

Hub of Application Laboratories for Equipment Assessment
In Laser Based Manufacturing

Editorial

Dear APPOLO newsletter readers,



The third year of the APPOLO project implementation has passed. Most of the initial assessment experiments have been progressed along the assessment value chains and are close to being finished. At the same time, the new experiments selected in an Open call procedure are gaining their speed.

In the course of WP6, excellent progress and new advantages in the laser-assisted electro-less plating for MID (moulded interconnect devices) were achieved. The selective metal plating is now possible without any expensive additives after laser treatment on pure polymers.

As a result of WP5 activities, the surface of polymers can be functionalized by micro- and nano-texturing. A replication of dimples using the 3D laser textured metal moulds was validated for automotive components.

Our activities in CIGS thin film solar cell scribing are about to reach the planned goals, as advances with new validated equipment have been made, and new knowledge has been generated during the work of collaborative research teams at BUAS, FTMC, IOM and UPM.

During a week-long workshop in April 2016 at the FTMC in Vilnius, plenty of experimental work was done: researchers and engineers from FTMC, LUT, UPM, AMSYS and ELAS were integrating and validating the on-line monitoring tools of LUT and AMSYS with galvo- and polygon scanners. Excessive testing of detection limits and process speed (up to 100 m/s) were performed on various materials.

Unfortunately, some delays in adopting the equipment to the very strict requirements of end-users have been shown: for example issues with limitations in physical performance or controllability of interaction are still problematic and must be solved.

The summer School on "Ultra-short Pulse Laser Applications in Material Processing" in the beginning of July 2017 in Vilnius is in preparation, whereas the selection of world-known lecturers is ongoing. In case of interest, please visit the website of APPOLO Project (<http://www.appolo-fp7.eu/>) in fall of 2016.

Traditionally, we introduce our participating partners in this issue.

We hope you enjoy this edition of the APPOLO newsletter,
Gediminas Račiukaitis, Project Coordinator

In this Issue

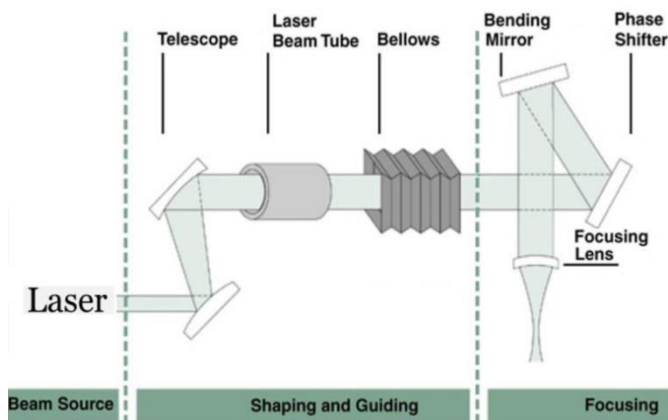
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www.appolo-fp7.eu

Focus Topic

Results from NewDeli Project

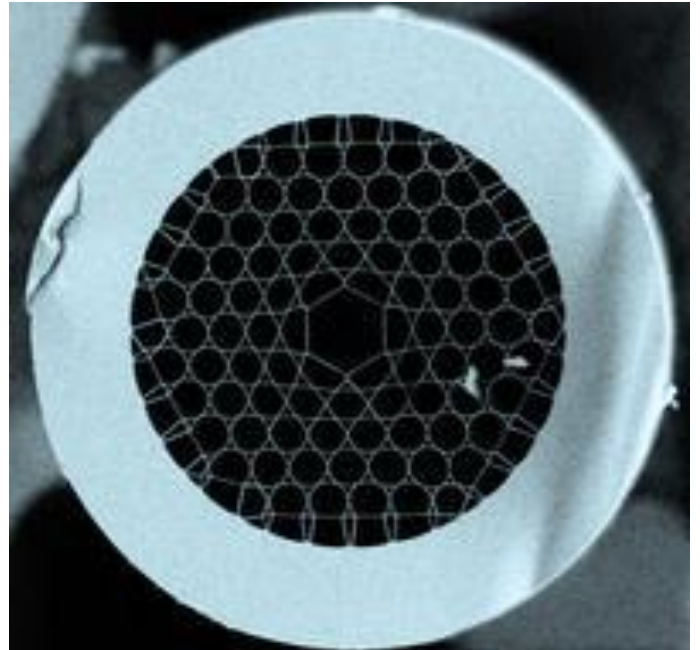
As part of the framework of APPOLO, the NewDeli sub-project disputes with laser ablation processes. Here, material from solid (occasionally liquid) surfaces is removed with lasers beams. At low laser flux, the material is heated by the absorbed laser energy and evaporates or sublimates. At high laser flux, the material is typically converted into plasma. Usually, laser ablation refers to removing material with a pulsed laser, but it is possible to ablate material with a continuous wave laser beam, too if the laser intensity is high enough. Laser pulses can vary over a very wide range of duration (milliseconds to femtoseconds) and fluxes, and can be precisely controlled. That makes laser ablation very valuable for both research and industrial applications. Usually, very short laser pulses are delivered via air exploiting a very complicated mirror system, as reported in the figure below. A system like this usually suffers from serious disadvantages in terms of reliability and maintenance.



Air Exploiting Guiding System ©NewDeli

The responsibility of the NewDeli experiment lies with the exploitation of the new class of hollow core photonic crystal fibers to transport ultrashort laser pulses, thus exploring the opportunities of the market of laser ablation. This technique can be employed in various fields, such as laser polishing, texturing, engraving, marking.

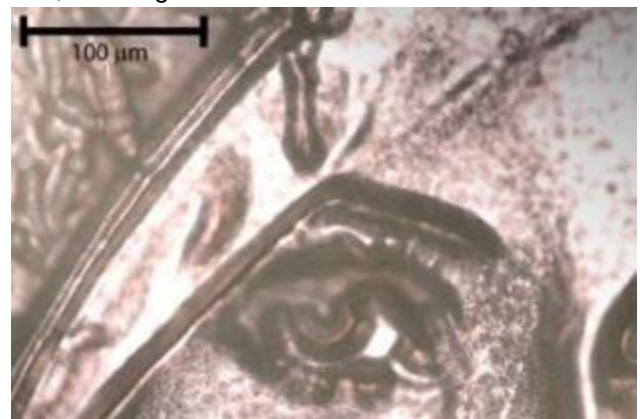
To address the outlined issues, a new class of crystal fiber has been introduced to the market. Its particularities are mainly a hollow core giving the radiation the chance of propagating through “nothing”.



Hollow photonic crystal fiber ©NewDeli

The new fiber will allow realizing an entirely new generation of high power cable with high power ultra-short pulse delivering capabilities.

This robust, fiber-based beam guidance system for ultra-fast lasers guarantees maximum transmission and preserves the laser beam parameters. For protection from stress in an industrial environment, the fiber is – as with all conventional guidance systems for high-powered lasers– integrated into a stable laser light cable. The responsibility of the NewDeli experiment lies with the exploitation of the new class of hollow core photonic crystal fibers to transport ultrashort laser pulses, thus exploring the opportunities of the market of laser ablation. This technique can be employed in various fields, such as laser polishing, texturing, engraving, marking, laser drilling, glass industry, production of nanoparticles of metals, cleaning of surfaces and so on.



Laser micromachining performed by BUAS, structured surface 1

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NANOTYPOS @ I4MS Exhibition

As new APPOLO project partner NANOTYPOS participated at the exhibition of the I4MS event in June (Fostering digital industrial innovation in Europe) 2016.

During Part one of I4MS conference Theodoros Tachtsidis lectured on APPOLO Project specific research and development results with following topic:

"Large Area Functional Surfaces By Roll-to-Roll Nanoimprint Lithography".

Source:

<https://www.industrialtechnologies2016.eu/conference/programe-outline/i4ms>

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ELAS moved into larger facility

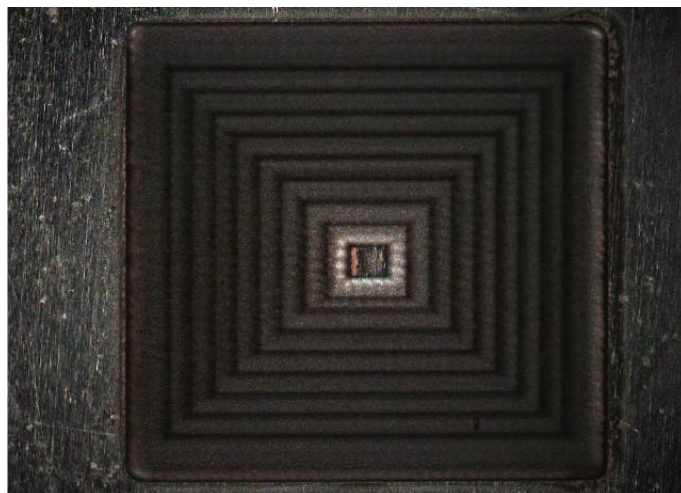
APPOLO partner ELAS (Lithuania) moved into new larger premises.



New ELAS facility with ELAS team; ©ELAS

They are now accessible at ELAS Ltd.; Savanoriu Ave. 231; Tel.: +370 655 14467; Fax.: +370 5 264 18 09; LT 02300 Vilnius; Lithuania

Source: <http://www.apollo-fp7.eu/news.html>



Laser structured surface 2

However, the focus of New Deli is directed to ablation of metals whereas the particular process addressed will be laser polishing, laser drilling, laser milling and laser texturing.

Industrial process requirements

Surface polishing	Ti	Roughness: 0,1 – 1,6 µm
Surface polishing	Al	Roughness: Up to 6,3 µm
Micro drilling	Al, Ti, Steel	10-100 µm up to 1mm
Milling	Al, Ti, Steel	Feature: 0,005 mm

Delivery system specifications

Max cable length [m]	6
Wavelength range [nm]	930 – 1100
Pulse duration [ps]	< 1
Pulse energy [mJ]	< 0,5
Max avg. optical power [W]	< 50
Input beam M ² factor	< 1,2
Output beam M ² factor	< 1,35

Cable features

Inner hose	Stainless steel
Outer hose	Flexible reinforced plastic
Safety (monitor)	Continuity, breakage, and temperature

The design of the cable has been carried out in such a way that it will be able to withstand all the characteristics of fluencies, pulse energy and peak power necessary to obtain the manufacturing features that have been identified as a representative for the Additive and Subtracting Manufacturing, without particular stresses.

The chosen hollow core fiber is able to handle laser pulses with pulse durations of 500 fs with maximum pulse energy of 0,5 mJ. The fiber is designed in single mode with a mode field diameter of 40 microns and an M2 factor lower than 1,35. Using his know-how on cables for high power CW laser, OPI realizes a prototype of cable for hosting the hollow core fiber.

The cable allows a connector compliant with the Trumpf LLK-B type, water cooling such as a high power AR-coated window to protect the hollow core fiber end will be available.



Assembled cable ©NewDeli

Lasers for cable testing routine

	OneFive Origami – 10XP	OneFive Katana HP10
Center wave-length	1030 nm	1064 nm
Pulse duration	< 500 fs	30-50 ps
Average output power	4 W	12 W
Pulse energy	40 µJ	15 µJ
Peak power	10 MW	1 MW
Repetition rate	1 MHz	1MHz

The output of the NewDeli experiment will be the realization of a proper delivery system, coupled with an appropriate laser source that is able to process a sample with a given surface quality within a certain processing time. Up to now, three Deliverables have been released, in the framework of WP11.4:

- D 11.4.1a: Industrial Requirements;
- D 11.4.1b: Cable Specifications and Constraints;
- D 11.4.1c: Validation Test Plan.

Based on the output of deliverables, an alpha sample will be realized and characterized to meet the functional specifications. Then, a final release of the delivery system will be realized to meet all quality and reliability specifications.

The industrial validation experiment outlined will be performed at BUAS' lab facilities. Eventually, the delivery system's quality and reliability will be assessed in the NewDeli experiment.

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APPOLO WP6 & WP8 Workshops successfully processed

APPOLO WP6 Technical Meeting @ FTMC

On June 7th in 2016, FTMC hosted the WP6 Technical Meeting at its own premises in Vilnius, Lithuania. Work package partners from FTMC, CRF, BIOAGE, EKSPLA and ELAS afterwards discussed the results of passed experiments on laser direct writing for the flexible 3D electronics.



Technical Meeting on WP6 experimental results @ FTMC;
©FTMC

Future prospects of this technology were also considered during the meeting, as achieved results, implemented in demonstrators, and attained process quality are attractive for further technology transfer to automotive and electronics industries.

Source: <http://www.appolo-fp7.eu/news.html>

APPOLO WP8 Experimental Workshop @ FTMC

From April 15th to 21st an experimental workshop was organized at the FTMC facilities. The main task was to perform experiments on integration of the on-line monitoring systems developed by APPOLO partners LUT and AMSYS into laser processing equipment.



Experimental set-up for WP8 @ FTMC; ©FTMC

APPOLO partners from FTMC, ELAS, LUT, AMSYS and UPM participated in this week-long exercise. A polygon scanner was provided by project partner Next Scan Technologies. Experiments on monitoring of the CIGS laser processing with picosecond lasers combined with galvano-scanner or polygon scanner were carried out.

After two-days of active workshop, the preparation work in the laboratories followed. The results of successfully conducted experiments, emerged technological challenges and efficient solutions to them were discussed between participants during the workshop review meeting.

Source: <http://www.appolo-fp7.eu/news.html>

Meet the Consortium

IRIS Srl.



Playground for new Ideas

© IRIS

IRIS Srl is a startup company founded in 2012 and located in Italy, in the industrial area of Torino. Consisting of twelve employees and supported by several external collaborations, IRIS owns a strong background in industrial laser and plasma technology applications, adding value in process optimization/qualification in order to guarantee best affordable product performances (dimensional, structural reliability, etc.). IRIS is involved in a European and regional network of companies, maintaining an active portfolio of investments in technological innovation. The network's activities aim at sharing of research and development efforts such as industrial resources and capacity (cutting, welding, machining, prototyping) to increase the competitiveness of the local industrial system.



© IRIS

Interview...

...with Manuel Lai, Co-founder and CEO of IRIS Srl



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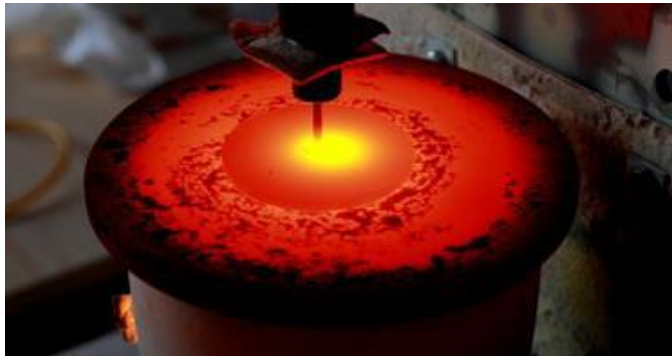
What are the biggest challenges in the field of laser-based manufacturing today?

State of the art of laser based additive manufacturing equipment currently uses optical solutions that are particularly limiting for machine designers since they require either using complex free-space optical chains to route the pulsed beam to the working area, or mounting the pulsed laser very close to the scanner head. Such an approach can be fitted on a gantry structure, but it's practically impossible to install on an anthropomorphic robot. Recent advances in high power pulsed lasers and their wide applications in micro-machining gave rise to the need of a more flexible and robust means for beam delivery over a meter-long optical path.

To which extent APPOLO can help to face those challenges?

The APPOLO Hub can help the laser based technology sector by integrating knowledge accumulated in the application laboratories (i.e. accessing partner's facilities and working with qualified researchers). It can help SMEs with valid ideas in assessing, validating and certifying their own solution in a way not otherwise possible to them and also making their solution visible to laser suppliers, system integrators and end users in order to attract potential customers.

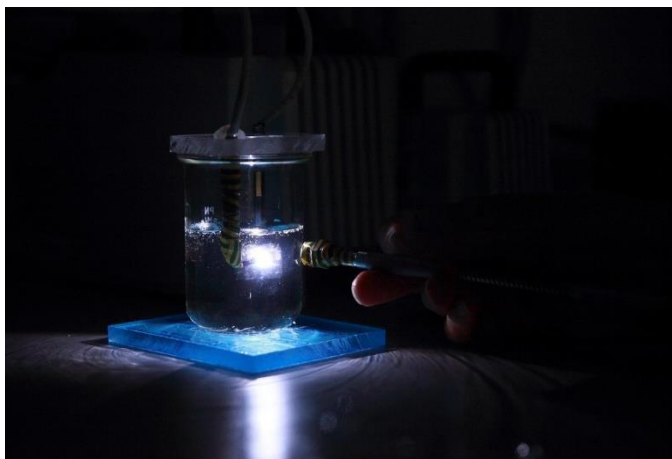
IRIS facilities include a 400 m² lab for experimental testing of laser and plasma processing, which will be added in 2017 by a Prima Industrie machine to integrate a new additive manufacturing processing head to develop and set up an affordable AM process. IRIS maintains partnerships with a group of local manufacturing SMEs specialized in laser and plasma cutting, CNC machining, bending and welding technologies, capable of building prototypes (e.g. novel equipment components, technological demonstrators) and testing new processes and equipment in an industrial environment. IRIS is also part of different running European funded projects, related to additive manufacturing and laser technologies, with extended partnerships with larger companies such as Avio Aero, Prima Industrie, SUPSI, and USFD.



© IRIS

Main fields of activity are the

- Development of environmental applications of plasma technology (2 patent applications pending approval)
- Design of industrial applications of laser technology with a strong focus on additive manufacturing ("3D printing" with metals)
- Support for innovation and technology transfer to SMEs.



© IRIS

Ongoing and recently completed projects are:

- NewDeli (assessing a new ultra-short pulse fiber delivery system candidate for a new generation of Additive Manufacturing and subtractive machines) - part of APPOLO project, FP7 FoF
- BOREALIS (the 3A energy class Flexible Machine for the new Additive and Subtractive Manufacturing of next generation of complex 3D metal parts) - H2020 FoF
- SYMBIONICA: Reconfigurable Machine for the new Additive and Subtractive Manufacturing of next generation fully personalized bionics and smart prosthetics aims to develop a new technological platform integrating cutting edge innovations in design and manufacturing in order to deliver better Medtech products and services for an improved quality of life.
- SeaLitterCrittters (feasibility of an unmanned autonomous sea vessel able to collect and treat on board floating marine litter) - H2020 SME Instrument Phase 1
- WHITE'R (White Room based on Reconfigurable robotic Island for optoelectronics) - EUfunded-7FP
- ECOWELD (Automated and flexible laser welding system for small-lot production)
- WATERPLASMA (Application of plasma to water treatment)
- GREENPLASMA (Plasma based solid waste/wastewater treatment)

Thanks to the experience in bidirectional technology transfer (from R&D centers global network to IRIS and from IRIS to local SMEs network), IRIS has often been involved as exploitation leader bringing a faithful and realistic industrial perspective in addressing technical project choices to the team.

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IRIS participated at Additive Manufacturing Europe 2016

During the Additive Manufacturing Europe exhibition of 2016 IRIS participated with an exhibition stand. From June 28th until 30th 2016 IRIS presented information on recent projects and the APPOLO HUB to a variety of interested people.

Source: <http://www.amshow-europe.com/iris-srl>

ELAS Ltd.



©ELAS

LASER SOLUTIONS FOR SCIENCE & INDUSTRY

ELAS Ltd. is a Lithuanian designer and manufacturer of laser micromachining systems for industrial and scientific applications. Highly customized micromachining workstations incorporate nanosecond, picosecond and femto-second laser sources in combination with advanced beam steering in order to achieve micrometer scale machining precision and repeatability.

In depth knowledge of micromachining processes is at the disposition of ELAS engineers, since it comes from two associated labs. ELAS is a spin-off company of the Center for physical sciences and technology (FTMC) in collaboration with EKSPILA (laser manufacturing company). Processes are tested for feasibility, tuned for performance and skillfully embodied into reliable and efficient workstations.

Know-how is being accumulated mainly for ablation, scribing and intro-volume marking processes, whereas ever extending the range of materials, already includes silicon, CIGS, sapphire, diamond, tungsten carbide, biological materials, biodegradable polymers, glasses, the majority of metals, ferroelectric ceramics. Our main applications are:

- Metals cold micro-marking
- Thin film solar cells processing
- Flexible electronics manufacturing and selective polymer ablation
- Silicon, glass and sapphire wafers cutting and scribing
- Metal, synthetic diamond or ceramic mechanical tools treatment
- Medical device manufacturing
- Optical and metal coatings patterning
- Fuel injector nozzles and mechanical filters drilling

Particular attention is always paid to ergonomics and safety of our systems. The company's advantage in the market is the ability to meet sophisticated functionality requirements of the customer. Due to this, ELAS' clients vary from world famous universities, research centers to industrial companies.

The company was established in 2010 and employs 11 people. Despite ELAS' youth as a company in the laser technology market, it already has national awards. In 2011 ELAS has been rewarded the national prize of "The most innovative product", in 2012, we won the gold medal in the contest for the "Product of the year" and at the same year, we have been nominated as one of the best developing knowledge economy companies in Lithuania. The reward of being "Strongest in Lithuania" was received in 2016.

Interview...

...with Saulius Mikalauskas, CEO at ELAS



What are the biggest challenges in the field of laser-based manufacturing today?

Laser-based industry finds a plenty of new application as well as replaces competing technologies nowadays. Industrial users show specific request and non-standard needs for the equipment. Manufacturers and scientists have to join and adjust laboratory experiences to novel manufacturing methods to satisfy high demands of the end-user.

To which extent can APPOLO help to face those challenges?

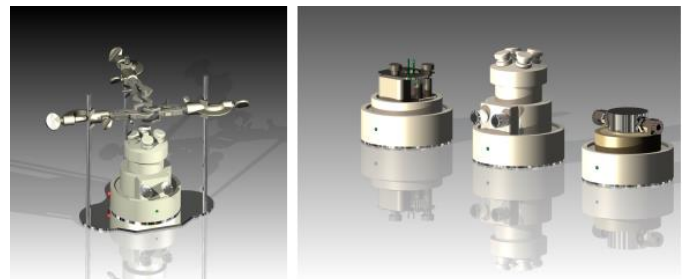
The APPOLO Hub is dedicated to test laser micromachining technologies in close to industrial environment. The role of the HUB is significant when experimental knowledge from application laboratories should be transferred to factories.

BIOAGE Srl.



BioAge is an Italian technological SME that develops and produces measurement instruments based on sensors, biosensors, and real-time monitoring systems. The company develops several kinds of transducers. Key technologies are nano gravimetric, capacitive and infrasonic wave systems. BioAge produces highly accurate quartz crystal microbalances (QCM) systems, developed for piezoelectric gravimetric in the ng-pg range. Such instruments are commonly used by research centers and universities; their application fields are extremely large and thanks to extreme accuracy and sensitivity our instruments are employed in the basic nanotechnology research, too.

Our main product is QCM Eureka, the first QCM, at world-wide level, self-powered only by the PC USB port.



EUREKA™: Electronic Quartz Crystal Microbalance; ©BIOAGE

BioAge designs, produces and installs infrasonic monitoring systems, used to monitor the volcanic activity in real time. In Italy, the Italian Civil Defense uses our systems to monitor the explosive activity of the Etna volcano, being the bigger active volcano in Europe. BioAge has designed and realized a real-time marine monitoring system that has been installed near the Stromboli Island (it is a volcanic island), this system is used by the Italian civil defense as a tsunami real time early warning alarm.

The scientific research is one of the main interests of BioAge that is involved in EC FP7 research projects. Lot-Oriel (<http://www.lot-oriel.com>) is a distributor of the BioAge instruments.

Interview...

...with Dr. Stefano Sinopoli, technical director of BioAge-srl

What are the biggest challenges in the field of laser-based manufacturing today?

Miniaturization, cost reduction and reduced environmental impact are the main drivers for change in electronics industries. Nowadays compact and cheap solid state lasers are available for processing novel material and for implementing innovative design on a microscopic scale. The most immediate objective is to identify new and evolving manufacturing applications where laser processing may play a significant enabling role. In addition, the aim is to identify relevant areas where research and development would be required to facilitate future laser-based solutions to such production needs.

The European challenge is bisected: the first goal is to lead the photonics technology innovation. Secondly the exploitation of these results through a successful commercialisation is a mayor prospect. In this way grand societal challenges may be solved and an European sustainable economic growth is achieved.

To which extent can APPOLO help to face those challenges?

It is essential for the future prosperity of the European industry, to sustain the competitiveness of local SMEs in the global market. One of the objectives of the FP7 APPOLO project is to establish and coordinate a virtual hub to accumulate knowledge and infrastructure, this hub ensures effective technical collaborations between academic and industry partners and it provides a model for future engagements. Within the project both academic and industrial involvement allows efficient technology transfer planning. For this reason the APPOLO research project establishes an innovation cluster that can help the SMEs to develop and promote an innovation model along all the laser scribing production chain, this very efficient and innovative approach supports the SMEs into the prototypes development, leading to shorter-term commercialization.

The scientific research is one of the main interests of BioAge that is involved in EC FP7 research projects. Lot-Oriel (<http://www.lot-oriel.com>) is a distributor of the BioAge instruments

BioAge currently is involved in the realization of a very innovative real-time monitoring system to detect fires: the system is based on a network of Micro Smart Autonomous Sensors. Each microsensor integrates a rechargeable battery; a micro solar panel used to recharge the battery, a temperature sensor, a micro RF transmitter and a tiny ultra-low power microcontroller. It is possible to create a wireless network of microsensors to monitor the temperature in real-time and also detect a fire born.



The smart microsensors and two hand-held data receiver; ©BIOAGE

The key factors to obtain a very innovative and competitive system are related to the cost reduction of the typical microsensor. The technologies that will be developed in the APPOLO project are very useful to decrease the cost of the microsensors, also for a very large production, in fact thanks to developments foreseen in the APPOLO project it will be possible to realize an "active enclosure": it is a plastic enclosure (realized by use of the laser technology) integrating conductive wires on the internal side of the enclosure. Using this approach, the electronic components will be assembled directly on the conductive wires present in the inner part of the "active" enclosure. The approach potentially offers the possibility to eliminate the use of a printed circuit board, saving money.

This new concept of "active enclosure" plays a vital role to achieve an innovative and very cheap family of autonomous smart sensors, opening new opportunities to gain new market shares. The BioAge application will be a strategic benchmark to test the innovative laser technologies that will be developed in the APPOLO project.

Upcoming Events 2016

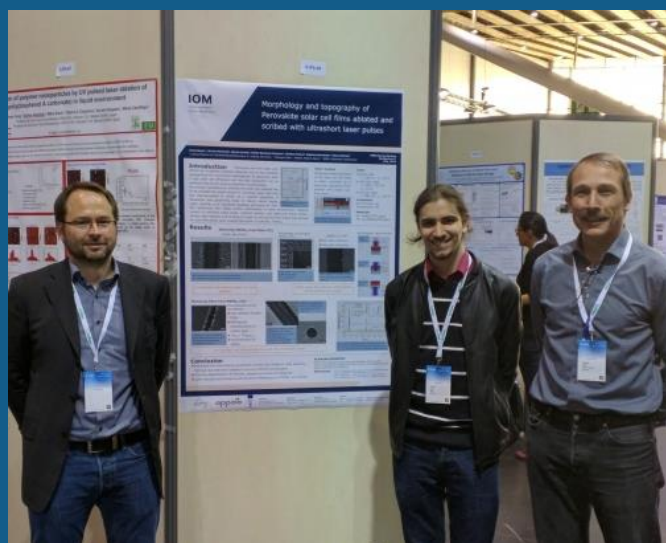
29.08. – 02. 09.	Brasov, Romania	ICPEPA
19.09. – 22. 09.	Fürth, Germany	LANE
12.10. – 14.10.	Yokohama, Japan	BioJapan
16.10. – 20.10.	San Diego, USA	ICALEO
30.11. – 01.12.	Munich, Germany	Automotive Surfaces conference

We invite you to meet us at these events and to get to know more about APPOLO and the partners!

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IOM @ EMRS Spring Meeting 2016

IOM participated at the EMRS Spring Meeting 2016 conference. It is one of the largest conferences on material research in Europe with a broad range of topics, which were covered by 31 parallel session symposia. New results from IOM were presented with two posters and an oral talk on **Processing of CIGS thin film with infrared nanosecond laser radiation**.



IOM @ EMRS Spring Meeting ©IOM

Source: <http://www.appolo-fp7.eu/news.html>

ICPEPA-10

The **10th International Conference on Photo-Excited Processes and Applications** (ICPEPA) will take place from August 29th to September 2nd, 2016 in Brasov, Romania.

The topics range from fundamental laser-material interactions, theory and modeling to applications with nano-particles and nano photonics as well as new trends in photo excitations. The conference intends to create an atmosphere for scientific presentations at the forefront of the field and an informal exchange of ideas in a relaxing environment.

<http://icpepa10.com/>

LANE 2016

The **9th International Conference on Photonic Technologies** will take place on September 19th to 22th, 2016 in Fürth, Germany.

Modern research has to act on social, economic and environmental developments to provide solutions for the existing and upcoming global challenges. To meet this challenge, LANE 2014 offers a platform for an international exchange of ideas, opinions, perspectives, results and solutions concerning photonic technologies.

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NANOTYPOS purchases nanoimprint lithography system

Nanotypos is excited to announce its investment in a state of the art roll-to-roll nanoimprint lithography system.



Roll-to-roll nanoimprint lithography system @Nanotypos;
©Nanotypos

This custom-made lithography equipment is an innovative solution for flexible processing and pilot scale production of large area micro/nano patterning surfaces

Source: <http://www.nanotypos.com/portal/news/>



BioJapan 2016
YOKOHAMA

© BioJapan

The **18th BioJapan World Business Forum 2016** will take place on October 12th to 14th, 2016 in Yokohama, Japan.

BioJapan has played an important role in facilitating interaction between Japanese and global companies/organizations and stimulating new business opportunities. The Japanese and global biotechnology industry's top business development and licensing professionals, alliance management professionals, R&D personnel and biotech company executives will gather in Yokohama for the 18th BioJapan

ICALEO

The **International Congress on Applications of Lasers & Electro-Optics (ICALEO®)** will take place from October 16th to 20th, 2016 in San Diego, CA, USA.

ICALEO has a 34 year history as the conference where researchers and end-users meet to review the state-of-the art in laser materials processing and predict where the future will lead. From its inception, ICALEO has been devoted to the field of laser materials processing and is viewed as the premier source of technical information in the field.

<http://www.lia.org/conferences/icaleo>

Automotive Surface 2016

The **Automotive Surfaces Conference** will take place from November 30th to 1st of December, 2016 at the Dolce Munich Hotel in Munich, Germany.

Automotive Surfaces Conference 2016, brought to you by Plastic News Europe, is the meeting place for the auto industry, focusing on vehicle interior fixings, applications and developments. The conference will act as a platform for industry experts to showcase new interior feature enhancements and explore smart surfaces. Join us at the conference to meet leading OEMs, Tier 1 manufacturers and automotive companies and discover the latest materials and manufacturing technologies.

<http://www.decorativeautomotiveplastics.com/>

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ELAS attended @ LASYS exhibition 2016

During the LASYS 2016 event ELAS has attended as exhibitor. APPOLO Project specific material and information have been presented.



Elas @ Lasys 2016 ©ELAS:

Source: <http://www.nanotypos.com/portal/news/>

Consortium



<http://appolo-fp7.eu/>



Coordinator

State research institute Center for Physical Sciences and Technology (FTMC)

Department of Laser Technologies
Savanoriu Ave. 231, LT-02300 Vilnius, Lithuania

Tel.: +370 5 264 9211, 266 1640/1643,
Fax: +370 5 260 2317

Contact Person

Dr. Gediminas Račiukaitis

Head of Department of Laser Technologies, FTMC

Tel.: +370 5 264 4868

E-Mail: graciukaitis@ar.fi.lt

