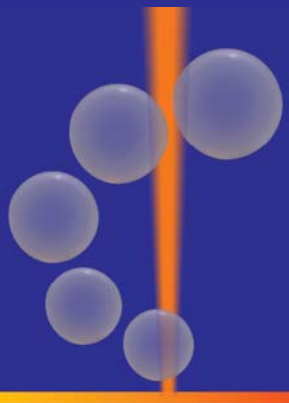
EOS Conference on Laser Ablation and Nanoparticle GEneration in Liquids 2010



29 June - 1 July 2010, RAMADA Hotel Regina Titlis, Engelberg, Switzerland

ADVANCE PROGRAMME

SESSIONS

- ... Bio applications
- ... Fragmentation and post irradiation
- ... Post irradiation
- ... Cavitation bubble & plasma dynamics
- ... Alloy nanoparticles
- ... Applications & scale-up
- ... Semiconductors I & II
- ... Non-equilibrium fluids
- ... Special

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LPM2010

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SYNOPSIS

Today, nanoparticles are widely implemented as functional elements in plastics, lacquers and ceramic products. Novel applications are targeted on nanomedicine, sensing, electronics, optics and biophotonics.
Nowadays, however, only a limited variety of materials that may be integrated into advanced functional materials are available: Nanoparticles synthesized by conventional gas phase processes are agglomerated to micro powders that are hardly redispersible into functional matrices, and chemical methods often lead to impurities of the nanoparticle colloids caused by additives and precursor reaction products.
In the last decade, laser ablation in liquids has proven to be a unique and efficient technique to generate, fragmentate, reshape and conjugate nanoparticles. This exciting method bears strong advantages:

- Laser-generated (metal) nanoparticles are charged and thus have an extremely high stability
- Nanoparticle colloids are not inhalable and thus lead to an improved occupational safety
- Chemical precursors are not required and thus the colloids are 100 percent pure
- This method can be applied universally with an almost unlimited variety of materials and solvents

Aspects of the fundamental physics of laser ablation in liquids as well as novel applications, such as the fabrication of core-shell particles, nano-alloys or laser ablation of nanoparticles in biological surroundings will be addressed in this conference. Moreover, the processes of laser nanoparticle interaction within liquid environments provide a large spectrum of applications, especially in biophotonics.The latest findings on appropriate focusing conditions, cross-effects with particle-laser interaction, flow conditions, kinetics etc. will be discussed on an international level with enough time for discussions and an informal exchange of ideas.

CHAIRS AND ORGANIZER

CHAIRS

Stephan Barcikowski
Laser Zentrum Hannover (LZH), DE

Fumitaka Mafuné
University of Tokyo, JP

ORGANIZER

Silke Kramprich
European Optical Society (EOS), DE

PROGRAMME COMMITTEE

Giuseppe Compagnini, Università di Catania, IT
Moreno Meneghetti, University of Padua, IT
Michel Meunier, École Polytechnique Montréal, CA
Georgy Shafeev, Russian Academy of Science, RU
Nikolay Tarasenko, Nat. Academy of Sciences of Belarus, BY
Wei (David) Qian, Georgia Institute of Technology, US

DAILY OVERVIEW & SESSIONS

Tuesday, 29 June		Wednesday, 30 June		Thursday, 1 July	
9:00-9:05	**Welcome**	**9:00-10:30**	**Alloy nanoparticles**	8:00-9:00	Programme Committee Breakfast (hotel restaurant)
9:05-10:35	**Bio applications**	10:30-11:00	Coffee break	**9.00-10:30**	**Semiconductors I**
10:35-11:15	Coffee break	**11:00-12:30**	**Applications & scale-up**	10:30-11:00	Coffee break
11:15-12:45	**Fragmentation & post irradiation**	12:30-14:00	Lunch break (hotel restaurant)	**11:00-12:40**	**Semiconductors II**
12:45-14:00	Lunch break (hotel restaurant)	14:00-18:00	Social programme (outdoor)	12:40-14:00	Lunch break (hotel restaurant)
14:00-15:30	**Post irradiation**	**19:00-20:30**	**Poster session (room tba)**	**14:00-15:50**	**Non-equilibrium fluids**
15:30-16:00	Coffee break			15:50-16:20	Coffee break
16:00-17:40	**Cavitation bubble & plasma dynamics**			**16:20-18:10**	**Special session, incl. the Student Presentation Award & ANGEL 2012 Announcement**
19:00 20:30	Conference dinner optional: FIFA World Cup 2010, match of the last sixteen, public viewing in the hotel bar				

9:00 - 10:35 Bio applications

Session chairs: Vincenzo Amendola, University of Padua, IT (tbc)
Michel Meunier, École Polytechnique, CA (tbc)

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9:00 **Welcome**
Stephan Barcikowski, Laser Zentrum Hannover (LZH), DE
Fumitaka Mafuné, University of Tokyo, JP

9:05 

Femtosecond laser interaction with plasmonic nanostructures in liquids: Modelling and application to biology KEYNOTE TALK

Michel Meunier, E. Boulais, R. Lachaine, J. Baumgart; École Polytechique, CA

Irradiating metallic nanostructures by a femtosecond laser beam produces highly localised processes on the nanoscale in the surrounding medium. This particular process is mainly attributed to the surface plasmon resonance of the nanostructures. When these nanomaterials are imbedded in a biological media, their irradiation by a femtosecond laser could results in a highly localized plasma, heat production and mechanical effects yielding to the nanosurgery of cells. Modeling these interactions and applications of this technique to perform cell optoperforation will be presented.

9:35 **Femtosecond laser ejection of gold nanoprisms fabricated by nanosphere lithography into liquid media**

Wei (David) Qian, Christopher Tabor, Wenyu Huang, Mostafa El-Sayed; Georgia Institute of Technology, US

In the first part of this presentation, I will talk about an novel strategy of produing highly monodipersed solution-phase gold nanoprisms by fabricating them first using nanosphere lithography and subsequently being released into various liquid media by femtosecond laser irradiation. In the second part, I will discuss applications of gold nanoparticles in ultrasensitive biosensing and long-term, continuous, and intermittence-free live cell imaging over several tens of hours.

9:55 **Modeling and enhancement of photothermal and photoacoustic properties of absorbing nanoparticles**

V.K. Pustovalov[1], L.G. Astafyeva[2], E. Galanzha[3] and V.P. Zharov[3]; 1Belarusian National Technical University, BY; 2National Academy of Sciences of Belarus, BY; [3]Philips Classic Laser and Nanomedicine Laboratories, University of Arkansas for Medical Sciences, US

Application of nanoparticles (NPs) as photothermal (PT) and photoacoustic (PA) contrast markers, agents, labels includes optical diagnostics of different materials, molecular imaging, diagnosis and therapy of cancer, etc. This direction of investigations is fast growing area of research with many potential benefits including possibility for diagnostics and imaging of different media, killing of individual abnormal cells or imaging of deeper tissues with higher resolution compared to optical methods. Here we present focused analysis of requirements to NPs and platform for optimization of NP properties (e.g., optical, thermal, acoustic, structural, geometric, and others) allowing to enhance their PT/PA contrast in the presence of different ambiences. The several types of NPs are described which provide significant increased conversion of laser pulse energy in PT, PA, and photothermally-induced bubbles as signal enhancer and cell killer.

10:15 **Gold nanobioconjugates by fast ex-situ functionalization using nanosecond laser ablation in liquid flow**

C. L. Sajti, A. Barchanski, S. Barcikowski; Laser Zentrum Hannover (LZH), DE

Plasmonic materials, such as gold nanoparticles, characterized by highly enhanced resonant absorption and scattering are particularly useful in monitored drug delivery, in-vivo bioimaging and targeted cell therapy when conjugated with one or several functional entities such as cell-penetrating peptides, oligonucleotides or mitochondria-targeting peptides. Recently, ultrashort laser ablation in liquids has been demonstrated as a novel approach in generating pure, size-controlled nanohybrids qualitatively overcoming competing chemical synthesis methods. Pulsed laser ablation in presence of a confining environment, such as a biomolecule solution, enables in-situ hybridization with functional biomolecules due to active groups such as thiol or amine [1,2]. On the other hand, even during in-situ conjugation by ultrashort lasers, significant degradation of biomolecules might occur due to nanohybrid-beam interactions [3].

10:35 - 11:15 Coffee break

11:15 - 12:45 **Fragmentation & post irradiation**
Session chairs: Fumitaka Mafuné, University of Tokyo, JP (tbc)
Tsuyoshi Asahi, Ehime University, JP (tbc)

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11:15 **Tailoring of organic nanoparticle colloids by laser ablation in water** INVITED TALK

Tsuyoshi Asahi; Ehime University, JP

Laser ablation of organic microsrystalline powder is opening new horizons, since the powder sample is converted directory into a stable colloidal solution without additives and chemicals. We demonstrate the preparation of aqueous nanoparticle colloids for various compounds including pigments, fluorescence dyes, photochromic diarylethene, C60, and an anticancer drug. In addition, particle size and phase can be controlled by tuning laser fluence, wavelength, and pulse width. As a representative example, nanoparticle formation of quinacridone, which is a well-known red pigment, is presented and the dependence on the laser parameters is discussed in terms of photothermal laser ablation mechanism.

11:45 **Laser-induced fragmentative decomposition of fine CuO powders in acetone: A highly productive pathway to Cu and Cu2O nanoparticles**

Mitsuo Kawasaki, N. Nishimura; Kyoto University, JP

This paper introduces a laser-induced fragmentative decomposition of fine CuO powders in acetone medium, which serves as a highly productive pathway to Cu and/or Cu2O nanoparticles. They are useful particularly for application as nanomaterials for conductive pattern making in the electronics industry. The presentation covers the background, prepartion, characterization, and methods to use them for conductive pattern (film) making.

12:05 **Fragmentation of differently capped Au nanoparticles by 532 and 355 nm ps laser irradiation: experimental analysis and theoretical modelling**

E. Giorgetti [1], F. Giammanco [2], P. Marsili [2], A. Giusti [2†]; [1] Consiglio Nazionale delle Ricerche, IT; [2] University of Pisa, IT; [†]present address: Université Paris-Sud 11, FR

Photofragmentation of metal nanoparticles (NPs) has been extensively studied for more than ten years. The experimental parameters spread up over a very wide range of wavelengths, fluences and laser pulse durations. Two basic mechanisms have been identified as responsible for NP fragmentation under laser illumination, which can be schematically summarized in: i) thermal heating followed by evaporation and ii) electron ejection, due to either thermoionic emission and/or photoionization, which leads NPs to fragment by Coulomb explosion.

12:25 **Pulsed-laser induced electron dynamics relevant to spontaneous splitting and lattice heating of gold nanoparticles in solution**

Daniel Werner[1], Shuichi Hashimoto[1], Takayuki Uwada[2]; [1] The University of Tokushima, JP; [2] National Chiao Tung University, TW

In situ spectroscopic study on laser-induced reshaping and size reduction of pseudo-spherical gold nanoparticles (NPs) with 54 $\pm$ 7 nm diameter allowed the observation of strong excitation wavelength-dependent heating efficiency (Fig. 1). This is due to the excitation energy-dependent specific heat capacity, c_p, a phenomenon that has not been realized previously. For instance, a 60 % reduced c_p value compared to that of bulk gold was obtained on interband excitation at 266 nm while a c_p value on excitation of intraband transition at 532 nm was unaltered. A qualitative explanation was given to this striking phenomenon induced by the excitation-relaxation cycles of electrons between 5d to 6sp bands, which lead to a reduced electron density contributing to the electron temperature rise in the vicinity of the Fermi level. By contrast, electronic excitation within the 6sp band does not result in a net reduction of the electron number near the Fermi level, giving rise to the value of c_p similar to that of bulk gold.

12:45 - 14:00 **Lunch break (in the hotel restaurant)**

14.00 - 15.30 **Post irradiation**
Session chairs: Wei (David) Qian, Georgia Inst. of Techn., US (tbc)
Georgy Shafeev, Russian Academy of Science, RU (tbc)

14:00 **Metallic nanoparticles in liquids as the target for laser initiation of nuclear reactions** INVITED TALK

G.A. Shafeev; Wave Research Center of A.M. Prokhorov General Physics Institute of the Russian Academy of Sciences, RU

The review of recent experimental results is presented on the initiation of nuclear reactions under laser exposure of metallic nanoparticles in aqueous solutions of in either Thorium or Uranium salts. It is demonstrated that the rate of nuclear transformations depends on the nanoparticle material (Au or Pd) as well as on the nature of the liquid medium in which they are synthesized by laser ablation (either H_2O or D_2O). Matching the laser wavelength into the plasmon resonance allows observation of large deviations from secular equilibrium of radionuclides in both ^{232}Th and ^{238}U branching. Real-time gamma-spectroscopy of the samples under laser exposure shows the presence of short-living isotopes. The post-irradiation decay of the samples activity shows non-trivial behavior. Possible mechanisms of the laser initiation of nuclear transformations are and its possible applications are discussed.

14:30 **Laser synthesis and manipulation of nanomaterials**

F. Mafuné; The University of Tokyo, JP

Nanoparticles have attracted much attention of scientists because of their size-dependent physical and chemical properties. In this relation, size-selected nanoparticles with diameters <10 nm are prepared using wet-chemistry techniques. Recently, laser ablation method has been developed to prepare metal nanoparticles in a solution. This fully physical method allows us to prepare nanoparticles without stabilizing reagents, but the size-distribution of the nanoparticles tends to be broadened.

14:50 **Laser-induced selective modification of core/shell colloids**

Ivano Alessandri, Laura E. Depero; University of Brescia, IT

Metal nanostructures such as nanospheres, nanoshells and nanorods are attracting ever increasing interests in nano- and bio-technology due to their versatile surface chemistry and tunable optical properties. In addition to that, these nanostructures can be exploited as very efficient photon-thermal converters, to generate and localize light-induced heat at the micro- and nanoscale. This key property is currently investigated for a number of important applications in various research fields, including drug delivery, cancer diagnostics and therapy, nanofabrication, heat transfer in fluids and microspectroscopy. Herein, we will show how the interaction between continuous-wave laser and metal nanoparticles can be exploited to generate extremely localized heating effects in core/shell colloidal systems, in order to achieve a selective modification of their morphology and/or to induce phase changes. Moreover, we will demonstrate how plasmonic heating and related effects can be harnessed and conveniently addressed to yield SERS-active sites in different metal oxide nanoshells.

15.10 **Long term stability of uncapped AuNPs obtained by ps laser ablation in different solvents: wavelength and concentration dependence**

E. Giorgetti [1], F. Giammanco [2], P. Marsili [2], A. Rindi [3], R. Gutièrrez [4], I. Moggio [4,] Eduardo Arias[4]; [1] Consiglio Nazionale delle Ricerche, IT; [2] University of Pisa, IT; [3] Consiglio Nazionale delle Ricerche and Dipartimento di Chimica e Chimica Industriale, Università di Genova, IT; [4] Centro de Investigación en Química Aplicada, MX*

Colloidal suspensions of gold nanoparticles (AuNPs) produced by pulsed laser ablation of a metallic target are of great interest, especially for the fast developing fields of human biology and medicine. The ablation method permits both a strong versatility in terms of NPs environment and thorough elimination of any contaminating substance in the suspension, including capping agents and stabilizers.
The stability of uncapped NPs is a key issue for their application. It may depend on different factors, such as solvent, dimensions and concentration. However, our experimental data, which were obtained with ps pulses, show that the laser parameters, such as wavelength and intensity, play an important role. In general, AuNPs obtained in pure water, acetone and ethanol with 1064nm ps pulses can be stable for months. However, in all cases, infrared ablation produces strongly dispersed NPs. A considerable narrowing of the statistical distribution of particle dimensions can be obtained by using shorter wavelengths, such as 532 or 355 nm, due to photofragmentation effects [1,2]. For example, in acetone we obtained stable and almost monodispersed 2-3 nm AuNPs with 532 nm, while with 1064 nm the particles were larger (average diameter around 5 nm) and many of them exhibited diameters in the range 10-30 nm.

15.30 - 16.00 Coffee break

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16:00 - 17:40	**Cavitation bubble & plasma dynamics** Session chairs: Masaharu Tsuji, Kyushu University, JP (tbc) Nikolai Tarasenko, Nat. Academy of Sciences, BY (tbc)
16:00	**Formation of nanoparticles in the laser-induced cavitation bubble** *A. Menéndez-Manjón, S. Barcikowski; Laser Zentrum Hannover (LZH), DE* The formation mechanism of nanoparticles after the laser ablation of a solid target in a liquid is still a controversial subject. Since the first investigations on this field, two main mechanisms have been discussed. The first relies on the nucleation and growth of ablated matter in the laser plume1; the second assumes ejection of droplets from the molten layer in the liquid matrix2. In order to get evidence on the nanoparticle generation process and understand the influence of the physical properties of the liquid on the final nanoparticle size distribution, we have generated gold nanoparticles by femtosecond laser pulses in water at different temperatures.
16:20	**Underwater production of nano particles by 1064 nm laser ablation on gold and silver targets** *T. Kovalchuk, G. Toker, V. Bulatov, I. Schechter; Technion - Israel Institute of Technology, IL* The underwater interaction of 1064 nm laser radiation with silver and gold targets was investigated for the purpose of understanding efficiency of production of nanoparticles under laser ablation. Two types of laser pulses were used: the gigantic pulse and the pulse in regime of free generation. The underwater processes of the NIR laser beam-metal target interaction were visualized and measured by applying Mach-Zehnder interference technique.
16:40	**Enhancing ablation efficiency in liquids: bypassing the cavitation bubble** *P. Wagener, A. Schwenke, S. Barcikowski; Laser Zentrum Hannover (LZH), DE* Ablation efficiency of high-repetitive laser systems is often margined by shielding of subsequent pulses by laser-induced cavitation bubbles in liquids. To enhance ablation efficiency, the cavitation bubble has either to be passed temporal or spatial. We performed pulsed laser ablation of zinc in tetrahydrofuran with a high-power picosecond laser system (25W) coupled to fast scanner optics to generate ZnO nanoparticles. Systematic variation of repetition rate and interpulse distance of subsequent laser pulses strongly affects the ablation efficiency.
17:00	**Spectroscopic investigation of single and double pulse laser induced plasma produced by laser-metal interaction in bulk water** *A. De Giacomo[1,2], G. Colonna[2], M. Dell'Aglio[2], O. De Pascale[2], R. Gaudiuso[1], F. Taccogna[2]; [1] University of Bari, IT; [2]CNR-IMIP sec. Bari, IT* In this work the Laser Induced Plasma (LIP) produced by the interaction of laser pulses with metallic targets has been investigated by time resolved emission spectroscopy with the support of theoretical models [1,2]. Emission spectra show the effect of liquid confinement on plume expansion in terms of internal energy waste when single pulse ablation is carried out in bulk water. As a consequence, the spectrum is dominated by a continuum radiation due to fast recombination of ions with electrons and to high density effects.
17:20	**Modeling of nanoparticle formation by laser ablation in liquids** *T.E. Itina1, G. Ledoux[2], D. Amans[2], C. Dujardin[2]; [1] CNRS UMR 5516/ University Jean Monnet, FR; [2] CNRS UMR 5620/Lyon University, FR* Pulsed laser ablation in the presence of a strongly confining environment; such as aqueous solutions, is known to enhance nanoparticle formation. Experimentally, several advantages of this technique were demonstrated, in particular the possibility of control not only over the mean size of the produced particles, but also over the size dispersion [1]. In addition, the possibilities of formation of a very narrow size distribution were discussed. Many points, however, are still puzzling. It is unclear, for instance, at what delay nanoparticles are formed and why their distribution becomes stable. In colloidal solutions, chemical and electrostatic effects affect furthermore the final size distribution. We discuss the results of several numerical calculations based either on atomistic approaches or on the master equation combined with the classical hydrodynamic model.

19:00	**Conference dinner in the hotel restaurant**
20:30	**optional: FIFA World Cup 2010, match of the last sixteen, public viewing in the hotel bar**

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9:00 - 10:30 Alloy nanoparticles

Session chairs: Georgy Shafeev, Russian Academy of Science, RU (tbc)
Philipp Wagener, Laser Zentrum Hannover, DE (tbc)

09:00 

Laser tailoring of nanoparticles INVITED TALK

Karl Kleinermanns, Heinrich-Heine-Universitaet Duesseldorf, DE

Laser induced size tailoring of nanoparticles (NP), formation of nano-alloys and core-shell particles, nano-hybrids with attached biomolecules and laser nanoparticle heating in connection with phototherapy will be topic of the talk.

09:30 **Laser fabrication and modification of compound nanoparticles in liquids**

N.V. Tarasenko, A.V. Butsen, M.I. Nedelko; B.I. Stepanov Institute of Physics, BY

This paper provides an overview of our recent research concerning the formation and modification of nanoparticles in plasmas produced by single and double pulse laser ablation in liquids. The capabilities of laser ablation technique for fabrication of metallic (Au, Ag, Cu, Gd), bimetallic (Ag-Cu and Ag-Au) as well as oxide (ZnO, ZnO:Ag, $Gd_2O_3:Tb^{3+}$) nanocomposites have been investigated. Laser-induced effects in metal and composite nanoparticles have been shown to be used as a tool to selectively change the particle morphology and inner structure.

09:50 **Femtosecond laser processing of nanomaterials in liquids for biomedical applications**

M. Meunier, S. Besner, P. Boyer, J-P. Sylvestre; École Polytechnique de Montreal, CA

An overview of our recent developments on ultrafast laser processing of nanomaterials and their applications in biomedical will be presented. The new process consists performing femtosecond (fs) laser ablation of a target immersed into a biocompatible liquid to produce nanoparticles. In addition, fs laser fragmentation is used to finely control the size of produced nanomaterials.

10:10 **Ni/NiO core/shell nanoparticle production by femtosecond laser ablation in liquid media**

A. J. Martins, P. Schellenberg, P. J. G. Coutinho, M. Belsley, L. Marques, M. M. D. Ramos; University of Minho, PT

We present a method to produce quality Nickel nanoparticles by femtosecond laser ablation in liquid solution. Nickel nanoparticles have unique magnetic properties at room temperature [1], which can be fine-tuned by varying their size and morphology. The production of pure metallic nanoparticles is often associated with surface oxidation which results in the formation of core/shell structure nanoparticles with unusual magnetic properties [2]. In order to control the magnetic properties of these core/shell nanoparticles it is necessary to tune the thickness of the shell and the size, shape, crystal structure and shape of the entire particle [1, 2].

10:30 - 11:00 Coffee Break

NOTES | NOTES | NOTES

11:00 - 12:30 Applications & scale-up

Session chairs: Heinrich Hofmann, EPFL, CH (tbc)
Vincenzo Amendola, University of Padua, IT (tbc)

11:00 

Plasmonic characterization and photonic applications of noble metal nanoparticles obtained by LASiS INVITED TALK

V. Amendola, M. Meneghetti; University of Padova, IT

Noble metal nanoparticles (NMNPs) are powerful tools in modern nanotechnology, thanks to their peculiarities: the intense surface plasmon resonance (SPR), the chemical stability and the simple surface chemistry. Many authors showed that laser ablation synthesis in solution (LASiS) is a viable and versatile technique for obtaining colloidal solutions of NMNPs.[1]

11:30 **Nanocomposites for bioactive medical devices: fabrication and testing**

P. Wagener, A. Schwenke, S. Barcikowski; Laser Zentrum Hannover (LZH), DE

Nanocomposites made of metal nanoparticles embedded in polymer matrices [1] are promising materials for medical devices with antibacterial properties by release of bioactive ions [2,3] . We present a novel, universal process route for the generation of pure metal (Ag, Zn, Mg, Cu) nanofilled thermoplastic polyurethane (TPU) nanocomposites, which is based on a combination of particle generation in organic solvent via pulsed laser ablation, solution compounding and injection molding to prototypes suitable for biological testing and later production of medical devices like catheters.

11:50 **Ablation in a flow-chamber for continuous nanoparticle generation**

T. Salminen, T. Niemi; Tampere University of Technology, FI

We have studied the generation of nanoparticles with a high repetition rate fiber laser in a flow cell that enables continuous production of the nanoparticles. The liquid can also be recycled to allow the particle concentration to be increased independently of the flow rate. We examine the influence of the flow rate, liquid recycling and the laser parameters including the fluence and the repetition rate.

12:10 **Scale-up of corundum nanoparticle productivity during laser ablation in liquid**

Ramin Sattari, Ata Oerneker, Csaba László Sajti, Philipp Wagener, Stephan Barcikowski; Laser Zentrum Hannover (LZH), DE

Laser ablation of materials for nanoparticle generation is a versatile technique which is becoming increasingly important. However, the significant drawback of the laser-assisted method is the current low productivity compared to well-established nanoparticle synthesis methods like mechanical ball milling or sol-gel processes.

12:00 - 14:00 Lunch break in the hotel restaurant

14:00 - 18:00 Social programme (outdoor), meeting point: in front of the hotel

19:00 - 20:30 Poster session

NOTES | NOTES | NOTES

ANGEL 2010_2591_01
Poly (3-alkylthiophene) and modified carbon nanotube composites for photovoltaic applications

Mohammad Rezaul Karim; Center of Excellence for Research in Engineering Materials, College of Engineering, King Saud University (SA)

The use of thin film organic π-conjugated polymers in organic photovoltaic cells is on the increase. Polythiophene based composites are in the forefront. Carbon nanotubes are the most recently tried electron acceptor materials. In the case of carbon nanotubes because of the anisotropy and presence of semiconducting tubes, the realization of its full potentiality is still a challenging task. Recently, people have attempted to bring in directionality to the orientation of the carbon nanotubes and attempts made to separate out metallic part of single walled carbon nanotubes exploiting the differential interaction with planar aromatic molecules, such as free-based porphyrin or pyrene with long alkyl chains [1]. Also, the transport properties of conducting polymers are known to be greatly influenced by the chemical instauration surrounding the polymer backbone, besides favorable conformation of the side chains present.

ANGEL 2010_2600_02
A novel route for the synthesis of CdS nanostructures by irradiation of 10 MeV electron beam onto Cd2+- DMP aqueous solution

D.S.Yoo[1]; S.Y.Ha[1], I.G.Kim[1], J.D.Lee[1], M.S.Choo[1], G.W.Kim[1], E.S.Lee[1], B.C.Lee[2]; [1]Department of Physics, Changwon National University (KR); [2]Laboratory for Quantum Optics, Korea Atomic Energy Research Institute, KR

We investigated a novel route for synthesizing CdS nanostructures (quantum dots and nanorods) by irradiation of 10MeV electron beam onto Cd2+-thiol aqueous solution. The CdS nanostructures were successfully formed by simple irradiation of 10MeV electron beam (100KGy) onto aqueous solutions which contained CdCl2 and 2.5mM of DMP (1,3-dimercaptopropane). TEM images showed that when the concentration of DMP was fixed at 2.5mM, the morphology of the synthesized nanostructure was changed with the change of CdCl2 concentration. It was found that when the concentration of CdCl2 was 0.4mM (DMP rich case), only small quantum dots were formed and when the concentration of CdCl2 was increased to 5mM (cadmium rich case), the mixture of quantum dots and nanorods were formed.

ANGEL 2010_2606_03
Laser ablation of graphite in liquids: formation of polyynes

Seung Keun Shin, Sang Soo Ha, Jae Kyu Song, Seung Min Park; Department of Chemistry, Kyung Hee University, KR

Recently, there has been a growing interest in laser ablation of a graphite target in liquid phase aiming at the growth of polyynes [1-3], which are hardly produced employing conventional organic synthesis methods. Hydrogen-capped polyynes, ($H(C\equiv C)_nH$), are linear carbon chain molecules consisting of *sp* hybridized orbitals, being observed in the interstellar space. Due to their typical one-dimensional electronic structures, polyynes have attracted considerable attention in their size-dependent band gap and nonlinear optical properties [3]. Large polyynes, in particular, have been prepared by laser ablation of graphite mostly in organic solvents, while we present experimental results on the formation of them by laser irradiation of a graphite target in neat water.

NOTES | NOTES | NOTES

ANGEL 2010_2615_04
Surface enhanced Raman scattering from copper nanoparticles obtained by laser ablation

M. Muniz-Miranda[1], C. Gellini[1], E. Giorgetti[2]; [1]Dipartimento di Chimica, Università di Firenze (IT), [2]ISC-CNR, IT

The study of the adsorption processes on copper substrates finds wide justification in the importance of both inhibiting the surface corrosion and analyzing the interactions with biomolecules. This investigation can be performed by means of the Raman spectroscopy with the help of the SERS (surface-enhanced Raman scattering) effect, ensured by the presence of nanoparticles of noble metals like silver, gold or copper. By using this technique the Raman signal of molecules adhering nanostructured metal surfaces is enhanced by several orders of magnitude, with a spectral resolution comparable to that observed in the normal Raman experiments. Moreover, by measuring the position and intensity changes of the SERS bands with respect to the corresponding Raman bands for non-adsorbed molecules, it is possible to gain information on the orientation of the adsorbate, on the metal/ligand interactions and on the nature of the surface active-sites.

ANGEL 2010_2610_05
Wurtzite-type ZnO nanoparticles by PLAL

B.C. Lin[1], P. Shen[1], S.Y. Chen[2]; [1]National Sun Yat-sen University, Department of Materials and Optoelectronic Science (TW), [2]I-Shou University, Department of Mechanical and Automation Engineering, TW

Wurtzite (W)-type ZnO condensates showing {1011} artificial epitaxy on glass have been fabricated by pulsed laser ablation (PLA) on Zn target in vacuum. Such dense nanocondensates were found to transform into rock salt type structure upon electron irradiation in vacuum and undergo {1011} and {1121}-specific growth and twinning to form ZnO whiskers or even tapered ZnO whiskers by {hkil}-specific mosaic twinning VLS growth from a partially molten bottom source when the predominant W-type ZnO and minor Zn condensates were subjected to a thermal oxidation process. Here PLA in liquid (PLAL, in water) was used to fabricate hydrogenated W-type ZnO nanocondensates regarding laser parameter dependence of particle size and growth mechanism.

ANGEL 2010_2617_06
Modeling of nano core (Ag)-shell (Au) generation in distilled water based on laser ablation

Hamid Reza Dehghanpour[1], Parviz Parvin[2]; [1]Physics Dep. Tafresh University (IR); [2]Physics Dep. Amirkabir University of Technology, IR

The nano core-shell can be generated in the water under controlled exposure conditions using Q-SW Nd:YAG laser shots at 1064 nm. At first, the gold target was irradiated in water to generate nano gold particles. Then the silver target was immersed into water-gold suspension to be irradiated by laser shots too. The nano core-shells Ag (core)-Gold (shell) are created in the size of 30-50 nm. Mixed Au-Ag nano-particles were obtained by pulsed laser ablation of metallic targets was modeled using Mie- theoretical calculations. The ablated fragments ejected from the Ag target during slowing down was modeled based on laser induced ablation, hydrodynamics equations and the non-uniform metal distribution over the aggregate surface by the arrangement of nanoshells in the aggregate were modeled by fractal clusters accompanying ion exchanges dipole-dipole interactions and the thermal effects.

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ANGEL 2010_2622_07
Fabrication of Pd nano spheres in water by Q-switched Nd:YAG laser

S.Z.Mortazavi[a], P.Parvin[a], A.Nozad Golikand[b], S.Alipour[a], S.Keshmiri[a]; [a]Physics Department, [a]Amirkabir University of Technology, IR; [b]Material Research School, IR

Pulsed laser ablation (PLA) of target in liquids has attracted much attention as a new technique to prepare nanoparticles since Henglein, Cotton and their co-workers first developed this synthesis technique [1,2]. It has been demonstrated that laser ablation of various noble metals settled in solvents can produce colloidal nanoparticles [3– 5]. A remarkable advantage of this method over chemical synthesis is simplicity of preparation procedures, the weak agglomeration and the possibility of producing multicomponent nanoparticle. It is relatively ease and free of contaminating process to fabricate nanoparticle having small size and narrow distribution.
In this study, Pd nanoparticles have been created by pulsed laser ablation at room temperature in deionized water.

ANGEL 2010_2624_08
nano core(Ag)-shell(SiO2) generation base on single stage laser ablation

S.Keshmiri, P.Parvin, S.Alipour, S.Z.Mortazavi; Amirkabir University of Technology, Physic Department, IR

The core-shell Ag-SiO2 nanoparticles were successfully synthesized by Q-swiched laser ablation in the distilled water. A couple of successive silica glass and silver targets were located in front of the laser beam respectively. Laser shot was traversing the glass before contacting the silver target and the beam was focused by a quartz lens on the silver target. The power densities were carefully controlled on the Ag target based on without variation spot size during exposure. The separation distance was altered each time to obtain the maximum production rate at the optimum distance between targets. In order to create the core-shells, the laser properties such as energy, repetition rate were investigated. Transmission electron microscopy (TEM), for determination of shape and structure were used and X-ray energy dispersive spectroscopy (EDX) was employed for elemental analysis of core-shell nanoparticles.

ANGEL 2010_2629_09
Modeling of the processes of laser-nanoparticle interaction

V.K. Pustovalov; Belarusian National Technical University, BY

Optical properties of metal nanoparticles (NPs) determine following photophysical and photochemical processes. The calculation of efficiency factors of absorption, scattering and extinction for spherical and ellipsoidal gold NPs with radiuses in the range 5-100 nm and for some laser wavelengths in the range 308-1064 nm is performed [1-2]. The calculation of efficiency factors of absorption, scattering and extinction for spherical core-shell silica-gold NPs with radiuses in the range 5-100 nm and shell thicknesses 10, 20, 40 nm for some laser wavelengths is performed.

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ANGEL 2010_2632_10
Growth of ZnS nanoparticles in water using liquid phase pulsed laser ablation technique

P. M. Aneesh, R. Sreeja, M. K. Jayaraj; Optoelectronic Devices Laboratory, Department of Physics, Cochin University of Science and Technology, IN

Recently sulphide semiconductor nanomaterials have attracted much attention because of their potential applications in electroluminescent displays, luminescence and nano devices. Zinc sulphide (ZnS) is an important semiconductor material with a wide band gap of 3.72 eV for the cubic crystal structure and 3.77 eV for the hexagonal structure at room temperature. Recently much attention has been focussed on the synthesis of ZnS nanostructures. But most methods need either high temperature or a complex process. Liquid phase pulsed laser ablation is found to be a suitable method for the synthesis of nanoparticles because of the simplicity and low cost of the experimental set up. Here we report the synthesis of ZnS nanoparticles in distilled water by liquid phase pulsed laser ablation and the dependence of fluence, time of ablation on particle size were also studied.

ANGEL 2010_2633_11
PLA of Ag and Cu for antibacterial and antifungal composite applications

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Colloidal silver and copper nanoparticles were synthesized by pulsed laser ablation (PLA) of pure bulk materials in different environments using the second harmonic (532 nm) of an Nd:YAG laser. Nanoparticles were characterized by TEM and UV-Vis. and FTIR spectroscopy techniques. We observed that the Ag and Cu nanoparticles that are formed in acetone are more stable with an average size of 5 and 9 nm respectively. So we chose acetone as a suitable medium to make Cu/polystyrene (PS) and Ag/PS nanocomposite sheets. Casting the colloidal silver nanoparticles in a solution of polystyrene resulted in yellowish transparent polymeric sheets. Samples indicated more hydrophobicity compared to the PS surface. Antibacterial and antifungal tests of the nanocomposites were studied using colony counting, evaluation of susceptibility constant (Z) and Turbidimetry methods.

ANGEL 2010_2635_12
Laser Ablation in Liquid: Colloidal Nanoparticles Synthesis

S. Messaoud Aberkane, S. Boudjemai, T. Kerdja; Centre de développement des technologies avancées (C. D. T.A); DZ

Formation of nanopartilces under laser ablation of solids either in gas or in vacuum has been extensively explored during the last decade. The understanding of the mechanisms of clusters formations is needed to control the process of pulsed laser deposition (PLD) now widely used for the deposition of a large variety of compounds. Recently formation of nanoclusters by laser ablation of solids target in liquids has received great attention due to the immense potential of these materials in a large number of applications, including electronic, and biomedical engineering, due to their unique properties that differ from the corresponding bulk materials. In this contribution we report formation of Ti and Si nanoparticles under laser ablation of metal targets in liquids medium (deionised water).

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ANGEL 2010_2637_13
Diamond-like carbon nanoparticles obtained in liquid by short and ultra-short laser pulses

A. De Bonis[1,2], R. Teghil[1,2], A. De Giacomo[3,4], R. Gaudiuso[3], M. Dell'Aglio[4], G.S. Senesi[4], A. Santagata[2], S. Orlando[2]; [1]Università degli Studi della Basilicata, Dipartimento di Chimica, IT; [2]CNR-IMIP, U.O.S. di Potenza, IT; [3]Università di Bari, Dipartimento di Chimica, IT; [4] CNR-IMIP, U.O.S. di Bari, IT

Diamond-like carbon nanoparticles have been produced by laser ablation of carbon based target in aqueous media. Laser pulse durations of 100 fs (@ 800nm), 250 fs (@527 nm) and 7 ns (@ 532 nm) have been applied. In the case of ns ablation both single and double pulse configurations have been applied, with the aim of exploring the effect of the laser induced cavitation bubble condition (pressure and temperature) on particles formation by adjusting the inter-pulse delay between the laser pulses. Micro-Raman, TEM, SEM and AFM characterization of nanoparticles collected on suitable substrates have been performed.

ANGEL 2010_2639_14
Plasmon-enhanced optical trapping of gold nano-aggregates prepared by laser ablation in liquid environments.

E. Messina[1], E. Cavallaro[2], A. Cacciola[3], R. Saija[3], F. Borghese[3], P. Denti[3], P.G. Gucciardi[2], M.A. Iatì[2], M. Meneghetti[4], G. Compagnini[1], V. Amendola[4], O.M. Maragò[2]; 1Università di Catania, Dipartimento di Scienze Chimiche, IT; [2]Istituto per i Processi Chimico-Fisici (CNR), IT, [3]Università di Messina, Dipartimento di Fisica della Materia e Ingegneria Elettronica, IT; [4]Università di Padova, Dipartimento di Scienze Chimiche, IT

We investigate experimentally and theoretically Plasmon-enhanced optical trapping of metal nanoparticles and aggregates. In particular, we show how light forces can be used to trap gold nanoaggregates of controlled size and structure obtained by laser ablation synthesis in solution. We use correlation function analysis of the trapped particle tracking signals to obtain a measure of the enhanced optical forces as a function of aggregation.

ANGEL 2010_2626_15
Structural and optical limiting properties of polyynes prepared by pulsed laser ablation of graphite in liquids

E. Fazio[1], S. Patanè[1], F. Neri[1], L. D'Urso[2], G. Compagnini[2]; [1]Dipartimento di Fisica della Materia e Ingegneria Elettronica Università di Messina, IT; [2]Dipartimento di Scienze Chimiche Università di Catania, IT

In the last years, the potential of using carbon nanoparticles as nonlinear optical materials is generating much research interest [1]. Carbon nanoparticles applied as optical limiters are usually prepared by diluting and filtering a commercially available ink. Generally, these colloids contains large particles up to 200 nm. However if the carbon particles have size of few nanometers, the optical sensitivity may be enhanced [2]. Linear polyynes have recently received considerable attention because they are promising one-dimensional conducting materials, excellent candidates for optical limiting and precursor in carbon nanotubes and fullerenes formation. In this work, polyynes were prepared by Nd:YAG laser ablation at different wavelengths of a graphite target immersed in water, acetonitrile and metal colloidal solutions.

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ANGEL 2010_2627_16
Synthesis and characterization of silicon nanoparticles by laser ablation in DMSO

M. Taheri, F. Hajiesmaeilbaigi, A. Motamedi; Solid State Group Laser and Optics Research School, IR

In this work, silicon nanoparticles have been prepared by a laser ablation method of silicon wafer in Dimethyl sulfoxide at different applied laser fluence levels. The silicon wafer was irradiated by Q-switched Nd:YAG laser under situation of fundamental wavelength 1064 nm with 20 ns pulse width operated at 10 Hz repetition rate.
Synthesized particles are characterized by UV-visible absorption spectrometry, transmission electron microscopy (TEM) and Fourier transform infrared (FTIR) spectra. UV-Visible spectrum shows characteristic shifts corresponding to size, consistent with quantum confinement. The blueshift of the optical absorption spectrum is observed for decreasing average diameter of the Si nanoparticles.

ANGEL 2010_2641_17
ZnO-Au nanocomposite by pulsed laser irradiation

Geetika Bajaj, R.K. Soni; Indian Institute of Technology Delhi, Physics Department, IN)

Semiconductor oxide-metal ZnO-Au nanocomposite promising for biosensing applications like DNA and protein detection and potential replacement for dye molecules as label materials which show lower photostability and weaker chemistability. We have synthesized ZnO-Au nanocomposite in colloidal form which involves formation of Au and ZnO colloidal solution by pulsed laser ablation of Zn and Au targets separately in deionized water. The colloidal solutions were then mixed and post irradiated by nsec pulses of Nd:YAG laser (532 nm). The laser fluence at target surface during the post irradiation was varied from 0.4 J /cm^2 to 1.3 J/cm^2.

ANGEL 2010_2644_18
Synthesis and characterization of gold nanoparticles in 535-4TB utilized in nano structured dye sensitized solar cell

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Flexible Dye-Sensitized Solar Cells (DSSCs) are new generation of nano structured photovoltaic solar cells that biomimetic the natural photosynthesis process. These cells work by absorbing photons on an inexpensive thin-film composed of dye molecules attached to a titanium oxide layer on a plastic substrate. One of the dyes using to fabricate of this solar cells is 535-4TB dye. Fig .1 shows the chemical structure of 535-4TB molecules .In this paper, gold nanoparticles have been prepared by pulsed laser ablation(PLA) method of gold metal target(99.9% of purity) in 535-4TB dye by using Nd:YAG laser with 1064nm wavelength. The different distribution of particles size is achieved by changing of the laser energy. UV-visible absorption spectroscopy, Transmission Electron Microscopy (TEM) and scanning electron microscopy (SEM) have been used to characterize the 535-4TB dye/Au nanoparticles.

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ANGEL 2010_2645_19

Optimization of silver nanoparticles laser synthesis with emission spectroscopy of induced plasma

S. Dadras[1], P. Jafarkhani[1], M. J. Torkamany[2], J. Sabbaghzadeh[2], A. Koohian[1]; [1]Faculty of Physics, Tehran University, IR; [2]Iranian National Centre for Laser Science and Technology (INLC), IR

The spectroscopic study of laser induced plasma can be used to optimize the laser synthesis of nanoparticles (NPs) by attributing the features of the synthesized NPs such as concentration and size distribution to the thermodynamic parameters of the plasma plume.
Several studies have been reported on the spectroscopic characterization of the laser ablation and the evolution of ablated species. However, the main purpose of these studies has been the optimization of the pulsed laser deposition of thin films. Also, a number of investigations have been performed on the relation of the features of NPs, synthesized in the vacuum or gaseous media, with the induced plasma characteristics. But a few comprehensive studies have been done to investigate the relation of plasma plume features with the quantitative and qualitative characteristics of the synthesized NPs.

ANGEL 2010_2646_20

Necklace shaped Au-Ag nanoalloys: laser assisted synthesis and nonlinear optical properties

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Here in this paper, necklace-shaped Au-Ag nanoalloys (NAs) have been synthesized by a laser-based approach. A chain of Ag nanoparticles (NPs) which was joint together with Au junctions were formed upon the copper vapor laser (CVL) irradiation on a colloidal mixture of Ag and Au NPs; while the corresponding NPs were distinctly provided by laser ablation of gold and silver targets in deionized water by a 1064 nm Q-switched Nd:YAG laser.

ANGEL 2010_2647_21

Laser microexplosions of nanoparticles in tumor

B.Y. Kogan[1], A.A. Pankratov[2], A.V. Butenin[1], R.A. Feyzulova[1], T.N. Andreeva[2], R.I. Yakubovskaya[2]; [1]State Research Center "NIOPIK", RU; [2]Hertsen Moscow Research Institute of Oncology; RU*

Light-absorbing nanoparticles (NPs) incorporated in a tissue can be heated by short-pulse laser irradiation up to explosion temperature. Average tissue temperature may be kept normal if average fluence rate is low. Earlier we have reported tumor growth inhibition using powerful laser irradiation of carbon NPs in tumor. In presented work an antitumor effect of phthalocyanine NPs has been studied.

ANGEL 2010_2648_22

Femtosecond laser assisted formation of gold nanoparticles: influence of CTAB molecules on nanoparticle stability

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Various types of surfactants have been used in the past to improve the size distribution of gold nanoparticles produced by laser ablation. These improvements are generally attributed to surfactants that cover the nanoparticle surface during the growth process and thus prevent particle agglomeration. Further, it has also been shown that surfactants play an important role in nanoparticles stability. However, a full quantitative analysis of the colloidal stability needs to be done by examining the transition point between stable and unstable behaviour of the colloids. This will yield new insights into the interplay between surfactants and the nanoparticles during the ablation process.

ANGEL 2010_2652_23

Gold nanoparticles produced by laser ablation onto ionic liquids

H.W.L. dos Santos[1], S.R. Teixeira[1], R.R.B. Correia[1], J. Dupont[2], M.L. Andreazza[3]; [1]Universidade Federal do Rio Grande do Sul, Instituto de Física, BR; [2]Universidade Federal do Rio Grande do Sul, Instituto de Química, BR; [3]Universidade de Caxias do Sul, CCET, BR

We examine the role played by ionic liquids (IL) and the IL-air interface in the growth of gold nanoparticles by laser ablation, motivated by the unnecessary addition of stabilizing products to avoid particle aggregation. Since bulk and interface processes evolve in different regimes of thermalization and stabilization of ejected clusters, sizes, shapes and structure of the formed nanoparticles, are observed to be quite distinct, as expected.

ANGEL 2010_2654_24

Synthesis of aluminum oxide nanoparticles using laser ablation in liquid

Bhupesh Kumar, R. K. Thareja Department of Physics, Indian Institute of Technology Kanpur, IN)

We report the synthesis of photo luminescent aluminum oxide nanoparticles (NPs) using pulsed laser ablation in liquid (PLAL). To understand the formation of NPs in PLAL thermodynamic conditions of plasma was estimated and an attempt has been done to correlate growth velocity and size of NPs using a kinetic model. The XRD characterization of NPs shows the presence of aluminum oxide and some intermediate oxides of aluminum. TEM measurement shows the spherical shape of the NPs with average size 25nm. Photoluminescence (PL) measurement has been done at room temperature using UV excitations shows broad peak implying the presence F centers responsible for luminescence. PL peaks shift was observed with the change in excitations wavelength. The red shift in PL peaks may be due to the inhomogeneous distribution of defect centers participating in PL emission under different excitations. Growth kinetics and effect of ablation parameters on NP formation and PL measurements in low temperature range of NPs will be discussed.

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ANGEL 2010_2655_25

Synthesis of Palladium nanoparticles by pulsed laser ablation in water and their characterization

F. Colao[1], G. Cristoforetti[2], A. Dinelli[2], F. Fabbri[1], V. Palleschi[3], E. Pitzalis[3], A. Rufoloni[1]; [1]ENEA, FISLAS, IT; [2]Istituto Nazionale di Ottica – CNR, sezione di Pisa, IT; [3]Istituto per i Processi Chimico-Fisici, IT

Nano-sized metal particles are often produced because of their peculiar physical and chemical properties, related to quantum size effects on the electron distributions with respect to bulk samples. Palladium nanoparticles have proven to be efficient catalysts toward many reactions, such as olefin hydrogenation.

In this work, palladium nanoparticles were produced by pulsed laser ablation in water. The effect of the wavelength (355 and 1064 nm), repetition rate (10 to 200 Hz), and energy of a Nd:YAG laser on the size distribution and produced quantity of nanoparticles were studied.

ANGEL 2010_2662_26

Impact of spacer length on laser-generated gold nanomarker design

N. Hashimoto[1], A. Barchanski[2], S. Petersen[2], S. Barcikowski[2]; [1]Chuo University, JP; [2]Laser Zentrum Hannover (LZH), DE

Gold nanoparticles are of increasing interest for biomedical applications such as drug delivery, diagnostics and high resolution imaging, due to their biocompatibility and higher magnitude of light scattering and resistance to photobleaching compared to molecular fluorophores. In particular, gold nanoparticles can be functionalized with biomolecules like oligonucleotides to design nanomarkers with the attribute for specific DNA sequence targeting.

Using ultrashort pulses, nanoparticles can be generated by laser ablation in solution in a fast, single-step process. No surfactants are used in this process, fabricating pure, stable nanoparticles with the possibility of *in-situ* functionalization.

In this study, we synthesized four different gold nanoparticle conjugates with an oligonucleotide sequence of varied spacer length and insert position and compared the conjugates to the same gold nanomarker without spacer.

ANGEL 2010_2666_27

Particular particle shapes achieved through pulsed laser ablation in liquid

C. Chubilleau[1], V. Kosalathip[2], B. Lenoir[1], H. Cao[3], S. Migot[1], A. Dauscher[1]; [1]Institut Jean Lamour, UMR 7198 CNRS-Nancy Université -UPVM, Ecole Nationale Supérieure des Mines de Nancy, FR; [2]Department of Physics, King Mongkut's University of Technology Thonburi, TH; [3]Laboratoire CRISMAT, ENSICAEN, FR

Pulsed laser ablation of a solid target or laser fragmentation of micronsized particles in a liquid medium (PLAL) is a simple and powerful way to produce nanoparticles and can be considered as an alternative route to the classically used chemical processes. It is attracting more and more attention and has been applied to the synthesis of nanoparticles of a large variety of materials, but especially metals. According to the experimental conditions used, some other shapes have been obtained (elongated particles, nanowires, …). The general focus of our work is to produce nanoparticles of semiconducting thermoelectric materials by PLAL, working with ns Nd:YAG laser.

ANGEL 2010_2672_28

Preparation of luminescent and optical limiting silicon nanostructures by nanosecond-pulsed laser ablation in liquids

E. Fazio[1], F. Barreca[2], S. Spadaro[2], G. Currò[2], F. Neri[1]; [1]Dipartimento di Fisica della Materia e Ingegneria Elettronica Università di Messina, IT; [2]Advanced and Nano Materials Research s.r.l., IT

Scientific and technological research in the field of silicon nanocrystals, is currently strongly active due to the envisaged impact in the optical and electronic device industry. Although self-assembly of nanocrystalline silicon structures has been reported, a reliable fabrication technique, capable of producing very small silicon nanocrystals surrounded by a tailored oxide shell and optical limiting, remains still a challenge. In this work, the results of a laser-induced ablation of silicon in three different liquid environments, that is pure water, hydrogen peroxide water solution and pure ethanol, are reported. The experiments were conducted using a Nd:YAG laser source operated at 532 nm, selecting different values of the beam fluence on the ablation target.

ANGEL 2010_2679_29

In-situ monitoring of laser ablation/nanoparticle fragmentation process in liquid media

P. Šmejkal[1], J. Pfleger[2], B. Vlčková[1]; [1]Charles University in Prague, Faculty of Science, Department of Physical and Macromolecular Chemistry, CZ; [2]Academy of Sciences of the Czech Republic, Institute of Macromolecular Chemistry, v.v.i., CZ

Besides other applications, Ag nanoparticles are used in Surface-enhanced Raman Spectroscopy as amplifiers of optical processes undergone by molecules located on their surfaces. In these applications, nanoparticles prepared by laser ablation in liquid media plays an important role due to purity of the nanoparticle surfaces and possibility to control the properties of the nanoparticles and their assemblies. This is difficult when nanoparticles are prepared by chemical routes. The employment of laser nanoparticles prepared by laser ablation can improve SERS activity of the nanoparticle assemblies. The properties of nanoparticle systems prepared by laser ablation can be influenced by variety of parameters as laser pulse fluence, wavelength of incident laser radiation, interactions with liquid environment etc.

ANGEL 2010_2680_30

Violet luminescence from ZnO/Poly (ethylene glycol) colloidal nanocomposite prepared by pulsed laser ablation in liquid media: effect of PEG/water ratio

S.C. Singh[1,2], R. Gopal[2]; [1]Laser Spectroscopy & Nanomaterials Laboratory, Department of Physics, University of Allahabad, IN; [2]National Centre for Plasma Science and Technology Dublin City University, IE

Laser ablation in liquid media has provided an easy, quick and versatile route for the synthesis of wide variety of nanostructures in the form of highly stable colloidal solution, which can be converted into powder as well as film form after simple processing method. Zinc oxide is an n type, wide and direct band gap (3.4 eV) semiconductor with high exciton binding energy, which makes it most suitable optoelectronic materials for Light Emitting Diodes (LEDs), Solar Cells, light detectors and other applications. Zinc oxide/ polymer nanocomposite materials have profound application in the fabrication of these devices due to their composition dependent tunable optical properties.

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ANGEL 2010_2688_31
CTAB assisted synthesis of Nickel nanoparticles by laser ablation and its characterizations

M. K. Singh[1], A. Agarwal[1], R. Gopal[2]; [1]Motilal Nehru National Institute of Technology, Department of Physics, IN, [2]University of Allahabad, Laser Spectroscopy & Nanomaterials Lab, Department of Physics, IN

Nickel nanoparticles is synthesized by laser ablation of nickel disc in aqueous medium of cationic surfactant cetyltrimethylammonium bromide (CTAB) is studied. The focused output of first harmonic from nanosecond pulsed Nd: YAG laser operating at 35 mJ/pulse energy is used for the ablation of disc suspended in different concentration of CTAB in aqueous medium. Produced nanomaterial is characterized by using transmission electron microscopy (TEM), UV-visible absorption, Fourier transform infrared and X-ray diffraction (XRD) spectroscopic techniques. The magnetic properties are measured by vibrating sample magnetometer (VSM). This study shows that pulsed laser ablation in liquid media is a good method to synthesize some nanoparticles with special structures, which are difficult to produce by other methods.

ANGEL 2010_2660_32
Hexagonal-phase ZnSe nanoparticles fabricated by femtosecond laser ablation

H. I. Wang[1], W. T. Tang[1], C. W. Luo[1], C. S. Yang[2], S. R. Jian[3], G. J. Chen[3], T. Kobayashi[1,4]; [1]Department of Electrophysics, National Chiao Tung University, TW; [2]Graduate Institute of Electro-optical Engineering, Tatung University, TW; [3]Department of Materials Science and Engineering, I Shou University, TW; [4]Department of Applied Physics and Chemistry and Institute for Laser Science, The University of Electro-Communications, JP

Recently, the femtosecond laser ablation for metals and semiconductors in a vacuum environment and in liquid has been investigated extensively. In this study, we first demonstrate that the fabrication of hexagonal-phase ZnSe nanoparticles by femtosecond laser ablation in air with atmospheric pressure and room temperature. After the irradiation of femtosecond laser pulses with 800 nm wavelength, 100 fs pulse duration, and 5 kHz repetition rate, many ZnSe nanoparticles formed on the surface of an undoped ZnSe (400) single crystal wafer. The diameter of ZnSe nanoparticles could be easily controlled in the range from 50 nm to 2 μm with increasing the laser fluences.

ANGEL 2010_2669_33
Ultra-short pulsed laser generation of alloy nanoparticles in liquid environment

J. Jakobi, A. Hahn, A. Schwenke, P. Wagener, S. Barcikowski; Laser Zentrum Hannover, (LZH) Materials and Processes Department, DE

Recently, the development of nanoparticles which combine different magnetic and optical properties, has attracted the attention of fundamental and application oriented scientists. Pulsed laser ablation enables the generation of stoichiometric alloy colloid nanoparticles, which are generally difficult to fabricate with conventional synthesis methods. Nevertheless, the mechanism of laser-induced disproportionation is still in discussion and for this reason, deeper investigations have to be due.

ANGEL 2010_2917_34
Nanoparticles generated by continuous-wave fibre laser ablation in liquid: mechanism and characteristics

S.Z. Khan, Y. Yuan, Z. Liu; Corrosion and Protection Centre, School of Materials, The University of Manchester, GB

In the last few decades, the studies on novel nano-material synthesis, in particular, laser ablation of solids in liquids for nanoparticle (NP) generation have increased rapidly. Most of the work has been focussed on the use of pulsed lasers, at different wavelengths with pulse width in a range of ns to fs. In this paper, we report our recent investigations on the generation of metal-oxide NPs (TiO_2, NiO and Al_2O_3) using a continuous-wave (CW) fibre laser ablation in liquid.

ANGEL 2010_3091_35
Transient liquefaction during laser ablation

N. Haustrup, X. Sedao, A.J. Conneely and G. M. O'Connor; National University of Ireland Galway, IE

There is significant interest in using gas and liquid ambients to actively enhance laser ablative processes. [1] In this post deadline paper, we introduce a new method for laser ablation in liquids, which can potentially combine the advantage of irradiating the material in a dry ambient and transporting the ejected ablated matter in a liquid ambient. The process is based on generating a localized transient liquid phase during laser ablation. [2] The study demonstrates the potential of transient liquefaction of assist gases for enhanced entrainment, transport, and assembly of ablated matter. The technique is particularly relevant as its operation in a dry ambient overcomes the complexity of the immersion techniques.

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9:00 - 10:30 **Semiconductors I**
Session chairs: Giuseppe Compagnini, Universitá di Catania, IT (tbc)
Vladimir Svrcek, AIST, JP (tbc)

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09:00 

Silicon nanocrystals prepared by nanosecond laser processing in liquid media: photovoltaic applications INVITED TALK

Vladimir Švrček[1], Davide Mariotti[2], Michio Kondo[1]; [1]National Institute of Advanced Industrial Science, JP; [2]University of Ulster, GB

In order to considerably enhance the solar cell efficiency, novel concepts (i.e. photonic absorption enhancement, quantum confinement effects) and innovative approaches to material synthesis are essential. At the same time, silicon-based solar cell technologies are well established and the related existing infrastructures can play a key role to achieve low-cost and industrially viable production. Laser ablation/fragmentation in liquids can be efficiently applied as a facile method for the fabrication of silicon nanocrystals (Sincs) structures with quantum confinement effects [1-3]. Most notably, we show how colloidal Sincs produced by nanosecond-pulsed laser generated plasma in liquid can be applied for the fabrication of novel structures and materials for solar cell development.

09:30 **Optical properties of femtosecond laser-synthesized Silicon nanoparticles in liquid environment**

R. Intartaglia, G. Das, A. Genovese, F. Brandi, E. Di Fabrizio and A. Diaspro; Italian Institute of Technology (IIT), IT

Silicon nanoparticles (Si-NPs) present a growing interest due to their particular size dependent optical characteristic leading to important applications such as optoelectronic devices, light-emitting devices, energy source and in particular in biomedicine as efficient photosensitizers of oxygen molecule [1]. A variety of physical and chemical approach such as electrochemical etching was developed to produce Si-NPs but among them laser ablation of a solid target in liquid environment is convenient alternative for bio-compatible applications since the synthesis is carried out in a contamination-free environment [2]. Recently, it was demonstrated that Si-NPs produced by laser ablation can generate singlet oxygen state upon UV irradiation [3].

09:50 **White light- and three primary colors of light- emitting Si nano crystals: generation by pulsed laser ablation in supercritical fluid**

K. Saitow[1,2], T. Yamamura[2], D. Kajiya[1], S. Wei[2]; [1] Hiroshima University, Natural Science Center for Basic Research and Development, JP; [2] Hiroshima University, Department of Chemistry, JP

The pulsed laser ablation in a supercritical fluid has several distinct properties: (i) physicochemical properties in the ambient of laser ablation is varied, from gas-like to liquid -like, by changing only the fluid pressure without the exchange of solvent; (ii) cooling rate immediately after the generation of hot nanoparticles is controlled by changing the pressure; and (iii) nanomaterials are generated by a dry process.

10:10 **Toward a new generation of nanolight sources**

M. Diouf[1], D. Amans[1], F. Chaput[1], G. Ledoux[1], C. Malaterre[1], C. Mancini[1], K. Masenelli-Varlot[2], P. Perriat[2], C. Dujardin[1]; [1]Université de Lyon, I FR; [2]Université de Lyon, FR

The interest for the nano-emitters with specific optical properties is growing in the fields of bio-medical, micro-fluidic and quantum optics. We have demonstrated the usefulness of pulsed laser ablation in liquids as a fast screening synthesis method able to prepare luminescent nanoparticles from a large variety of doped materials, such as high efficient phosphors [1] (see Fig.1). The phase, the stoichiometry and the luminescence properties of the ablated materials are preserved while the sizes are reduced down to 2–10 nm. The average particle size is adjusted with the laser power. In solution, the aggregation is avoided by using a complexing molecule, which stabilizes the colloidal solution and leads to a narrower size distribution [2] (see Fig.2). Organically modified individual particles can then be isolated and their luminescence spectroscopy measured with a confocal microscope.

10:30 - 11:00 **Coffee break**

11:00 - 12:40	**Semiconductors II** Session chairs: Nikolai Tarasenko, Nat. Academy of Sciences, BY (tbc) Csaba Laszlo Sajti, Laser Zentrum Hannover, DE (tbc)

11:00 **Luminescence of single particles synthesized by pulsed laser ablation in liquids**

C. Mancini, D. Amans, F. Chaput, M. Diouf, G. Ledoux, C. Dujardin; Université Lyon 1, FR

Particles of rare earth doped insulators (YAG:Ce3+, Gd2O3:RE3+, RE=Dy, Eu, Tb) have been synthesized by pulsed laser ablation in liquids. The particle size distribution can be decreased by the use of complexant molecules which in addition hinders the particles agglomeration as evidenced by Transmission Electron Microscopy.

11:20 **II-VI semiconductor nanoparticles synthesized by laser ablation in liquid environments for applications in organic electronics**

N.G. Semaltianos[1], S. Logothetidis[1], W. Perrie[2], S. Romani[2], R.J. Potter[2], S.P. Edwardson[2], P. French[3], M. Sharp[3], G. Dearden[2], K.G. Watkins[2]; [1]Aristotle University of Thessaloniki, GR; [2]University of Liverpool, GB; [3]Liverpool John Moores University, GB

Nanoparticles made out of II-VI semiconductors are important nanomaterials for optoelectronic applications. This is because size dependent quantum confinement makes the properties of the nanoparticles tunable based on their size. When the size of the nanocrystals is close to or smaller than the exciton Bohr radius within the corresponding bulk material they are termed as quantum dots and show very special physical and chemical properties. In the field of organic electronics, incorporation of II-VI semiconductor nanoparticles into solution processable conducting polymers results in the formation of hybrid nanoparticle-polymer nanocomposites with tunable optical, electrical, mechanical and structural properties which are used in the fabrication of organic optoelectronic devices such as solar cells and light emitting diodes with improved performance.

11:40 **Bismuth telluride based nano-particles produced by pulsed laser ablation in liquid**

V. Kosalathip[1], C. Candolfi[2], B. Lenoir[2], S. Migot[2], A. Dauscher[2]; [1]King Mongkut's University of Technology Thonburi, TH; [2]UMR 7198 CNRS-Nancy Université-UPVM, FR

The technique of laser ablation in a liquid medium has been applied to the synthesis of n-type (Bi0.95Sb0.05)2(Te0.95Se0.05)3 and p-type (Bi0.2Sb0.8)2Te3 semiconducting nanopowders which are the best conventional materials currently used for thermoelectric applications close to room temperature. The nanopowders have been produced either from a bulk target or from micronsized particles, using a nanosecond Nd:YAG laser.

12:00 **Effects of nature of liquid media on the morphology and optical properties of Zinc oxide nanostructures synthesized by pulsed laser ablation**

S.C. Singh, R. Gopal; Univ. of Allahabad, IN; Dublin City University, IE

Present communication deals with the laser ablation in different liquid media for the synthesis of various zinc oxide nanostructures. Effect of nature of liquid media such as dielectric constant and dipole moment on the size, shape, distribution, crystallinity and optical properties of as synthesized zinc oxide nanostructures is investigated. Water, methanol, ethanol, 2-propanol, acetic acid and acetone were used as different ablation media, while keeping all other experimental conditions constant. In a typical experimental procedure, a high purity zinc rod placed on the bottom of glass vessel containing 40 ml of liquid media is allowed to irradiate with the focused output from pulsed nanosecond Nd:YAG laser operating at 1064 nm wavelength, 40mJ/pulse energy and 10Hz repetition rate for 60 minutes.

12:20 **Reactive quenching process for the generation of nanoparticles, nanocomposites by laser ablation in liquid medium: in the case of metallic Zn**

Changhao Liang; Chinese of Academy of Sciences, CN

Laser ablation in liquid has been proven as a facile and efficient approach to generate and organize functional nanomaterials and nanostructures.1-2 The advantages of chemical-clean synthesis, applied of almost unlimited materials and liquid solvents are benefit to the study of numerous liquid-solid systems and synthesis of a broad scope of interested structures. Since 2002, we have begin the pursuit of novel functional semiconductor materials by laser ablation of active metal targets in liquids such as Zn, Ti, Mg, Sn, Fe, Mn, etc.

12:30 - 14:00 **Lunch break in the hotel restaurant**

NOTES | NOTES | NOTES

14:00 - 15:50 **Non-equilibrium fluids**
Session chairs: Moreno Meneghetti, University of Padua, IT (tbc)
Ken-ichi Saitow, University of Hiroshima, JP (tbc)

NOTES | NOTES | NOTES

14:00 

Carbon nanostructures grown by plasma processes in liquid environments INVITED TALK

Giuseppe Compagnini; University of Catania, IT

Carbon-based materials are currently considered to be key elements in nanotechnology for the ability of carbon atoms to accommodate various degree of confinements, thus creating structures frequently referred to as zero-dimensional (fullerenes), one-dimensional (nanotubes) and two dimensional (graphene)[1].

14:30 **Formation of gold nanowires by laser ablation in liquid helium**

V. Lebedev[1], P. Moroshkin[1], B. Grobety[2], E.B. Gordon[3], A. Weis[1]; [1]University of Fribourg, Dept. of Physics, CH; [2]University of Fribourg, Dept. of Geoscience, CH; [3]Institute of Problems of Chemical Physics RAS, RU

Laser ablation of solid targets immersed in liquids, such as water or ethanol is widely used for producing metallic (Au, Ag, Cu, etc.) nanoparticles and their aggregates [1, 2]. The particles' shape and size distribution strongly depends among others on the properties of the solvent, the presence of a surfactant, and the properties of the laser radiation. Liquid ^{4}He is a peculiar solvent because of its low temperature, its exceptionally low electric polarizability, very large heat conductivity and high purity. Moreover, it has the unique feature of becoming superfluid and of forming quantized vortices which influence the diffusion and coalescence of ablated atoms and clusters.

14:50 **Control of nanopartcles' size by pressurizing ambient water in liquid-phase laser ablation**

Wafaa Soliman[1], Noriharu Takada[1], Koichi Sasaki[2] ; [1]Nagoya University, Department of Electrical Engineering and Computer Science, JP; [2]Nagoya University, Plasma Nanotechnology Research Center, JP

Previously, we investigated the growth processes of nanoparticles in unpressurized liquid-phase laser ablation using a laser-light scattering technique. For laser light scattering, an OPO laser operated at wavelengths of 500 and 680 nm was used to illuminate the area of ablation and to estimate the size of nanoparticles. The experimental work showed the occupation of the cavitation bubble with nanoparticles from the early stage of the expansion to the collapse [1-3]. In addition, the growth of nanoparticles occurred inside of the cavitation bubble, which was confirmed by the increase in the intensities of scattered laser light inside the cavitation bubble [4-6]. On the basis of the theory of Rayleigh-Mie scattering [7], the size of nanoparticles was estimated to be greater than 400 nm.

15:10 **Preparation of metal nanoparticles using laser ablation with liquids under evacuated environments**

T. Tsuji[1], T. Hirai[2], T. Mizuki[2], M. Tsuji[1]; [1]Kyushu Univ., Inst. Mater. Chem. Eng., JP; [2]Kyushu Univ., Grad. Sch. Eng. Sci., JP

Nowadays, laser ablation in liquids (LAL) is interested as a promising technique to prepare colloidal nanoparticles (NPs) using a simple procedure. However, because of the complex formation mechanism of NPs in LAL in which liquids play various critical roles, it is difficult to control the particle size using LAL. To overcome this disadvantage, we have recently developed an alternative laser ablation technique to prepare colloidal NPs having more controlled size. In this technique (Liquid supported laser ablation, LSLA) a liquid instead of a solid substrate is settled in an evacuated chamber to collect NPs produced by laser ablation in a gas (Fig. 1). In this paper, we show two topics regarding with LSLA.

15:30 **Interaction between linear carbon chains and metal NPs prepared by laser ablation in water**

G.C. Messina[1], L. D'Urso[1], E. Messina[1], S. Scalese[2], O. Puglisi[1], G. Compagnini[1]; [1]Università di Catania, IT;: [2]Istituto per la Microelettronica e Microsistemi, CNR, IT

Many distinctive physical and chemical features of metal nanoparticles depend on their reduction to the nano-scale size. A number of works report advanced applications in molecular devices as a result of peculiar optical, electronic and magnetic properties, which are strongly correlated to aggregation phenomena and to the formation of extended nanoparticle networks [1,2]. In this respect, Linear Carbon Chains (LCCs) seem to be good candidates to create carbon shells around the nanoparticles, therefore allowing the formation of extended networks of stable metal nanoparticles connected by π- electron rich carbon nanowires [3].

15:50 - 16:20 Coffee Break

16:20 - 18:10 **Special**
Session chairs: Tsuyoshi Asahi, Ehime University, JP (tbc)
Douglas B. Chrisey, Rensselaer Polytechnic Inst., US (tbc)

NOTES | NOTES | NOTES

16:20 

Laser ablation in liquids: a unique route to fabricate hollow micro/nanoparticles from bulk materials INVITED TALK

Zijie Yan[1], Ruqiang Bao[1], Yong Huang[2] and Douglas B. Chrisey[1]; [1]Rensselaer Polytechnic Institute, US; [2]Clemson University, US

Hollow micro- and nanoparticles are attractive due to the wide range of applications based on their high specific surface area, e.g., drug delivery, catalysis, microelectronics, energy storage.1 Laser ablation in liquids has been a subject of intensive research in the past decade, but the particles generated by this method were limited to solid ones. Quite recently we found that hollow particles could be generated by excimer laser ablation of Al, Cu, Pt, Fe-Ni alloy, TiO2 and Nb2O5 targets in water or aqueous solutions.

16:50 **On-line quantification of underwater-generated laser aerosols by ICP-MS**

Luca A. Flamigni, Joachim Koch, Detlef Guenther; ETH Zurich, CH

Due to fractionation effects observed during the analysis of nanosecond laser ablation (LA) generated aerosols using ICP-MS and conventional gas transport [1], an underwater LA sampling method was conceived. This setup consisted of a small cylindrical plastic (PTFE or PC) cell with a top glass window. LA was accomplished by a commercial dual head (Q-switched) Nd:YAG laser system (Continuum® Minilite™ PIV) operated at 532 nm (pulse duration: 5 ns). To evaluate the analytical capabilities offered by this method, LA ICP-MS analyses of brass and copper samples were performed both with double pulse experiments with a delay of 0 to 25 µs and with beam energies between 0.5 and 10 mJ.

17:10 **Metal nanoparticles by pulsed laser ablation in liquid media: synthesis, characterizations and application**

R.K. Swarnkar and R. Gopal; University of Allahabad, IN

Metal nanostructures have received much attention because of their potential applications in the fields of information storage, catalysis, electronics and optics. The surface plasmon resonance and large effective scattering cross section of individual metal nanoparticles make them ideal candidates for molecular labeling, where phenomena such as surface enhanced Raman scattering can be exploited. There are several techniques reported for synthesis of metallic nanoparticles like sol-gel, hydrothermal, electrochemical and laser ablation etc. Pulsed laser ablation of solid in liquid media has found a simple and versatile tool for the production of nanomaterials in solid as well as in liquid phases with same chemical composition as bulk with surfaces free from chemical contamination.

17:30 **Silver nanochain generation using Q-switched Nd:YAG laser ablation technique in distilled water**

S. Alipour[1], P. Parvin[1], S. Keshmiri[1], S.Z. Mortazavi[1]; [1]Amirkabir University of Technology, IR

The interaction of pulsed-laser beam with silver target in distilled water due to Q-switched Nd:YAG laser shuts (10ns,100mj,10Hz) is investigated. The fabrication of silver nanochains suspended in water was accomplished via the laser ablation technique. Photo-induced melting and dipole-dipole interaction of nanoparticles are involved mechanisms in the formation of nanostructures with fluences and exposure time. The resonance plasmon wavelengths lies at and for transverse and longitudinal polarizations of nanochains, respectively. Then, the resonance plasmon wavelength of nanoparticles take place at around 405nm for the different experiments. We have characterized the nano products using UV-Visible spectrophotometer and transmission electron microscopy (TEM).

17:50 **Preparation of Mg and MgO nanostructures using laser ablation method**

F. Abrinaei[1], M.J. Torkamany[2], M.R. Hantezadeh[1], J. Sabbaghzadeh[2], M. Ghoranneviss[1]; [1]Islamic Azad University, IR; [2]Iranian National Centre for laser science and technology (INLC), IR

The magnesium (Mg) and magnesium oxide (MgO) nanoparticles have gotten more and more attention in recent years [1-13]. Furthermore, in the past decades, the studies toward novel material formation, in particular, of nanocrystals via laser ablation of a solid target in a liquid environment, have emerged in multitude [14-21]. In this paper, Nd:YAG (wavelength: 1064 nm, FWHM: 240 nm, repetition rate: 200 Hz.) [22], and copper vapor (wavelength: 510.5 nm (green) and 578 nm (yellow), FWHM: 35 ns, repetition rate: 10 kHz.) [23] lasers pulse irradiations, separately were used to vaporize Mg target in 2-propanol, so that Mg and MgO nanoparticles were produced.

18:10 **Student Presentation Award Ceremony & Announcement of ANGEL 2012**

INFORMATION FOR AUTHORS AND ATTENDEES

REGISTRATION DESK (located in the lobby of the RAMADA hotel)
Opening times

... Tuesday, 29 June	7:30 - 18:00
... Wednesday, 30 June	8:00 - 18:00
... Thursday, 1 July	8:00 - 18:00

Payment receipts and confirmations of attendance will be available on-site at the registration desk. Attendees paying by cash are requested to bring the exact change in Euro.

ORAL PRESENTATIONS

Regular speakers are allotted 20 minutes (15 minutes presentation plus 5 minutes for discussion). Invited speakers are allotted 30 minustes (25 minutes presentation plus 5 minutes for discussion). Please plan your presentation accordingly to meet the 20 minute maximum.

Technical equipment:

All technical equipment (presentation computer, projector, sound system, laser pointer, microphone) will be provided on-site.
Please bring your presentation on a USB mass storage, CD-ROM or DVD and include all video files. File formats: ppt, pptx and pdf. A Windows-based presentation computer will be provided. For Mac users: To make sure your presentation is displayed correctly, please:

... bring your presentation as pdf-file with fonts embedded or
... restrict yourself to Arial, Times New Roman (not Times), Courier New (not Courier), Symbol and Windings when creating your ppt- or pptx-file.

All authors are requested to upload their presentation to the presentation computer well in advance of their talk.

POSTER PRESENTATIONS

The poster session will be taking place on Wednesday, 30 June from 19.00—20.30 (room tbd). Authors are requested to be present at their posters during the poster session. Poster set-up and removal is in the responsibility of the authors.
The maximum poster size is 841 mm (width) x 1189 mm (height). Poster strips and pins will be provided by the organizers.

EOS CONFERENCE DIGEST

All abstracts of accepted contributions will be published in the EOS Conference Digest (ISBN numbered) that is handed out on-site.

PAPER PUBLICATION & COVER IMAGE COMPETITION

The papers of this conference will be published in a special section of the Journal of Physical Chemistry B (JPC-B) titled "Laser Ablation and Nanoparticle Generation in Liquids". The instructions for JPC authors are available at http://pubs.acs.org/page/jpcbfk/submission/index.html. **The paper submission will be open from 1 August - 30 September 2010.** Please make sure you submit your paper in time.

Submit your best image for the cover image competition. The ANGEL 2010 Chairs will select the best photograph or drawing for the cover image of the special section in JPC B.
Requirements:

... tiff (or jpeg) format. Resolution: 300 dpi at desired print size. Color: RGB or CMYK or
... eps or pdf format. Color: CMYK builds. Other: Supply all embedded images separately

Please submit your image to angel2010@myeos.org until **28 May 2010**.

STUDENT PRESENTATION AWARD

SPONSORED BY TRUMPF

The best student presentation will be awarded a prize sponsored by TRUMPF. A jury will select the best student presentation on-site and the winner will be announced in the last session on Thursday, 1 July in the afternoon.

WIFI

Free high-speed WIFI will be available in the meeting room. WIFI cards for use in the hotel rooms can purchased at the reception of the RAMADA hotel.

CONFERENCE DINNER & SOCIAL PROGRAMME

The conference dinner will be taking place in the restaurant of the RAMADA hotel on Tuesday, 29 June 2010 starting at 19:00. Participation in the conference dinner requires extra registration. More details and the dinner registration form will be circulated until the end of May 2010. An outdoor social programme is planned for Wednesday, 30 June in the afternoon. More details will follow until the end of May.

TRAVEL AND ACCOMODATION

GETTING THERE

Engelberg can easily be reached by by car or by frequent trains from Lucerne in one hour, and from Zurich in about two hours. Trains from Zurich or Lucerne to Engelberg are leaving on an hourly basis. From Engelberg Railway Station it is only 210 m to the RAMADA Hotel Regina Titlis (duration: 2 min.).

Useful links:

City of Engelberg:	www.engelberg.ch
RAMADA Hotel Regina Titlis	www.ramada.de/hotels/hotels_index.php?hotel_code=15742
Zurich transport association (train timetable)	www.zvv.ch/en/
Zurich airport	www.zurich-airport.com
Lucerne transport association (train timetable)	www.vbl.ch

If you need assistance with your travel arrangements, please contact the Engelberg-Titlis Tourism Agency at welcome@engelberg.ch or by telephone: +41 (0)41 639 77 77.

ACCOMODATION

Rooms at a special rate have been blocked at the venue hotel. The booking details and a list of alternative hotels you will find below.

VENUE HOTEL

RAMADA Hotel Regina Titlis Engelberg ****
Dorfstraße 33
6390 Engelberg
Switzerland

Phone: +41 (0)41 / 639 58 58
Fax: +41 (0)41 / 639 58 59
regina-titlis@ramada-treff.ch
www.ramada.de/hotels/hotels_index.php?hotel_code=15742

Remarks: Use of the wellness area, swimming pool, steam room and whirlpool included. Free WIFI will be available in the meeting room. WIFI cards for use in the hotel rooms can be purchased at the reception.
Rate(s): Single or double room incl. breakfast 163.20 CHF (108 Euro)/person.
Keyword: Please mention the keyword "EOS" when making your reservation.

ALTERNATIVE HOTELS

Price range ~ 80 - 105 Euro	
Europäischer Hof Hotel Europe *** Dorfstrasse 40 CH-6390 Engelberg Phone: +41 (0)41 639 75 75 Fax: +41 (0)41 639 75 76 info@hoteleurope.ch, www.hoteleurope.ch	Distance*: 100 m, about 1 minute by feet Remarks: Internet & wireless corner. Sauna and solarium. Rate(s): Single room incl. breakfast 135 CHF (90 Euro)/person Double-room incl. breakfast 115 CHF (76 Euro)/person
Hotel Terrace *** Terracestrasse 33 6390 Engelberg Phone: . +41 (0)41 639 66 66 Fax: +41 (0)41 639 66 99 terrace@terrace.ch, www.terrace.ch	Distance*: 500 m, about 8 min. by feet Remarks: WIFI (available in hotel lobby). Sauna, solarium, steam room. Rate(s): Single room incl. breakfast 155 CHF (105 Euro) /person Double room incl. breakfast 120 CHF (80 Euro)/person
Hotel Waldegg **** Schwandstr. 91 6390 Engelberg Phone: +41 (0)41 637 18 22 Fax: +41 (0)41 637 43 21 info@waldegg-engelberg.ch, www.waldegg-engelberg.ch/	Distance*: 1.3 km, about 20 min. by feet Remarks: Wireless corner, internet corner. Wellness paradise, sauna and gym included. Rate(s): Double-room incl. breakfast ~ 145 CHF (96 Euro)/person
Sporthotel Eienwäldli *** Wasserfallstr. 108 6390 Engelberg Phone: +41 41 637 19 49 Fax: +41 41 637 44 23 info@eienwaeldli.ch, www.eienwaeldli.ch	Distance*: 2 km, about 25 min. by feet Remarks: Wireless corner, internet corner. Sauna, solarium, steam room. Rate(s): Single-room incl. breakfast ~145 CHF (96 Euro)/person Double-room incl. breakfast ~130 CHF (86 Euro)/person

* Distance from venue hotel

ACCOMODATION AND TRAVEL

Price range ~ 50 – 80 Euro	
Spannort Hotel & Restaurant *** Dorfstrasse 28 6390 Engelberg Phone +41 (0) 41 639 60 20 Fax +41 (0) 41 639 60 30 info@spannort.ch, www.spannort.ch	Distance*: 68 m, less than 1 min. Remarks: Free WIFI in all rooms. Sauna, solarium. Rate(s): Single room incl. breakfast 95 CHF (63 Euro) Double room incl. breakfast 105 CHF (70 Euro)/person
Hotel Restaurant Engelberg *** Dorfstrasse 14 6391 Engelberg Phone: +41 41 639 79 79 Fax +41 41 639 79 69 mail@hotel-engelberg.ch, www.hotel-engelberg.ch	Distance*: 200 m, approx. 2 min. by feet Remarks: Internet connection available on request. Rate(s): Single or double-room incl. breakfast 105 CHF (70 Euro)/person
Hotel Bellevue-Terminus Bahnhofplatz CH- 6390 Engelberg Phone +41 (0)41 639 68 68 Fax +41 (0)41 637 44 49 www.belleuve-terminus.ch, welcome@bellevue-terminus.ch	Distance*: 200 m, approx. 2 min. by feet Remarks: Free WIFI. Rate(s): Single room incl. breakfast 75 CHF (50 Euro) Double room incl. breakfast 90 CHF (60 Euro)/person Triple room incl. breakfast 85 CHF (56 Euro)/person

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Engelberg offers a wide range of vacation homes for 1-8 persons. Please see www.engelberg.ch —> accommodations —> apartement search, or contact the Engelberg-Titlis Tourism Agency at welcome@engelberg.ch or by phone: +41 (0)41 639 77 77 for assistance.

EXTEND YOUR STAY

Engelberg is a holiday paradise at 1050 m above sea level. The village radiates the special charm of the Benedictine monastery, the wonderfully fresh countryside and an impressive mountain panorama. The conference hotel has an indoor swimming pool and sauna. Ending on Thursday afternoon, ANGEL 2010 presents a good opportunity to stay until the end of the week and to enjoy the attractive scenery, multiple outdoor-activities or a relaxing wellness programme. At www.engelberg.ch in the "activities" section you will find suggestions for various activities. Be it hiking or biking, climbing or golfing, fishing or visiting the Lake Lucerne - Engelberg is the ultimate destination for outdoor sports and activities.






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a) This registration category is available for all EOS members (full member status; associate members are required to buy an upgrade first) and members of the Laser Institute of America (LIA).
b) The registration fee includes admission to the meeting, one copy of the meeting digest, coffee and lunch breaks.
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Abstract due date: 7 June 2010

co-located with

This year's EOS Annual Meeting will be taking place at Parc Floral de Paris, France, from 26 to 29 October 2010 alongside PRI-OPTO (26 - 28 October 2010) to bridge the gap between science and industry.

TOPICAL MEETINGS & WORKSHOPS

- ... **TOM 1:** Biophotonics - Advanced Trapping and Optofluidics in Life Sciences
- ... **TOM 2:** Terahertz Science and Technology
- ... **TOM 3:** Nanophotonics and Metamaterials
- ... **TOM 4:** Micro-Optics
- ... **TOM 5:** Organic Photonics
- ... **TOM 6:** Nonlinear Optics and Photonics
- ... **TOM 7:** ICO/EOS TOM on Optics & Energy
- ... **Workshop** on Entrepreneurship and Business Innovation in PhD Education

1st EOS Conference on Optofluidics

Munich, Germany | 22 – 27 May 2011 | www.myeos.org/events/munich2011

Abstract due date: 5 January 2011

Topics

- ... Microfluidic lasers
- ... Fluid-fluid waveguides
- ... Microfluidically tuned optical fiber and interferometers
- ... Fluid paper
- ... High resolution in-chip lensless microscopy
- ... Optical and photonic tweezers
- ... High sensitivity biomolecular sensor platforms
- ... and specific application areas

Manufacturing of Optical Components

Munich, Germany | 22 – 27 May 2011 www.myeos.org/events/munich2011
More information soon at www.myeos.org/munich2011

Abstract due date: 5 January 2011

2ND EOS TOPICAL MEETING ON "BLUE" PHOTONICS - OPTICS IN THE SEA

Bremerhaven, Germany | 5 - 7 September 2011
www.myeos.org/events/bluephotonics2 | bluephotonics2@myeos.org
Would you like to be alerted when the call for papers is published? Send an email with your contact details to bluephotonics2@myeos.org.

1st EOS TOPICAL MEETING ON PHOTONICS FOR SUSTAINABLE DEVELOPMENT - FOCUS ON THE MEDITERRANEAN (PSDM 2011)

Tunis, Tunisia | 11 - 13 July 2011
Would you like to be alerted when the call for papers is published? Send an email with your contact details to dalichow@myeos.org (Julia Dalichow, EOS Committee & Event Manager).

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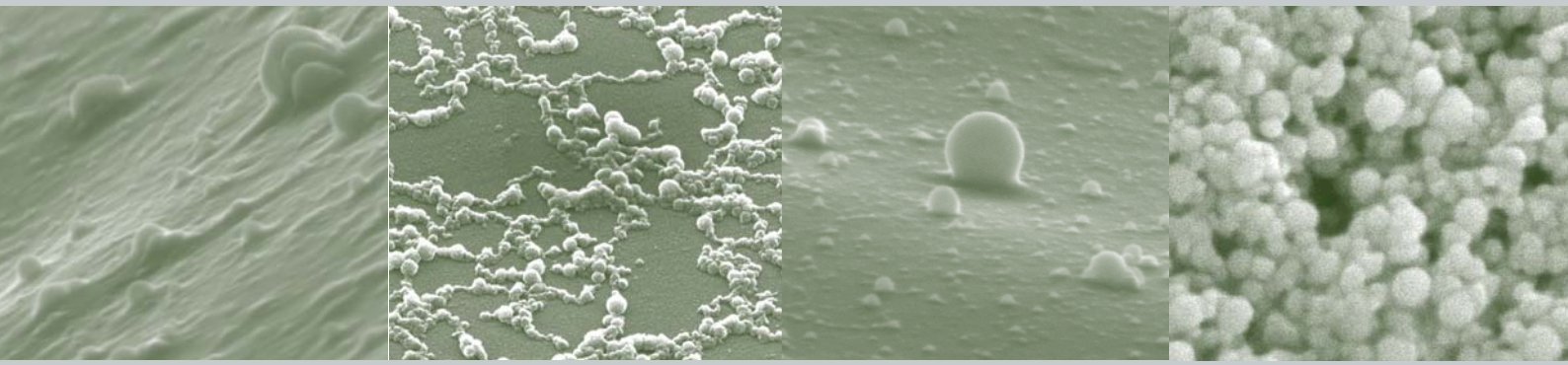

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