One-Day mini-Symposium/Workshop on Laser-Induced Damage and Laser Beam Characterization

This year, the newly-formed ISOTEST Laboratory of the National Institute for Laser, Plasma, and Radiation Physics (NILPRP), Bucharest, Romania, is finalizing a three-year project for developing a facility for laser-induced damage (LID) measurements in optical materials and components, and in implementing methods for laser beam characterization (LBC), using recommended ISO standards procedures (http://ssll.inflpr.ro/isotest/index.htm). Two automated stations for LID threshold measurements were developed, using nanosecond and femtosecond pulses, respectively, and currently are performing R&D-type tests on various optical components. Classical, as well as new LBC methods were implemented as R&D results. ISOTEST Laboratory is interested in exchanging know-how, performing joint tests and inter-comparisons, and involving interested people in this kind of R&D activity (especially young researchers and PhD students).

A one-day mini-Symposium/Workshop on Laser-Induced Damage and on Laser Beam Characterization will be held on Wednesday, 22 May 2013, as part of the Section Laser Metrology and Testing of the 3-rd International Conference "Modern Laser Applications" INDLAS 2013 (http://indlas.inflpr.ro/index.html), to be held in Bran, Romania, 20-24 May 2013. Six invited speakers will attend the LID&LBC mini-Symposium/Workshop and will give seven lectures (new advancements in the field and tutorials) covering LID and LBC subjects. Contributed papers in the same fields have been also submitted and accepted.

Goal: Bringing together people involved in the fields of Laser-Induced Damage (LID) and Laser Beam Characterization (LBC).

Length, date, venue: 1 day, on 22 May 2013, part of the Section **Laser Metrology and Testing** within the **3-rd International Conference "Modern Laser Applications", INDLAS 2013, Bran, Romania,** 20-24 May 2013 (see: http://indlas.inflpr.ro/index.html). The venue of the Conference is Vila Bran (www.vilabran.ro).

Type of papers: Oral invited papers presenting the state of the art, or reviewing new results, or giving tutorials in these fields; oral and poster contributed papers.

- Invited, oral presentation: typical 35 min., including 2 min. Q&A.
- Contributed, oral presentation: typical 15 min., including 1-2 min. Q&A.
- Poster papers: To be presented in the regular INDLAS 2013 poster session (Tuesday 21 May).

Informal round table discussion on LID and LBC (moderator George Nemes, ISOTEST Lab.): sample roughness measurements; sample cleaning, manipulation, storage before LIDT measurement; influence of polishing technology on LIDT; how reproducible is a result of measuring the LIDT of "identical samples" with different stations having "similar characteristics"? Discussion on new methods to measure laser beam spatial parameters. Choosing fitting parameters and the errors' propagation – is the ISO 11146 correct?

Publishing the contributions: The abstract of the contributions will be published in the Preliminary Program of the Conference. The invited papers and selected contributions will be published in an ISI quoted journal. However, the authors may consider submitting their contributions to any journal they consider appropriate.

Date	*Time*	*Hall II*
May 22, Wednesday		**Special Session: LID-LBC (Hall 2)**
		Chair: George Nemes
	9:00 - 9:05	Opening remarks
	9:05 - 9:40	**I1 – Alexis Kudryashov** Laser beam characterization with M^2 meter and wavefront sensors
	9:40 - 10:15	**I2 – Klaus Mann** Laser beam characterization and thermal wavefront distortions in optical components
	10:15 -10:35	***Coffee break***
	10:35 - 11:10	**I3 – Andrius Melninkaitis** Statistical effects in laser damage testing
	11:10 - 11:45	**I4 – Lars Jensen** Measurement of defect driven laser-induced damage
	11:45 - 12:20	**I5 – Julio Serna Galán** Light orbital angular momentum and its relation to laser beam characterization
	12:20 - 14:30	***Lunch***
		Special Session: LID-LBC (Hall 2)
		Chair: Andrius Melninkaitis
	14:30 - 14:55	**I6 – George Nemes** Automated stations for LIDT measurements according to ISO 21254-1,2,3,4 standards, using nanosecond and femtosecond pulses
	14:55 - 15:20	**I7 – George Nemes** Characterizing laser beams in general and laser spots for LID experiments on targets - a comparison
	15:20 - 15:35	**O1 – Gheorghe Honciuc** Antireflection coatings for 650 nm and 1064 nm with highlaser induced damage threshold
	15:35 - 15:50	**O2 – Alex Zorila** How to not use ISO 11146-1:2005 standard and get small relative errorsin spatial beam characterization
	16:10 - 16:25	**O3 – Ioana Dumitrache** Change in spatial beam parameters introduced by light shaping diffusers
	16:25 - 16:40	**O4 – Sandel Simion** Controlling the number of pulses on target in laser damage experiments,using kilohertz repetition rate pulses
	16:40 - 16:55	**O5 – Laurentiu Rusen** Laser beam diagnosis techniques to measure changes in gamma irradiated glasses
	16:55 - 17:10	**O6 – George Nemes** New method to diagnose spatial laser beam parameters
	17:10 - 17:30	*Coffee break*
	17:30 - 18:30	Moderator: George Nemes **Informal round table discussion**

Extended Program

Time	*Hall II*
	Special Session: LID-LBC (Hall 2)
	Chair: George Nemes
9:00 - 9:05	Opening remarks
9:05 - 9:40	**I1 – Laser beam characterization with M^2 meter and wavefront sensors** Alexis Kudryashov *Moscow State Open University, and Director on Science and General Manager, Active Optics NightN Ltd., Moscow, Russia*
9:40 - 10:15	**I2 – Laser beam characterization and thermal wavefront distortions in optical components** Klaus Mann *Head of Dept. Optics/Short Wavelengths, Laser-Laboratorium Göttingen, Germany*
10:15 -10:35	***Coffee break***
10:35 - 11:10	**I3 – Statistical effects in laser damage testing** Andrius Melninkaitis *Vilnius University, and CEO LIDARIS, Vilnius, Lithuania*
11:10 - 11:45	**I4 – Measurement of defect driven laser-induced damage** Lars Jensen *Head of Characterization Group, Laser Components Dept., Laser Zentrum Hannover, Germany*
11:45 - 12:20	**I5 – Light orbital angular momentum and its relation to laser beam characterization** Julio Serna Galán *Deputy Dean, Departamento de Óptica, Facultad de Ciencias Físicas, Complutense University, Madrid, Spain*
12:20 - 14:30	***Lunch***
	Special Session: LID-LBC (Hall 2)
	Chair: Andrius Melninkaitis
14:30 - 14:55	**I6 – Automated stations for LIDT measurements according to ISO 21254-1,2,3,4 standards, using nanosecond and femtosecond pulses** George Nemes *Head of ISOTEST Laboratory, NILPRP Bucharest, Romania, and President, ASTiGMAT™, Sacramento, CA, USA*
14:55 - 15:20	**I7 – Characterizing laser beams in general and laser spots for LID experiments on targets - a comparison** George Nemes *Head of ISOTEST Laboratory, NILPRP Bucharest, Romania, and President, ASTiGMAT™, Sacramento, CA, USA*

15:20 - 15:35	**O1 – Antireflection coatings for 650 nm and 1064 nm with high laser induced damage threshold** Gheorghe Honciuc[1], Nicoleta Nedelcu [1], Alexandru Zorilă[2,3], Laurenţiu Rusen[2], Liviu Neagu[2], Ioana Dumitrache[2,3], Aurel Stratan[2] [1] *Ophir Optics SRL, 5 Răcari Str., Bucharest, Romania; gheorghe.honciuc@ophiropt.com* [2] *ISOTEST Laboratory, National Institute for Laser, Plasma, and Radiation Physics, 409 Atomistilor Str., 077125 Măgurele-Bucharest, Romania* [3] *"Politehnica" University of Bucharest, 313 Splaiul Independenţei, 060042 Bucharest, Romania* The development of fiber lasers with application in cutting machines requires an antireflection coating for 650 nm and 1064 nm with high laser-induced damage threshold (LIDT). The paper presents some theoretical solutions, the materials used to achieve a high LIDT, the testing method, and the experimental LIDT results.
15:35 - 15:50	**O2 – How not to use ISO 11146-1:2005 standard and get small relative errors in spatial beam characterization** Alexandru Zorilă[1,2], Aurel Stratan[1], George Nemeş[1,3] [1] *ISOTEST Laboratory, National Institute for Laser, Plasma, and Radiation Physics, 409 Atomiştilor Str., 077125 Măgurele-Bucharest, Romania; alexandru.zorila@inflpr.ro* [2] *"Politehnica" University of Bucharest, 313 Splaiul Independenţei, 060042 Bucharest, Romania* [3] *ASTiGMAT™, 3409 Pecky Cedar Ct., Sacramento, CA 95827, USA; gnemes@astigmat-us.com* Keywords: spatial beam characterization, ISO 11146-1 standard, measurement errors, nonlinear fit We have performed a propagation-of-errors analysis on the measurement procedure recommended by ISO 11146-1:2005 standard to determine the spatial parameters of a laser beam. The measured beam-width data along the propagation axis were fitted to a hyperbolic function specified in the ISO procedure. We find that, despite the *relative errors* on *fitted* parameters are small (i.e., less than 1 %), the resulting relative errors of the spatial beam parameters derived from the fit parameters can be greater than 100 %. In this paper we analyze other alternative methods to fit the experimental data, and select the fitting parameters leading to minimum relative errors of the resultant spatial beam parameters. The fitting methods were applied on three sets of beam-width data measured on three laser sources: two nanosecond systems and a fully-integrated kHz repetition frequency Ti:sapphire femtosecond system. The results are comparatively discussed, and a better fitting procedure is proposed.
16:10 - 16:25	**O3 – Change in spatial beam parameters introduced by light shaping diffusers** Ioana Dumitrache[1,2], L. Neagu[1], L. Rusen[1], A. Stratan[1], G. Nemeş[1,3] [1] *ISOTEST Laboratory, National Institute for Laser, Plasma, and Radiation Physics, 409 Atomiştilor Str., 071125 Măgurele - Bucharest, Romania; ioana.dumitrache@inflpr.ro* [2] *"Politehnica" University of Bucharest, 313 Splaiul Independenţei, 060042 Bucharest, Romania* [3] *ASTiGMAT™, 3409 Pecky Cedar Ct., Sacramento, CA 95827, USA; gnemes@astigmat-us.com* Light shaping diffusers are relatively new optical components used to smooth out the light from incoherent or coherent light sources. We are interested to measure the change in spatial beam parameters introduced by such diffusers on relatively good (low M^2) light beams. The experimental arrangement contains a He-Ne laser (model 25-LHP-151-230, Melles Griot, USA), a holographic-type diffuser (type LSD0.5PC10-2 or LSD1PC10-2, Physical Optics Corporation, USA), a well-characterized spherical focusing lens (type PLCX-50.8-154.5-UV780, CVI-Melles Griot, USA), and a beam profiler with the appropriate software (GRAS20 camera/BeamGage software, Ophir Optronics, USA). The tests were done according to the ISO 11146-1:2005 standard. The measurements were performed first on the He-Ne laser beam without any diffuser, and then on the beam after each diffuser. A low angle diffuser acts as a secondary, partially coherent light source, its beam having the waist on the diffuser surface. The spatial parameters of the original laser beam and of the beams after each diffuser are compared and discussed. As expected, the larger the diffusing angle, the larger M^2 of the diffused beam. The results suggest the possibility of constructing light sources with controllable spatial parameters (especially M^2) for future measurements.

16:25 - 16:40	**O4** – **Controlling the number of pulses on target in laser damage experiments, using kilohertz repetition rate pulses** L. Rusen[1,3], M-R. Ioan[2], P. Ioan[2], A. Zorilă[1,4], I. Gruia[3] [1] *ISOTEST Laboratory, National Institute for Lasers, Plasma and Radiation Physics, 409 Atomiştilor Str., 077125 Măgurele - Bucharest, Romania; laurentiu.rusen@inflpr.ro* [2] *"Horia Hulubei" National Institute of Physics and Nuclear Engineering - IFIN HH, 30 Reactorului Str., 077125 Măgurele - Bucharest, Romania* [3] *Physics Department, University of Bucharest, 405 Atomiştilor Str., 077125 Măgurele - Bucharest, Romania* [4] *"Politehnica" University of Bucharest, 313 Splaiul Independenţei, 060042 Bucharest, Romania* Within the ISOTEST project two automated stations for laser-induced damage (LID) experiments were developed and are used for current experiments. The threshold damage measurements uses the S-on-1 algorithm, according to the ISO 21254-1,2,3,4:2011 standards. This algorithm controls the number of laser pulses hitting each site of the optical component under test. One automated station is based on a nanosecond pulse laser with a repetition frequency of 10 Hz. At this repetition rate the laser beam is blocked with an optical shutter. The second automated station is based on a femtosecond laser pulse with a repetition frequency of 2 kHz. At this repetition rate any optical shutter is too slow to be used. Instead, the Pockels cell of the laser's regenerative amplifier is normally used to control the number of pulses allowed to the site under irradiation. For a steady delivery of the femtosecond output pulses, without controlling the number of output pulses, the long term fluctuation of the pulse energy for the femtosecond laser is about 2%. However, by directly controlling the Pockels cell inside the regenerative amplifier, the fluctuation of the pulse energy increases to about 6% for the first 50 ms after the laser beam is switched ON, because the system induces a non-stationary operating regime of the laser. Experimentally we recorded such energy fluctuations of the laser pulses, causing difficulties during the LID measuring process. To avoid the fluctuation issue, a new method was conceived and used to control the number of laser pulses, which is described in this paper. It is based on a secondary, outside laser cavity Pockels cell shutter and its associated electronics. The schematics used and the experimental results are presented. Using this method the pulse energy fluctuations remained at the steady level of about 2%.
16:40 - 16:55	**O5** – **Laser beam diagnosis techniques to measure changes in gamma irradiated glasses** L. Rusen[1,3], M-R. Ioan[2], P. Ioan[2], A. Zorilă[1,4], I. Gruia[3] [1] *ISOTEST Laboratory, National Institute for Lasers, Plasma and Radiation Physics, 409 Atomiştilor Str., 077125 Măgurele - Bucharest, Romania; laurentiu.rusen@inflpr.ro* [2] *"Horia Hulubei" National Institute of Physics and Nuclear Engineering - IFIN HH, 30 Reactorului Str., 077125 Măgurele - Bucharest, Romania* [3] *Physics Department, University of Bucharest, 405 Atomiştilor Str., 077125 Măgurele - Bucharest, Romania* [4] *"Politehnica" University of Bucharest, 313 Splaiul Independenţei, 060042 Bucharest, Romania* The goal of this work is to apply laser beam diagnosis techniques to study changes of transparent glass properties induced by their irradiation with strong ionizing and/or nuclear radiation (e.g., γ, X, p, n, e radiation). Specifically we investigated the changes due to the color centers or other defects produced by irradiating borosilicate glasses with gamma rays. In principle we can expect changes in transmittance properties of these glasses and perhaps, for larger-size induced defects, even an increase in their scattering properties, or a change in the spatial profile of the laser beam used as a test beam. Several BK-7 glass samples were irradiated using the IFIN-HH Co-60 gamma irradiation facility using a dose rate of about 100 Gy/h ± 7% and an average energy of 1.25 MeV. Energetic and spatial beam characterization, according to ISO 11554 and ISO 11146-1 standards, respectively, was performed on a low power He-Ne laser beam, before and after passing the beam through each irradiated glass sample. From the changes in the glass transmittance the value of the absorption coefficient was determined for several samples. Spatial beam characterization was performed to see whether or not there are changes in the internal structure of glass samples to modify the beam propagation factor M^2. No such significant changes were put in evidence within the uncertainties of the measurement arrangement (He-Ne laser type 25-LHP-151-230, Melles Griot, USA; powermeter type PowerMax-USB UV-VIS, Coherent, USA; beam profiler type GRAS20 with a dedicated software BeamGage, Ophir Optronics, USA).

16:55 - 17:10	**O6** – **New method to diagnose spatial laser beam parameters** G. Nemes[1,2], A. Stratan[1], A. Zorila[1,3], Ioana Dumitrache[1,3], L. Rusen[1], L. Neagu[1] [1] *ISOTEST Laboratory, National Institute for Laser, Plasma, and Radiation Physics, 409 Atomiştilor Str., 077125 Măgurele-Bucharest, Romania; george.nemes@inflpr.ro* [2] *ASTiGMAT™, 3409 Pecky Cedar Ct., Sacramento, CA 95827, USA; gnemes@astigmat-us.com* [3] *"Politehnica" University of Bucharest, 313 Splaiul Independenţei, 060042 Bucharest, Romania* The traditional method to measure the spatial laser beam parameters, recommended by ISO 11146-1:2005 standard, transforms the original laser beam by a well-characterized focusing lens and measures the transformed beam behind the lens by translating along its axis (z-axis) a CCD-based beam profiler which records the beam diameters at several fixed z values. From these sampled diameters the hyperbolic longitudinal profile of the transformed beam is recovered, and by back-propagation through the lens, the original laser beam parameters are recovered. Our new method uses instead of a spherical lens a special zoom device named VariSpot™ using rotating cylindrical optics. For a stigmatic incident beam, VariSpot™ gives a round and adjustable-diameter spot size, $D(\alpha)$, at a fixed distance, d_0, where α is the control parameter, varying between 0^0 – 90^0. The CCD camera is placed behind VariSpot™ at the distance d_0 which should be experimentally determined. Theoretical analysis shows the striking analogy between the classical method (first quantities) and the new one (second quantities), through the correspondence: $D(z) \leftrightarrow D(\alpha)$; $z \leftrightarrow \sin(\alpha)$; $D_0 \leftrightarrow D_m$; $z_R \leftrightarrow r$; $z_0 \leftrightarrow \sin(\alpha_0)$. VariSpot™ can be used either as an equivalent spherical lens, for $\alpha = 0^0$, or as a variable-spot size optical system, for $0^0 < \alpha \leq 90^0$. Preliminary experimental results, discussed here, of measuring a HeNe laser with traditional method and with a VariSpot™, validate the theory.
17:10 - 17:30	Coffee break
17:30 - 18:30	Moderator: *George Nemes* **Informal round table discussion**

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