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World of Photonics Congress 2015

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ISBN: 978-1-5108-1779-1
11:00 Optofluidics for self-tracking solar concentration

Christophe Moser
EPFL, Switzerland

Self-tracking solar concentration passively aligns a solar concentration system to the changing sun’s position. Micro-mechanical actuators based on the phase change of either a liquid or a solid can be exploited to obtain a large acceptance angle (>30 degrees) while maintaining a medium concentration (up to 200).

11:30 Optofluidics for Energy Applications

David Sinton
University of Toronto, Canada

Microfluidic and optofluidic methods developed primarily for medical applications have much to offer the energy sector. This talk will describe my group’s recent work in two areas: (1) microfluidics and optofluidics for bioenergy and (2) microfluidics for fluids underground: CO2, oil and gas. Within the bioenergy theme, we are developing photobioreactors to quantify and increase the productivity of microalgae. Within the fluids underground theme we are developing a suite of methods to study (a) pore-scale transport and reactivity, and (b) relevant fluid properties. I will close the talk with an overview of future opportunities for optofluidics in advancing renewable technologies and improving legacy energy operations.

12:00 Optofluidics biochip for rapid algae population screening

Yves Bellouard1, Allison Schaap2
1Ecole Polytechnique Fedérale de Lausanne, Switzerland; 2Eindhoven University of Technology, Netherlands;

The rapid identification of algae populations is not only of practical importance for assessing the water quality of watersheds in general, but also for future exploitation of algae as an energy source. Here we demonstrate how an integrated optofluidics device fabricated by femtosecond laser processing and chemical etching can provide a robust and yet, efficient rapid identification means.

12:30-14:30 LUNCH BREAK

14:30 Mid-IR Plasmonics for Time-Resolved and Ultra-Sensitive Vibrational Biospectroscopy

Hatice Altug, Dordaneh Etezadi, Odeta Limaj, Daniel Lopez, Ronen Adato
EPFL, Switzerland

We will present a plasmonic-fluidic technology performing real-time and ultra-sensitive infrared (IR) absorption spectroscopy in aqueous environment by directly accessing distinct molecular and structural specific chemical fingerprints of biomolecules. We will demonstrate that the technology is uniquely capable of monitoring protein interaction kinetics and biomimetic cell membranes without using any external labels. By leveraging engineered plasmonic antennas for IR absorption enhancement and demonstrating their use for biologically significant measurements in solution, our results represent a dramatic advance over previous studies.
15:00 Fiber-based platform for tracking unlabeled nanoparticles with elastic light scattering
Sanli Faez1, Yoav Lahini2,3, Stefan Weidlich4,5, Rees F. Garmann2, Katrin Wondraczek4, Matthias Zelsberger4, Markus A. Schmidt4, Michel Orrit1, Vinothan N. Manoharan2
1Leiden University, Huygens-Kamerlingh Onnes Laboratory, Leiden, The Netherlands; 2Harvard University, Department of Physics, Cambridge, MA, USA; 3MIT, Department of Physics, Cambridge, MA, USA; 4Leibniz Institute of Photonic Technology, Jena, Germany; 5Heraeus Quarzglas GmbH and Co. KG, Hanau, Germany
We present a tracking method based on detection of elastic light scattering from diffusing particles inside a nano-fluidic silica fiber. Using this method, we have tracked the diffusion of unlabeled 26-nm cowpea chlorotic mottle virions and 20-nm latex particles at rates of over 3 kHz. Our setup can be easily incorporated into common optical microscopes and extends their detection range to nanometer-scale particles and macromolecules. The ease-of-use and performance of this technique support its potential for widespread applications in medical diagnostics.

15:15 Biolasing from fluorescent proteins and live bacterial cells suspended in liquid droplet microcavities
Alexandr Jonas1, Mehdi Aas2, Yasin Karadag2, Selen Maniloglu2, Suman Anand3, David McGloin3, Halil Bayraktar2, Alper Kizaz2
1Istanbul Technical University, Turkey; 2Koc University, Turkey; 3University of Dundee, United Kingdom
We report miniature optofluidic biolasers that exploit active liquid optical resonators formed by surface-supported aqueous microdroplets containing purified yellow fluorescent protein or a suspension of live E. coli bacteria cells expressing the fluorescent protein. We characterize the dynamics of lasing emission from these biological gain media and show that a single micron-sized fluorescent bacterial cell confined in a droplet-based cavity can serve as a laser gain medium. Aqueous droplet microcavities allow the maintenance of the bacteria under conditions compatible with unimpeded growth. Therefore, our results also suggest a route to microscopic sources of laser light with self-regenerating gain media.

15:30 Biological Optofludic Lenses
Pietro Ferraro
Istituto di Cibernetic, Italy
We show that the Red Blood Cells (RBC) can work as a tuneable liquid lenses. Imaging properties of RBCs are proofed. Moreover, fast diagnostic blood screening is demonstrated by testing RBCs by adaptive-optics technology.

16:30 Affinities, Kinetics and Synthetic Life with optically generated Temperature Fields
Dieter Braun
LMU Munich, Germany
The movement of proteins in a temperature gradient is a sensitive and versatile way to probe all-optically protein interactions, including fragment screens for pharmacological compounds. The physical basis of the movement was studied with DNA and polystyrene beads and could be understood with a capacitor model of ionic shielding. Recently, we were able to achieve thermophoretic movement inside living cells. The method was brought to the market with the award winning Startup company NanoTemper. Fast reaction speed inside living cells can be measured using fast temperature oscillations and a molecular lock-in method.

17:00 Optical DEP for immobilization and orientation of microbial organisms
Lisa Miccio, Valentina Marchesana, Martina Mugniano, Simonetta Grilli, Pietro Ferraro
CNR, Italy
Biofilms formation is a critical issue in several fields as health-care and food-enterprise. Biofilm growth depend on the bacteria spatial organization. Here, an innovative electrode-free dielectrophoresis is applied for immobilization and orientation of Escherichia Coli.
17:15 Micro flow vane & Brownian probes: Applications of optical forces in the near-field of nanocavities

Christophe Pin1,2,3, Claude Renaut1,2,4, Emmanuel Picard2, David Peyrade3, Emmanuel Hadji3, Frédérique De Fornel1, Benoît Cluzel4

1Université de Bourgogne, France; 2CEA, France; 3CNRS, France; 4ICFO, Spain

Operating at the nanoscale without any contact, near-field optical forces offer interesting practical advantages. Two original applications of optical forces in the near-field of photonic nanocavities are investigated. We report first on the demonstration of a self-assembled micro flow vane. Then we explore the possibility of imaging the optical near-field of nanocavities using optically trapped particles as Brownian probes.

Invited Talk 17:30 On-chip light sheet illumination enables accurate size and concentration measurements of extracellular vesicles in biological fluids

Kevin Braeckmans

Ghent University, Belgium

Here we present a disposable microfluidic chip with integrated light sheet illumination for fSPT size and concentration measurements [6]. The sheet of light only illuminates EVs in the focal plane of the microscope’s detection lens so that contrast is markedly improved. On-chip fSPT measurements were performed on cell-derived EVs secreted in cell culture medium of breast cancer cells. A 4× higher concentration was found using the microfluidic chip with a size distribution shifted towards smaller values. On-chip fSPT measurements were subsequently successfully performed on EVs secreted in interstitial fluid harvested from human breast cancer specimens.

18:00 - 21:00 International Year of Light 2015 Opening Reception, Foyer ICM

8:30–10:00 Fundamental Optofluidics 1

8:30 Optical Manipulation with Random Light Fields: From Fundamental Physics to microfluidics

Giorgio Volpe1,3, Lisa Kurz1, Agnese Callegari2, Giovanni Volpe2,4, Sylvain Gigan1

1Laboratoire Kastler Brossel, France; 2Soft Matter Lab, Physics Department, Turkey; 3Department of Chemistry, University College London, United Kingdom; 4UNAM – National Nanotechnology Research Center, Bilkent University, Turkey

Speckles are random light fields that share some universal statistical properties. Because of this, they can be used to perform deterministic optical manipulation tasks on a Brownian particle as well as control its diffusion properties. I will present some numerical examples, as well as proof-of-principle experimental demonstration.

9:00 A light-controlled optofluidic switch using ZnO as actuating material

Ioannis Konidakis, Maria Konstantaki, Stavros Pissadakis

Foundation for Research and Technology, Greece

We hereby report on a reversible optofluidic switch of a ZnO-overlaid microstructured optical fiber Fabry-Perot interferometer, based on an all-light controlled actuation mechanism upon exposure to ultraviolet (248 nm) and green (532 nm) laser radiation.

9:15 Optofluidic droplet router

Michael Esseling1, Annamaria Zaltron1, Wolfgang Horn1, Cornelia Denz1

1University of Muenster, Germany; 2University of Padua, Italy

An optofluidic droplet router for the manipulation of free-flowing liquid droplets is presented. The device consists of a custom-made PDMS droplet generator sealed by a photorefractive lithium niobate crystal as the bottom layer. Upon structured illumination, dielectrophoretic forces act on the droplets, guiding them on a light-shaped network.
9:30 Air-suspended polymer grating coupler applied as optofluidic refractive index sensor 25
Christoph Prokop1,3, Nico Irmler1, Bert Lägel2, Sandra Wolff2, Arnan Mitchell3, Christian Karnutsch1
1Karlsruhe University of Applied Sciences, Institute for Optofluidics and Nanophotonics (IONAS), Karlsruhe, Germany; 2Nano Structuring Center, Forschungszentrum OPTIMAS, Technische Universität Kaiserslautern, Kaiserslautern, Germany; 3RMIT University, School of Electrical and Computer Engineering, Microplatforms Research Group, Melbourne, Australia
Air-suspended polymer grating couplers were fabricated by transferring SU-8 layers onto KMPR air cavities using a structured PDMS stamp. We report on the fabrication and characterization of a resulting optofluidic refractive index sensor that is probing an analyte transported in a micro-channel below the grating coupler.

9:45 Light-driven microfluidics with a MOEMS based laser scanner 27
Marcus Baumgart, Andreas Tortschanoff, Diana Damian, Matthias P. Kremer
CTR Carinthian Tech Research AG, Austria
Using a compact MOEMS based laser scanner device, thermal flows were induced in a microfluidic environment enabling the manipulation of polystyrene beads in an unstructured microfluidic chamber. In our paper we present the scanner device and show experimental results.

10:00-10:30 COFFEE BREAK

10:30– 12:00 Fundamental Optofluidics 2

Location: Room 22, 2nd Floor, Congress Centre

Invited Talk 10:30 Selective optofluidic manipulation of chiral particles 29
Georgiy Tkachenko, Artur Aleksanyan, Etienne Brasselet
University of Bordeaux, CNRS, France
The interplay between the chirality of matter and light allows considering several options to manipulate, in a selective manner, both positional and angular mechanical degrees of freedom of chiral objects depending on their chirality. This is illustrated experimentally by using the helicity of light as a control parameter.

11:00 Interaction of laser beams with single droplets in pendant position 31
Mihail Lucian Pascu1, Ionut Relu Andrei1, Mihai Boni1, Viorel Nastasa1, Ruxandra Pirvulescu2
1National Institute for Lasers, Plasma and Radiation Physics, Romania; 2Faculty of Medicine, University of Medicine and Pharmacy Carol Davila, Bucharest, Romania
Results are shown about the unresonant interaction of a single laser pulse at 532 nm with a droplet of water or ethyl alcohol, DCM, DCM mixed with ethyl alcohol, DMSO, DCM mixed with DMSO, Rhodamine 6G solution in ethyl alcohol. The effects produced on a droplet of Rhodamine 6G solution in ethyl alcohol at resonant interaction with a laser beam emitted at 532 nm are also presented.

11:15 A holographic tracking method for characterization of microfluidic particles flow 33
Pasquale Memmolo1,2, David Dambhauser1, Domenico Rossi1, Francesco Merola2, Lisa Miccio2, Filippo Causa1, Pietro Ferraro2, Paolo Antonio Netti1,2
1Center for Advanced Biomaterials for Healthcare@CRIB, Istituto Italiano di Tecnologia, Italy; 2CNR-Istituto di Cibernetica “E. Colaninno”, Italy
A new holographic tracking method, able to calculate simultaneously and in a single step, all the spatial coordinates of particles flowing in a microfluidic channel is presented. The experiments are performed on a microfluidic-induced particle migration.

11:30 Resonant interaction of laser beams with pendant droplets of emulsions 35
Mihail Boni1,2, Viorel Nastasa1, Ionut Relu Andrei1, Angela Stanciu1, Mihail Lucian Pascu1,2
1National Institute for Lasers, Plasma and Radiation Physics, Romania; 2Faculty of Physics, University of Bucharest, Romania
In this paper we show results about resonant interaction of laser beams with pendant droplets containing emulsion of Rhodamine 6G (Rh6G) solution in water with oily Vitamin A. We studied the fluorescence emission, by varying different parameters such as: volume of the pendant droplet, dimension of the oil droplets in the emulsion, dye concentration in water solution, energy of the pumping beam.
11:45 Low-cost polymer guided mode resonance filters for sensing applications

Pétur Gordon Hermannsson1, Christoph Yaninahme1, Kristian T. Sørensen1, Jan J. Klein2, Cameron L.C. Smith1, Maria-Melanie Russow3, Gabi Grützner2, Anders Kristensen1

1Technical University of Denmark, Denmark; 2-micro resist technology, Germany
We present an inexpensive, all-polymer guided mode resonance filter fabricated by means of a vacuum-less process, using UV nanoreplication and spin-coating. The structure exhibits state-of-the-art sharp resonant reflection with a FWHM of 3.8 nm and a sensitivity of 60 nm/RIU for media with refractive indices around that of water. These polymer devices are more suitable for high throughput industrial production than more traditional titanium dioxide based devices, and thus well suited for single-use biological and refractive index sensing.

12:00-14:00 LUNCH BREAK

14:00– 15:00 Fundamental Optofluidics 3

Location: Room 22, 2nd Floor, Congress Centre
Session Chair: David Sinton

14:00 One Specific Velocity Mapping in Optical Coherence Tomography
Anton Yurievich Poltov, Sergey Vyacheslavovich Sindeev, Sergey Vladimirovich Prolkov, Sergey Gennadievich Proskurin
Tambov State Technical University, Russian Federation
The method of sign-sensitive mapping of one specific velocity (OSV) in a flow with complex geometry based on the principles of optical coherence tomography (OCT) is described. The mapping is controlled using two parameters, the value of velocity, V, and the accuracy of its determination, ΔV. Structural image and two OSV images (for positive and negative direction of motion) are obtained as a result of selecting and processing the relevant parts of the signal spectrum. The final image is a result of complexing these three and can be used as a Doppler equivelocity color map.

14:15 Frequency pulling of optically rotating spheroidal oblate particles
Petr Jákl1, Alejandro Vásquez Arzola2, Stephen Simpson1, Lukáš Chvátal1, Pavel Zamánek1
1ASCR, Institute of Scientific Instruments, Czech Republic; 2Instituto de Física, Universidad Nacional Autónoma de Mexico, México
Dielectric oblate particles trapped in an optical vortex exhibit circulating motion where the angular frequency depends on the properties of the particle and parameters of the vortex beam. The hydrodynamical interaction between two rotors in vicinity causes angular frequency pulling that we studied under different experimental conditions.

14:30 Optofluidic 3D hydrogel particle fabrication by gravity and inertia assisted flow shaping
Kevin S. Paulsen, Aram J. Chung
Rensselaer Polytechnic Institute, United States of America
We present a novel method of creating 3D hydrogel particles by fluid and light shaping. Fluid inertia and gravity are used to deterministically shape fluid streams, which are then exposed to patterned UV light to create complex 3D hydrogel particles. By varying light and flow conditions, an infinite set of shapes is available.

14:45 Integration Aspects of Solar-Hydrogen Generators
Miguel Antonio Modestino, Claudia Alejandra Rodriguez, Christophe Moser, Demetri Psaltis
School of Engineering, EPFL, Switzerland
Integrated optofluidic devices that generate Hydrogen (H2) from sunlight have the potential to lead to viable sources of clean fuels. Here we analyze the underlying factors that drive the H2 production cost in solar-fuel devices, and describe the design space and degree of integration that can result in cost-effective solar-H2 generators.

15:30– 16:00 COFFEE BREAK
EOSOF– Tuesday, June 23

16:00– 17:30 Handheld Devices

Location: Room 22, 2nd Floor, Congress Centre

Session Chair: Anders Kristensen

Invited Talk: 16:00 Democratization of Next-Generation Imaging, Sensing and Diagnostics Tools through Computational Photonics

Aydogan Ozcan
UCLA, United States of America

In this presentation I will discuss some of the emerging applications and the future opportunities and challenges created by the use of mobile phones and other consumer electronics devices as well as their embedded components for the development of next-generation imaging, sensing, and diagnostics tools through computational photonics techniques.

Invited Talk: 16:30 Phase conjugate focusing of light onto moving target in a random medium

Changhuei Yang
California Institute of Technology, United States of America

I will discuss our recent work on the use of digital optical phase conjugation to focus light on a moving target within a random medium. This method employs the information inherent within the scattered speckle patterns to provide the appropriate wavefront solution. This work can potentially be applied to perform in vivo flow cytometry on contents within a blood vessel.

Invited Talk: 17:00 Optofluidics: Photonic Technologies for Mobile and Global Health

David Erickson
Cornell, United States of America

Smartphones and other mobile technologies will be transformative to the deployment of molecular diagnostics both domestically and worldwide. In this talk, I will review the existing commercial and technical roadblocks to the deployment of molecular diagnostics to the consumer market and how they can be fundamentally altered by taking advantage of the now ubiquitous installed base of smartphones. In addition to covering the basic engineering science advancements that led to the development of these technologies, I will also discuss our strategies for deployment and commercialization.

17:30– 20:00 EOSOF Poster Session

Location: Hall B0, Ground Floor, Congress Centre

POSTERS

Development of a Micro-optofluidic Temperature Sensor
Manoj Kumar Sharma1, Arjan Frijns2, Ton Janssen3, Rajesh Mandamparambil4, David Smeulders5
1Eindhoven University of Technology, Netherlands; 2Eindhoven University of Technology, Netherlands; 3Eindhoven University of Technology, Netherlands; 4TNO, Eindhoven, Netherlands; 5Eindhoven University of Technology, Netherlands

A fluorescent micro-optofluidic temperature sensor is developed using a temperature sensitive dye. The sensor can measure temperatures in microregions up to 70 ºC and is applicable in lab-on-a-chip devices. It is fabricated using soft lithography method and uses Rhodamine B dissolved in water as a temperature indicator.

Micro-fluidic chip for cell sorting
Mojmír Šerý, Zdeněk Pilát, Jan Ježek, Jan Kaňka, Pavel Zemánek
Institute of Scientific Instruments of the ASCR, v. v. i., Czech Republic

We demonstrate micro-fluidic platform specially designed for optical sorting of cells. The deep reactive ion etching technique is used to manufacture bio-compatible chips on glass type substrates. Micro-fluidic chip was incorporated into our active optical sorting system with Raman signal detection to prove of vitality of the cells.

Optical measurement of temperature modification induced by infrared light exposure
David Moreau, Claire Lefort, Philippe Leveque, Rodney P. O’Connor
Xlim research institute, France

The work presented here attempts to describe an optical method of temperature measurement in various materials under infrared laser excitation using Rhodamine B fluorescent dye. The temporal precision of this method is of the order of few milliseconds. The use of an optical fiber allows the access to different regions of the material.
On-site three-dimensional fabrication of organic optical system with micro-dispensing method
Mitsuhiro Nakano, Noboru Hirakawa, Hiroaki Yoshioka, Yuji Oki
Kyushu-University, Japan
Fabrication technique based on “micro-dispensing method” have been developed for fully polymeric optical micro 3D system with additive manufacturing scheme. The technique provides polymeric optical system that contains microwire microridge, micro-bottle, and spindle-shaped microrod that mounted in high-precision control. Ultra-fine polymer microwire array successfully bridged in diameter of 1.0~1.5 μm. In addition, spindle shaped microrod was fabricated by irradiating a focused laser beam (1064 nm). We have succeeded in the stacking prepolymer vertically. The rod diameter was approximately 40 μm, and maximum height of 100 μm was obtained.

Tapered optical waveguide based on liquid core/liquid cladding optofluidic waveguide
Mohammadreza Oraie1,2, Hamid Latti1,2, Jalal Sadegh1, Hamed Nikbakht2
1Physics Department, Shahid Beheshti University, Iran; 2Laser and Plasma Research Institute, Shahid Beheshti University, Iran
In this paper, we focus on the possibility of forming a tapered optical waveguide based on liquid core/liquid cladding waveguides. We perform 2D simulations based on incompressible Navier Stokes equations and examine the possibility of forming a tapered optofluidic waveguide.

Polarimetric refractive index sensitivity of a side-hole optical fiber as an optofluidic channel
Jalal Sadegh1, Hamid Latti1,2, Mohammadreza Oraie1,2, Farnood Mirkhosravi1, Michal Murawski3
1Laser and Plasma Research Institute, Shahid Beheshti University, Iran; 2Department of Physics, Shahid Beheshti University; 3Inphotech Ltd. Slominskiego 17/31 Warsaw and Military University of Technology, Poland
In this letter, we present a theoretical analysis of a microfluidic fiber device, with an emphasis on the polarimetric analyzing of the wave guidance of a side-hole fiber microchannel. We found that by using one of the two side-holes as a microfluidic channel, the polarimetric refractive index sensitivity is enhanced.

Model studies of blood flow for cerebral aneurysms prediction using 3D LDA
Sergey Vladimirovich Frolov1, Tat’yana Anatol’evna Frolova1, Sergey Vyacheslavovich Sindeeв1, Dieter Liepsch2, Andrea Ballas3, Sergey Gennadievich Proskurin1, Anton Yuriyevich Potlov1
1Tambov State Technical University, Russian Federation; 2Munich University of Applied Sciences, Germany; 3Technical University of Munich, Germany
It is proposed an integrated approach to the study of blood flow using 3D LDA for identifying the causes of genesis of cerebral aneurysms. Feature of the work is the combined usage of both mathematical modeling and experimental methods. Proposed an integrated approach using both experimental and numerical methods of research to identify the causes of the cerebral aneurysms development.

Lithium niobate crystals for opto-microfluidic sensors
Cinzia Sada1, Giacomo Bettella1, Gianluca Pozza2, Annamaria Zaltron3, Mathieu Chauvet3, Blandine Guichardaz4
1University of Padova, Physics and Astronomy Department, Padova, Italy; 2FEMTO-ST Institute, UMR CNRS 6174, University of Franche-Comté, Besançon, France
In micro-analytical chemistry and biology, the realization of lab-on-chip systems with higher levels of integration of different stages on the same platform is constantly addressed. The recent results on the integration of a microfluidic circuit with optical waveguides will be presented, addressing to the potential realization of optical sensing platforms in a lab-on-chip system entirely based on LiNbO3 substrate.

Optical fiber probes with integrated nanostructured micro-optics for optofluidic applications
Bernard Piechal1, Adam Filipkowski1,2, Dariusz Pysz1, Ryszard Stepienko1, Andrew Wadding2, Ryszard Buczyński1,2, Mohammad Taghizadeh3
1Institute of Electronic Materials Technology, Poland; 2Heriot-Watt University, UK; 3Warsaw University, Poland
We present the integrated optical fiber probe for optifluidic studies. It is based on single mode optical fiber with the nanostructured micro-axicon integrated on its end. The probe produces non diffracting beam at the distance of 50 μm from the surface of the probe.

Optofluidic waveguides in hydrophobic aerogels formed by femtosecond laser ablation
Berna Yalızay1, Yağız Morova1, Koray Dincer1, Yaprook Ozbakır2, Alexandr Jonas1, Can Erkely3, Alper Kiraz2, Selçuk Aktürk1
1Istanbul Technical University, Turkey; 2Koc University, Turkey
Silica aerogels are distinctive nano porous materials which have extremely low refractive index, high surface area to volume ratio and optical transparency. These properties make silica aerogels very interesting for optical applications like optofluidic waveguides. However, it is very hard to process aerogels with common mechanical methods like cutting, milling or drilling. In this study, we were able to form high quality cylindrical microchannels inside hydrophobic silica aerogels with direct femtosecond laser pulses. We demonstrate waveguiding in the ethylene glycol filled microchannels, with an optical loss of 9.9 dB/cm.