal modules, a 1-D radiation-hydrodynamics code that is used to simulate the dynamic evolution of laser created plasmas [4] and a finite element code to study shock evolution and target deformation. The microforming experiments reported in this paper were performed on AISI 304 alloy using a Q switched Nd:YAG laser at 1064 nm wavelength with 9.4 ns FWHM and 54 mJ per pulse and 150 microns of spot radius. The sample curvatures were measured using laser confocal microscopy to find the bending angle. The analysis of the influence of laser spot position, number of pulses and thin sheet clamping is presented. The observed experimental profiles are in good agreement with the numerical model predictions, the suitability of laser shock microforming of thin metal sheets using ns pulsed lasers being consequently demonstrated.

FR-A-12:00

CLOSING :STUDENT AWARDS AND ANNOUNCEMENT OF LPM 2009

M. Meunier and K. Sugioka