TECHNISCHE UNIVERSITÄT DRESDEN

# Annual report 2022/2023

Chair of Laser-based Manufacturing

Professur für Laserbasierte Fertigung

DRESDEN concept

CAMP CENTER FOR ADVANCED MICRO-PHOTONICS

Fraunhofer IWS

## Preface

Dear friends and partners,
Dear readers,

In 2023, our research portfolio has evolved to hold new topics following the approval of the denomination's change of our chair by the Faculty of Mechanical Engineering. The new "Chair of Laser-based Manufacturing" focuses now on wide-ranging research encompassing various laser-based manufacturing methods. This includes Laser Micro Processing, Laser-based Surface Functionalization, Laser Welding, Cutting and Hardening, Process Development and Simulation, Photonic-based Metrology, Optics Development and Multibeam Laser-based Processing.
Over the past two years, our chair has maintained its commitment to conducting high-quality research in laser-based processes. Within this context, we continually updated different lecture modules for our students, addressing the applications of laser methods and photonic measurement technologies. The Laser and Plasma Technology module is also undergoing changes to include new topics that are currently relevant in production.
In addition to an impressive number of publications in peer-reviewed journals, we successfully organized the "Laser Precision Microfabrication Symposium 2022" in collaboration with the Deutsche Gesellschaft für Materialkunde e.V. This event, held in Dresden, brought together the most prestigious researchers working in the field of laser technology.
Our robust collaboration with the Fraunhofer Institute for Material and Beam Technology (IWS) in Dresden, within the "Center for Advanced Micro-Photonics (CAMP)", has empowered us to contineously develop innovative solutions for laser systems, processes, and metrology components.
We take this opportunity to express our gratitude to our national sponsors, the European Union, our partners, and customers for their trust, as well as our employees for their trustful and constructive cooperation.
This report presents a selection from our numerous research projects. We invite you to delve into our work and wish you an inspiring read!

Best regards,

Prof. Andrés Fabián Lasagni

## Contents

# 1. The chair in numbers

## Expenditure from R&D Income

| | 2022 | 2023 |
|---|---|---|
| Raised funding | 831.133 € | 915.055 € |

## Employees

| | 2022 | 2023 |
|---|---|---|
| Scientific staff | 14 | 11 |
| Technical employees | 1 | 1 |
| Administration | 1 | 1 |
| Student assistants | 1 | 4 |
| External PhD students | 11 | 17 |
| Visiting scientists | 6 | 3 |
| **Total employees** | 34 | 37 |

## Final theses

| | 2022 | 2023 |
|---|---|---|
| Doctoral theses | 1 | 1 |
| Diploma theses | 11 | 9 |
| Student projects | 8 | 5 |

## Publication record

| | 2022 | 2023 |
|---|---|---|
| Books and book contributions | 0 | 1 |
| Peer-reviewed papers | 30 | 27 |
| Proceedings and conference articles | 27 | 24 |
| Participation in conferences (talks and posters) | 54 | 59 |
| Total | 111 | 111 |

## 2. Organization chart

**Prof. Andrés F. Lasagni**
Chair keeper

**Lisa Becher**
Assistance / controlling

**Dr. Bogdan Voisiat**
Technology development and transfer

**Dr. Robert Baumann**
Operation manager and process development

**Dr. Marcos Soldera**
Manager Modelling and project management

**Alexander Bock**
Laboratory manager

## Chair keeper
Prof. Dr. Andrés F. Lasagni

## Assistance / controlling
Lisa Becher

## Technology development and transfer
Dr. Bogdan Voisiat

## Operation manager and process development
Dr. Robert Baumann

## Manager Modelling and project management
Dr. Marcos Soldera

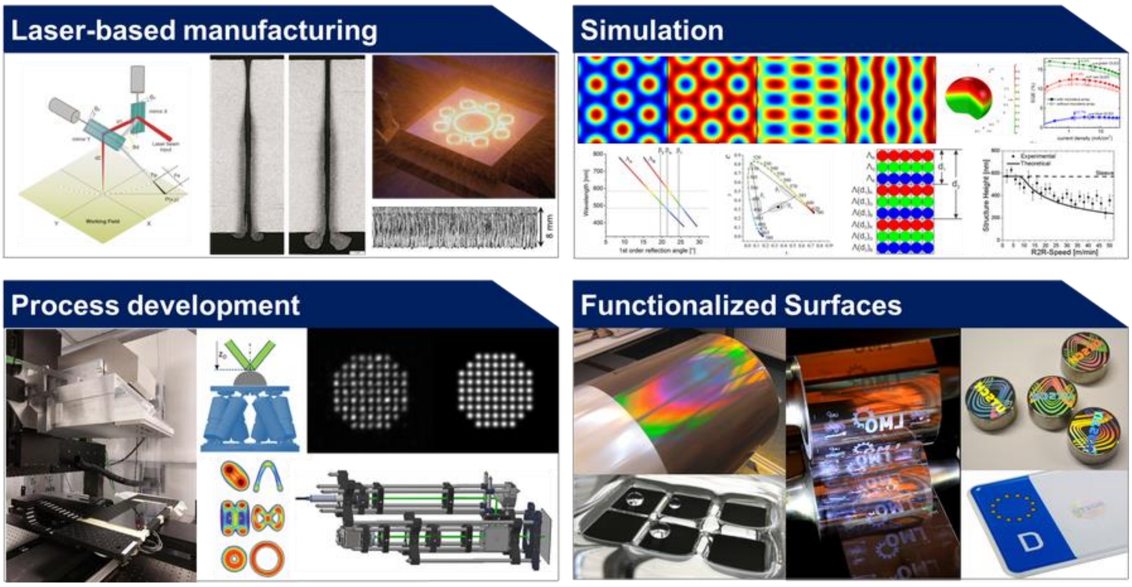
## Laboratory manager
Alexander Bock

## Post docs / Scientists
Prof. Dr. Bruno Henriques (Alexander von Humboldt)
Dr. Marcelo Daniel Sellece
Dr. Beate Lehmann
Dr. Yangxi Fu
Dr. Lucinda Mulko

## PhD students
Felix Bouchard
Mikhael El-Khoury
Florian Kuisat
Nikolai Schröder
Lis Zschach
Herman Heffner
Madlen Borkmann (IWS)
Lukas Olawsky (ALOTEC)
Marina Skiba (EAH-Jena)
Ignacio Tabares
Wei Wang (SFU)
Fabian Ränke
Dirk Obergfell (HS Furtwangen)
Jana Gebauer (IWS)
Frederic Schell (IWS)
Tobias Steege (IWS)
Tianhao Wu
Eric Pohl (IWS)
Christian Bischoff (TOPAG)
Hans-Julius Langeheinecke (BMW)
Björn Michelberger (STZ)
Leander Klaeber (FH – Zwickau)
Michael Seiler (EAH-Jena)
Antje Schuschies (EAH-Jena)
Caitlin Walls (SRH – Berlin)

## 3. Research and teaching activities

The chair of Laser-based Manufacturing was created in 2014 (firstly under the name Chair for Large Area Laser-based Surface Micro/Nano Structuring) after successfully being awarded with an Open Topic Tenure Track professorship. We are dedicated on research related to the field of laser-based manufacturing methods, including Laser micro processing, Laser-based surface functionalization and simulation, Laser welding, cutting and hardening, Process development and simulation, Photonic-based metrology, Optics development and simulation, and Multibeam laser-based processing.




### Focus in research and teaching

- Laser micro processing
- Laser-based surface functionalization and simulation
- Laser welding, cutting and hardening
- Process development and simulation
- Photonic-based metrology
- Optics development and simulation
- Multibeam laser-based processing
- Replication methods including roll to roll processes

## 4. Center for Advanced Micro-Photonics (CAMP)

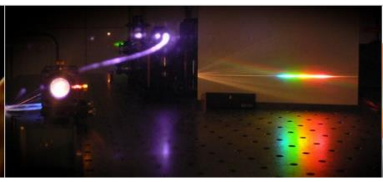
CAMP focuses on laser-based surface modification and patterning processes. The center targets opportunities and challenges in the development of new system, process and measurement solutions. To transfer technologies into the industry, our scientists develop solutions in every step along the entire process chain.

TECHNISCHE UNIVERSITÄT DRESDEN | CAMP CENTER FOR ADVANCED MICRO-PHOTONICS | Fraunhofer IWS

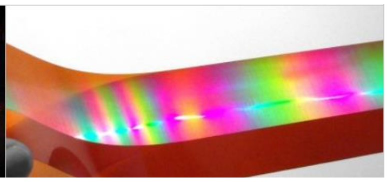

CAMP employs cross-operational approaches ranging from simulation, laser processes and optical measurements to machine learning. The scientists at Fraunhofer IWS and TU Dresden focus on various applications of laser microprocessing and measurement engineering.

**The CAMP partners:**


Fraunhofer IWS, Business unit Microtechnology



Fraunhofer Application Center for Optical Metrology and Surface Technologies



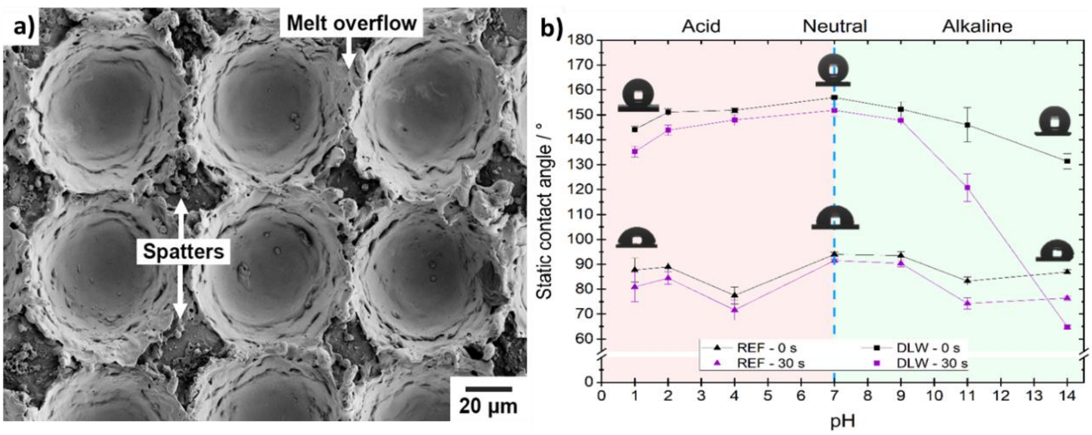
Chair of Large Area Laser Based Surface Structuring

## 5. Selected projects

### Effect of pH on wettability properties on aluminium alloy surfaces treated with direct laser writing

| | |
|---|---|
| Funding agency: | Ministry of Science, Technology and Innovation (MINCyT) of Argentina |
| Period: | 12/2022 – 12/2023 |
| Project partners: | TU Dresden, Universidad Nacional de Rosario |
| Project manager: | Eng. Josefina Dib |

Lightweight materials like Al 2024, are gaining importance in automotive and aerospace industries. Innovative surface properties, such as superhydrophobicity, are broadening their applications. Laser structuring is favored for its flexibility, simplicity, limited thermal distortion, and environmental friendliness. Although wettability studies after laser structuring typically measure the static contact angle (SCA) with deionized water, the influence of the pH of the liquid on these surfaces remains unexplored. The project aimed to investigate the effect of pH on superhydrophobic Al 2024 surfaces. To achieve this, a dot pattern was fabricated using direct laser writing with a nanosecond laser source. The laser-treated surfaces achieved a superhydrophobic state and maintained contact angles ranging from 151.1 ± 1.5° to 157.0 ± 0.5° within a pH range of 2 to 9. However, at higher pH values, the droplets collapsed due to a rapid chemical reaction with the surface. On the other hand, the unstructured samples exhibit a maximum contact angle of 95.0 ± 0.5° at a neutral pH. The difference in chemical stability at high pH values between the treated and untreated surfaces can be attributed to the detachment of $Al_2CuMg$ precipitates from the surface of the Al 2024-T351 alloy during the laser structuring process. This detachment makes the surface more susceptible to corrosion reactions. These findings fill a gap in the understanding of the chemical stability of superhydrophobic laser-structured surfaces, broadening their range of potential applications.




(a) Scanning Electron Microscopy (SEM) of the laser-treated aluminium surface and (b) variation of the contact angle of the laser-treated samples (DLW) and the reference (REF) exposed to different pH values.

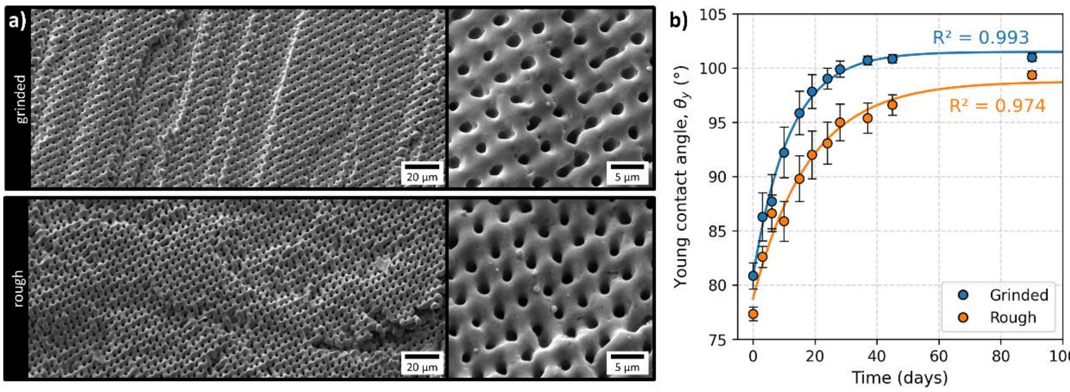
Sponsored by:
Ministerio de Ciencia, Tecnología e Innovación (Argentina)

Ministerio de Ciencia, Tecnología e Innovación Argentina

## Investigating transition and steady-state wettability of laser-textured rough stainless steel surfaces


| | |
|---|---|
| Funding agency: | EU - Horizon 2020 |
| Period: | 10/2017 – 03/2021 |
| Project partners: | Fraunhofer IWS, GF Machining Solutions AG, Heriot-Watt University, Sensofar-Tech, ATS Applied Tech Systems, Simtec, Sandvik Coromant, Unilever, Johnson & Johnson, MAN Energy Solutions |
| Project manager: | Eng. Tobias Steege, Eng. Frederik Schell |


Controlling wetting properties of functional metal surfaces can provide benefits for a wide variety of industrial applications, such as influencing biocompatibility, ice adhesion and achieving self-cleaning effects. When it comes to metal surfaces, laser-texturing methods provide a flexible and robust approach to modify both the chemistry and microtopography in a single processing step. In this project, using the technique of direct laser interference patterning (DLIP) with four interfering beams, periodic dot-like micro-textures were applied to stainless steel surfaces. Experiments were conducted on high initial roughness specimen to investigate how microtexturing can influence wetting on not specifically prepared surfaces, which are often found in industrial applications. Rough as-built samples and pre-grinded samples were used to represent two types of initial surface finish. The textured surfaces exhibited a transition from hydrophilic to hydrophobic wetting over the course of 90 days, achieving water contact angles up to 154.4°. Using the Wenzel model, the transition of the average Young contact angle was estimated for both types of initial surface finish. In the steady-state, water and diiodomethane CA measurements showed that surfaces were hydrophobic and oleophilic, with diiodomethane contact angles as low as 0°. Measurements of CA hysteresis revealed that textured surfaces exhibit the rose-petal effect, where water contact angles are high while drops adhere strongly to the surface with undefined sliding angle. It was shown that the high adhesion forces originated from the initial surface roughness, while the high water contact angle was a consequence of the DLIP texturing.




Stainless steel surfaces laser-textured with a dot-like pattern (a) with a period of 4.2 µm on a grinded and rough sample surface and estimated Young contact angle (b) of laser-textured grinded and rough surfaces over a duration of 90 days.

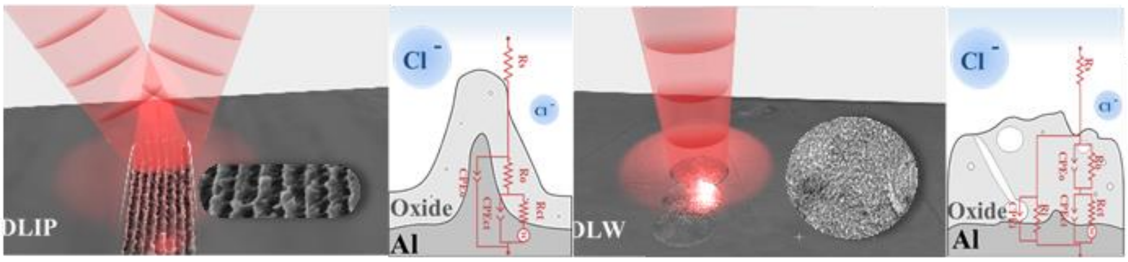

Sponsored by:
European Union | Horizon 2020

This project has received funding from the European Union's Horizon 2020 Framework Programme for research and innovation under grant agreement no 768701

## On the Corrosion Properties of Aluminum 2024 Laser Textured Surfaces with Superhydrophilic and Superhydrophobic Wettability States


| | |
|---|---|
| Funding agency: | Deutscher Akademischer Austauschdienst (DAAD) |
| Period: | 10/2021 – 10/2023 |
| Project partners: | TU Dresden |
| Project manager: | M.Eng. Lis Geraldine Zschach |


Recently, numerous studies have investigated the development of methods for modifying wettability to fabricate superhydrophobic surfaces. While various applications of these surfaces have been explored, corrosion resistance has received limited attention, and its enhancement has been directly linked to the wettability state. This study was focused on the fabrication of superhydrophobic and superhydrophilic surfaces on aluminum 2024 using laser-based technologies, aiming to determine the relationships between wetting behaviors and corrosion resistance. In order to generate topographies with very different wetting conditions, two laser-based techniques were used, Direct Laser Writing (DLW) and Direct Laser Interference Patterning (DLIP). In both cases, the infrared laser sources were used to produce ns pulses with the same energy.  The wettability measurements indicated that the DLIP samples could achieve either a hydrophobic or superhydrophobic state. In contrast, all Al-surfaces processed with DLW became superhydrophilic. For both methods, including superhydrophilic and hydrophobic/superhydrophobic conditions, the corrosion rate decreased from 12.6 to approximately 0.3 μm $yr^{-1}$. Therefore, the corrosion resistance of the laser-treated samples can be attributed mainly to the thicker oxide layers produced by the laser, as confirmed by STEM images of the FIB-cuts and the increased impedances shown in the EIS measurements. Finally, the corrosion rates obtained for both treated surfaces were very similar. However, surfaces produced with DLIP may be more beneficial when additional surface properties, such as ice repellency or self-cleaning properties, are required.




Schematic drawing of the DLIP and DLW processes, their respective beam spots and the electrical characterization of the interface of the surface generated by each laser process and the saline medium (3.5% NaCl) in which the corrosion tests were performed.

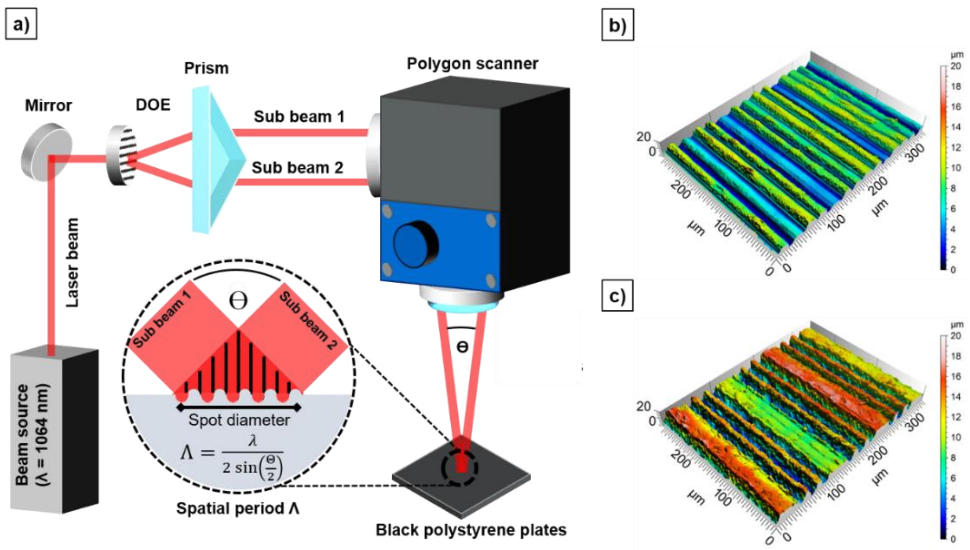
Sponsored by:
Deutscher Akademischer Austauschdienst (DAAD)

## High throughput micro-structuring by combining direct laser interference patterning with polygonscanner technology

Funding agency: European Union – Photonics21
Period: 01/2019 - 12/2023
Project partners: TUD, Trumpf, Lasea, NIT, NextScan, Bosch, BSH, EPIC
Project managers: Dipl.-Ing. Fabian Ränke

Surface modification of polymer materials is a useful way to obtain surface functionalities by producing well-defined topographical elements or modifying their chemistry. This increases the potential range of applications in the fields of microfluidics, biomedical applications and electronics. In particular, Direct Laser Interference Patterning (DLIP) is considered to be a flexible and highly versatile solution for generating periodic and deterministic microstructures. To implement the DLIP method on an industrial scale, it is imperative to devise beam manipulation systems capable of achieving high scanning speeds and, consequently, enabling high material throughputs.

In this project, Direct Laser Interference Patterning was combined for the first time worldwide in conjunction with a polygon scanner to fabricate textured polystyrene surfaces at high thourgout. This is achieved by using a high power picosecond lasersource in combination with a polygon mirror-based scanning system. The two-beam DLIP optical configuration leads to the formation of line-like structures with a spatial period of 21.0 µm. The influence of the scanning speed and the repetition rate on the structure formation is investigated, allowing structure heights up to 23.0 µm. The formation of the micro-structure was found to result from swelling and ablation mechanisms. By applying scanning speeds of 350 m/s, a throughput of 1.1 $m^2$/min is reported for the first time using this method.




a) Experimental set-up using a polygon scanner unit with a two-beam interference optics. Confocal microscope images of surface topographies produced on black polystyrene using scan speeds of (b) 200 m/s and (c) 100 m/s.

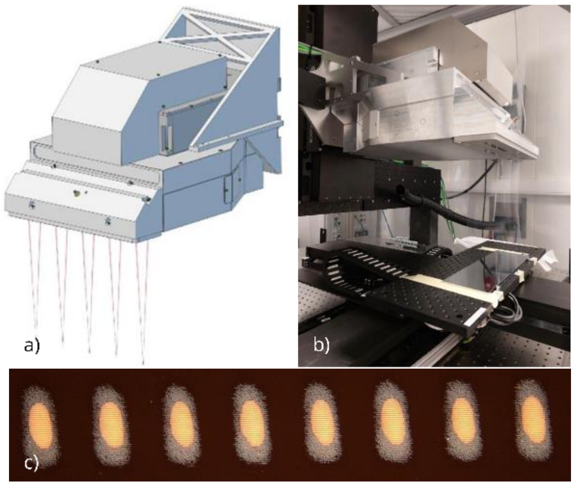
Sponsored by: European Union Horizon2020
An initiative of the "Photonics Public Private Partnership" - Photonics21.org
PHOTONICS21
PHOTONICS PUBLIC PRIVATE PARTNERSHIP

## Development of a DLIP-Polygon structuring system for high-througthput surface functionalization

| | |
|---|---|
| Funding agency: | European Union – Photonics21 |
| Period: | 01/2019 - 12/2023 |
| Project partners: | TUD, Trumpf, Lasea, NIT, NextScan, Bosch, BSH, EPIC |
| Project managers: | Dr.-Ing. Bogdan Voisiat, Dr.-Ing Robert Baumann |

The LAMpAS project marked a significant leap in laser technology, particularly in high-throughput laser structuring for advanced surface functionalities. Central to this achievement was the innovative integration of Direct Laser Interference Patterning (DLIP) with polygon scanning technology, culminating in the development of the DLIP-Polygon scanner module. This collaborative effort, led by NST and TU Dresden, among others, dramatically increased patterning speed, a groundbreaking improvement over conventional methods.

This high-speed patterning capability, essential for efficient and precise surface structuring, allowed for the creation of interference patterns at speeds previously unattainable. The DLIP-Polygon scanner module successfully achieved feature sizes down to ~ 3 µm at extended working distances, significantly outperforming traditional polygon systems. Overcoming technical challenges, the project team enhanced the uniformity of pattern projection over large areas and maintained high processing speeds without sacrificing quality. The project's culmination saw notable improvements in system adaptability for higher laser power, as well as advancements in alignment and usability. The integration of DLIP with polygon scanning technology not only set new standards in the field of high-throughput laser structuring but also opened up new possibilities for future research and applications in laser-based surface structuring technologies.




Final design of the DLIP-Polygon scanner module (a) and photograph of the produced and integrated device (b); first DLIP pattern scribe results (horizontal dot separation is 350 µm) (c)

Sponsored by: European Union Horizon2020
An initiative of the "Photonics Public Private Partnership" - Photonics21.org

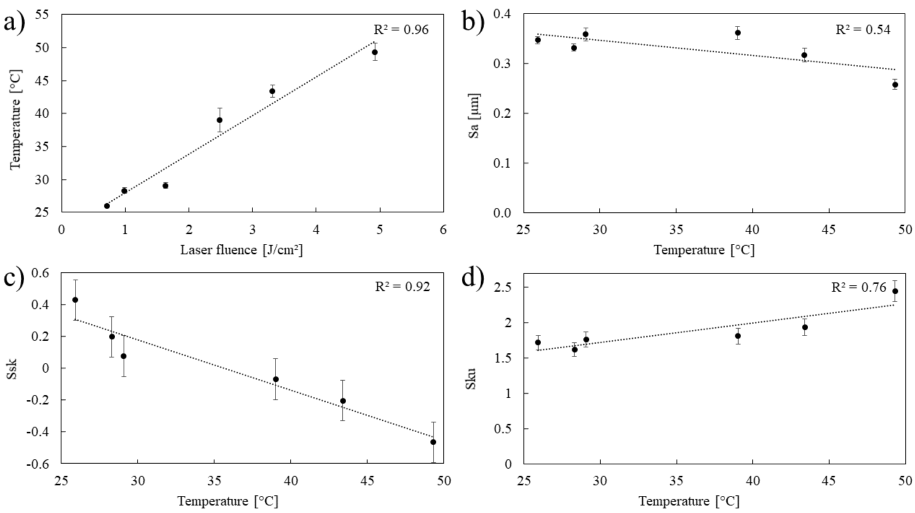
## Laser-based functionalisation of forming tools using industrial robots

Funding agency: Federal Ministry for Economic Affairs and Climate Action
Period: 05/2021 – 02/2024
Project partners: TU Dresden, EdgeWave GmbH, ALOtec Dresden GmbH
Project manager: Dipl.-Ing. Lukas Olawsky (ALOtec Dresden GmbH)

The project focuses on developing a laser-based technology to fabricate microstructured 3D forming tools for the sheet metal forming industry. This aims to reduce friction and enhance performance in deep-drawing processes. The project encompasses the development of a new laser source, a compact laser interference optics as well as a process monitoring concept.

Direct Laser Interference Patterning (DLIP) is a technique enabling the fabrication of uniform microstructures in the micrometer and sub-micrometer range. Traditionally, the topography of these structures is assessed ex-situ using methods like confocal microscopy or white light interferometry. However, these techniques are unsuitable for real-time process observation due to their extended measurement times. In our case, an infrared camera system was employed to investigate the correlation between the captured average temperature during DLIP treatment and topographical parameters in real-time.

The results reveal a linear relationship between the applied laser fluence (0.7 to 4.9 J/cm²) and the measured average temperature. Significant changes in surface roughness, skewness, and kurtosis within this fluence range are also observed. These findings suggest that the presented method could be utilized for in-situ indirect monitoring of topography during DLIP treatment, enabling rapid identification of process fluctuations.



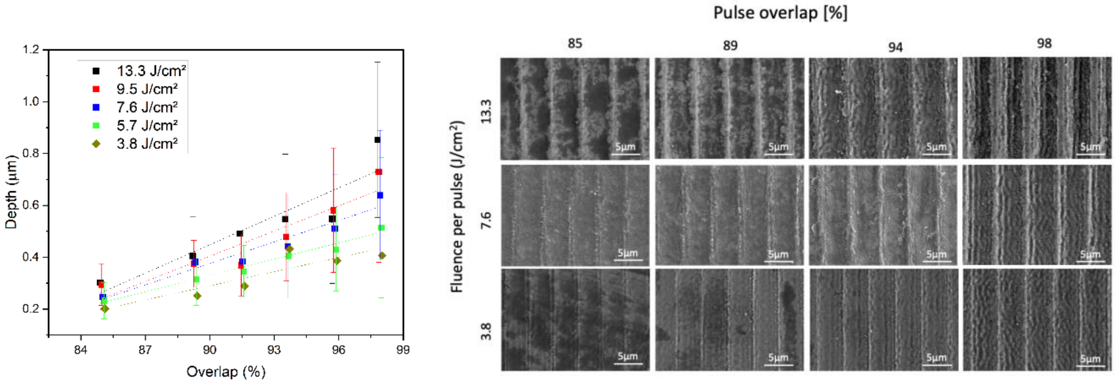

Average measured temperature depending on the laser fluence (a); *Sa* (b), *Ssk* (c) and *Sku* (d) depending on the temperature.

Sponsored by:
Federal Ministry for Economic Affairs
and Climate Action

## Multi-Scale Structuring of CoCrMo and AZ91D Magnesium Alloys using Direct Laser Interference Patterning


| | |
|---|---|
| Funding agency: | Alexander von Humboldt Foundation, Coordination of Superior Level Staff Improvement (CAPES-Brazil) |
| Period: | 11/2019 – 06/2022 |
| Project partners: | LMO, TU Dresden; CERMAT, UFSC |
| Project manager: | Prof. Dr. Bruno Henriques |


In this project, the technique of Direct Laser Interference Patterning (DLIP) was used to fabricate micrometric structures at the surface of Cobalt-Chromium-Molybdenum and AZ91D magnesium alloys. Line-like patterns with spatial periods of 5 µm were textured using an ultra-short pulsed laser (10 ps pulse duration and 1064 nm wavelength) with a two-beam interference setup. The surface topography, morphology, and chemical modifications were analysed using Confocal Microscopy, Scanning Electron Microscopy, and Energy Dispersive Spectroscopy (EDS), respectively. Laser fluence and pulse overlap were varied to evaluate their influence on the final structure. Homogeneous structures were achieved for the CoCrMo alloy for every condition tested, with deeper structures (up to 0.85 µm) being achieved for higher energy levels (higher overlap and/or fluence). For high energy, sub-micrometric secondary structures, so-called LIPSS, could also be observed on the CoCrMo. The EDS analysis showed some oxidation after the laser texturing. Regarding the AZ91D alloy, deeper structures could be achieved (up to 2.5 µm), but more melting and oxidation was observed, forming spherical oxide particles. Nonetheless, these results bring new perspectives on the fabrication of microtextures on the surface of CoCrMo and AZ91D using DLIP.




Average depth of line-like structures obtained by DLIP on CoCrMo sur-faces for different combinations of pulse overlaps and laser fluence. SEM images of textured surfaces of the CoCrMo samples for different conditions.


Sponsored by:
CAPES-Brazil, AvH Foundation

CAPES

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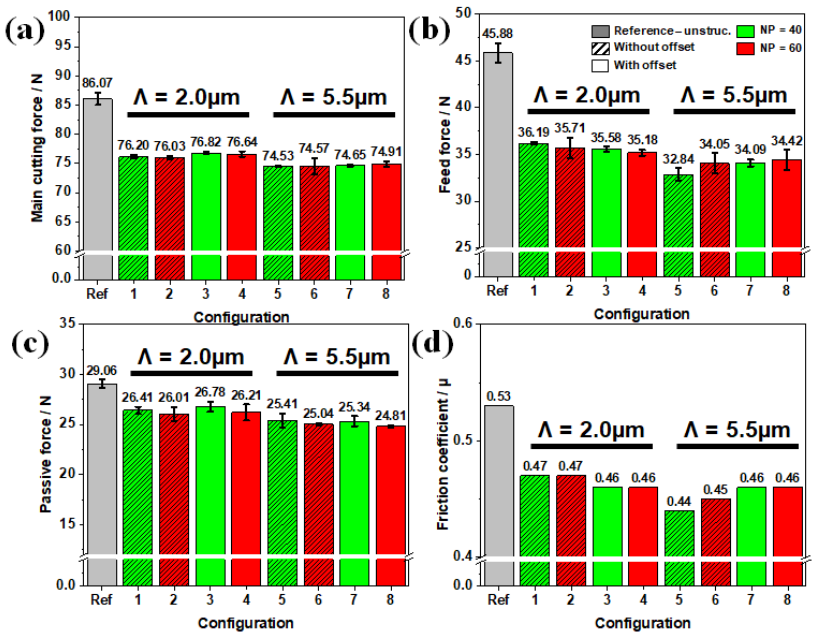
Stiftung/Foundation

## Tailored laser structuring of tungsten carbide cutting tools for improving their tribological performance

| | |
|---|---|
| Funding agency: | TU Dresden Internal |
| Period: | 09/2021 – 02/2023 |
| Project partners: | TU Dresden, Fraunhofer IWU |
| Project manager: | Dr.-Ing. Robert Baumann |

In times of societal development, sustainability has become a major concern for many manufacturers in metal industries. Surface texturing of cutting tools offers a promising approach in terms of reducing energy consumption and material losses. This project used direct laser interference patterning (DLIP) to create periodic line-like structures on rake-flank faces of hard metal cutting inserts. Turning experiments under lubricated condition were carried out on Al 6061 T6 using textured and untextured tools to investigate the tribological performances. The wetting behavior of the manufactured textures was also studied using two different metalworking fluids. It could be observed that the wettability decreased with an increase in spatial period. Moreover, the quality of the generated structure significantly influences the wetting behavior. Furthermore, structure depths up to ~ 1.76 µm are reached by controlling the applied number of laser pulses. Turning experiments under lubricated conditions revelead that the main cutting force could be reduced by ~ 11% and the feed force by ~21%. In addition, the passive force decreased by ~9% due to the corresponding improvement in frictional behavior at the tool/chip interface.




Machining forces evaluation for different configurations (conventional tool (Ref), (1 - 4) textured tools with Λ of 2.0 µm and (5 - 8) with Λ of 5.5 µm: (a) Main cutting force, (b) feed force, (c) passive force and (d) the calculated friction coefficient

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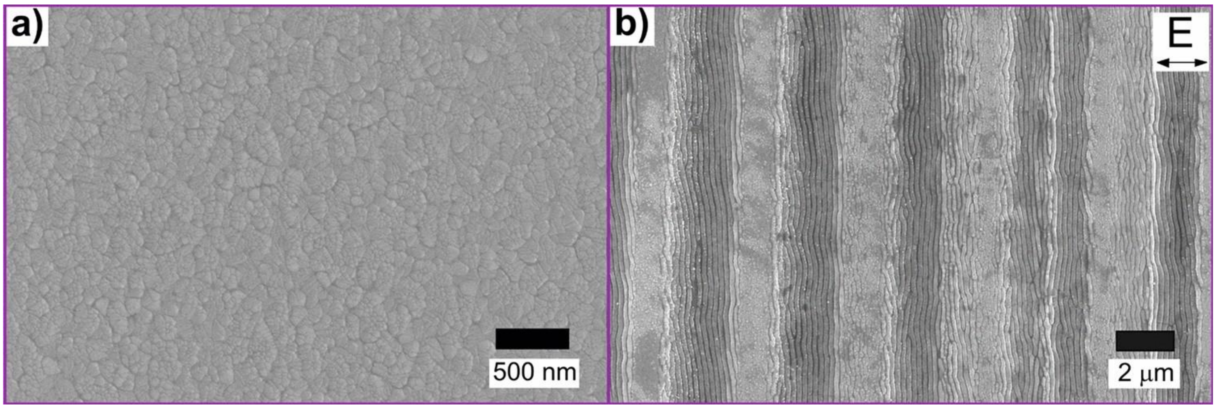
## Fabrication and characterization of microstructured thin films to improve the efficiency of dye-sensitized solar cells

Funding agency: German Academic Exchange Service (DAAD)
Period: 04/2021 – 03/2023
Project partners: LMO, TU Dresden
Project manager: Eng. Herman Heffner

A route to increase the efficiency of thin film solar cells, such as those based on dye sensitizers, is improving the light-trapping capacity by texturing the top Transparent Conductive Oxide (TCO) so that the sunlight reaching the solar absorber scatters into multiple directions. In the framework of this project, TCO based on Indium Tin Oxide (ITO) and Fluorine-doped Tin Oxide (FTO) thin films were treated by two-beam Direct Laser Interference Patterning (DLIP) using laser sources with different wavelengths and pulse durations from the femtosecond to the nanosecond range. The modified surface topography induced by the laser process had a strong influence on the optical and electrical properties of all samples. Surface analysis by scanning electron microscopy and confocal microscopy reveals the presence of periodic microchannels with an average height between 15 and 450 nm, depending on the laser parameters and decorated with Laser-Induced Periodic Surface Structures (LIPSS). In the case of the ITO films irradiated with laser source emitting infrared radiation at a wavelength of 1030 nm and a pulse duration of 900 fs, a relative increase in the average total and diffuse optical transmittances up to 10.7% and 1900%, respectively, was obtained in the 400 – 1000 nm spectral range as an outcome of the interaction of white light with the generated micro- and nanostructures. The estimation of Haacke's figure of merit suggests that the surface modification of ITO with fluence levels near the ablation threshold might enhance the performance of solar cells that employ ITO as a front electrode.




Scanning Electron Microscopy (SEM) images of (a) pristine and (b) DLIP-treated ITO film. In the microstructured surface, a well-defined periodic texture with a spatial period of 5 μm can be seen. Moreover, inside the trenches a finer structure consisting of LIPSS oriented parallel to the main texture can be observed.

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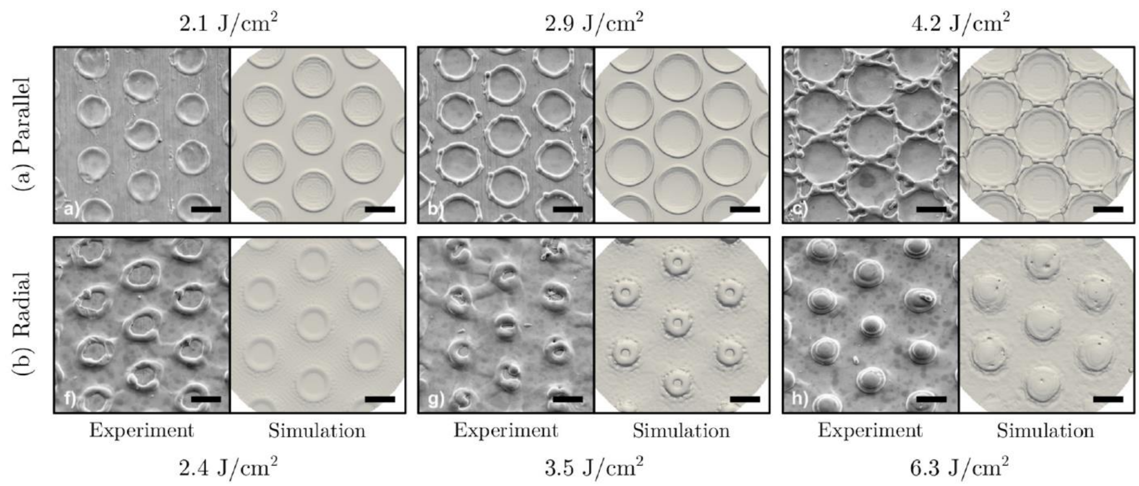
German Academic Exchange Service

Deutscher Akademischer Austauschdienst
German Academic Exchange Service

## Numerical simulation of periodic surface structures created by direct laser interference patterning

Funding agency: TU Dresden (Intern)
Period: 06/2022 – 12/2022
Project partners: TU Dresden, TU Freiberg
Project manager: Dr. Martin Heinrich, Dr. Bogdan Voisiat

A numerical model was developed for resolving the physical effects during formation of periodic structures using three-beam interference patterning using ns-pulsed laser sources. The three-dimensional, compressible computational fluid dynamics model considers the gas, liquid, and solid material phase and includes various physical effects, such as heating due to the laser beam for both parallel and radial polarization vector orientations, melting, solidification, and evaporation, Marangoni convection, and volumetric expansion. The numerical results reveal a very good qualitatively and quantitatively agreement with experimental reference data. Resolidified surface structures match both in overall shape as well as crater diameter and height, respectively. Furthermore, this model gives valuable insight on different quantities during the formation of these surface structures, such as velocity and temperature. As it can be seen in the figure, the numerical results show a very good agreement with the experiments, both in terms of resolidified surface structures, their position, and size. The transition from individual craters to merged hexagonal structures is predicted correctly for the parallel polarization vector orientation as well as the formation of smaller craters with increasing laser fluence and, finally, the accumulation of large quantities of molten material at radial polarization vector orientation. The model gives also the ability to resolve how these surface structureswere created due to different effects acting on the molten material.



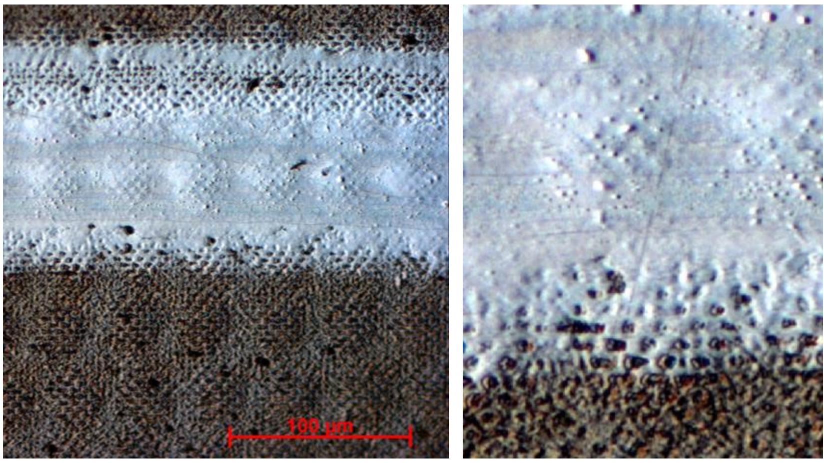

Experimental and numerically simulated three-dimensional surface structures for (a) parallel and (b) radial polarization orientations for different laser fluences.

Sponsored by:
TU Dresden

## Tribologically induced interfacial and structural change processes in dry lubrication systems under defined atmospheres (TRIGUS)

| | |
|---|---|
| Funding agency: | Deutsche Forschungsgemeinschaft |
| Period: | 04/2019 – 1/2024 |
| Project partners: | LMO, TU Dresden |
| Project manager: | Lars Lorenz |

Vacuum conditions present several challenges to tribological contacts. The absence of gases like oxygen, nitrogen and water prevents passivation of nascent surfaces. Low pressure promotes fast evaporation of conventional liquid lubricants and furthermore would contaminate technical vacua. Therefore, surfaces that need to endure friction in vacuum condition must have self-lubricating and self-passivating properties. Although coatings made from molybdenum disulfide ($MoS_2$), which belongs to the group of transition metal dichalcogenides (TMD), are state of the art for vacuum applications, they have several drawbacks, such as their soft nature resulting in high wear as well as their high sensitivity to moisture. However, in vacuum conditions, $MoS_2$ can achieve very low friction by sliding on crystalline atomic smooth layers, and even achieve superlubricity. Furthermore, a simple bilayer coating approach of $MoS_2$ on top of a ta-C coating was found to have improved wear life in humid and vacuum conditions due to the underlaying hard ta-C coating. Additionally, patterning a surface is another strategy for improving the material's tribological properties by reducing the contact area and promoting traps for wear debris. Motivated by the emergence of new industrial-scale processes for high-throughput surface structuring and advanced coating technologies capable of depositing ta-C and $MoS_2$ films in one process, this project focuses on exploring the interaction of ta-C/$MoS_2$ multilayer coatings on structured steel surfaces aiming to improve friction and wear performance in vacuum sliding.




Optical microscopy image of a steel/DLIP/ta-C/$MoS_2$ surface after 67 minutes of sliding. DLIP reversed structure can be clearly seen in the middle of the wear track.

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## 6. Other activities

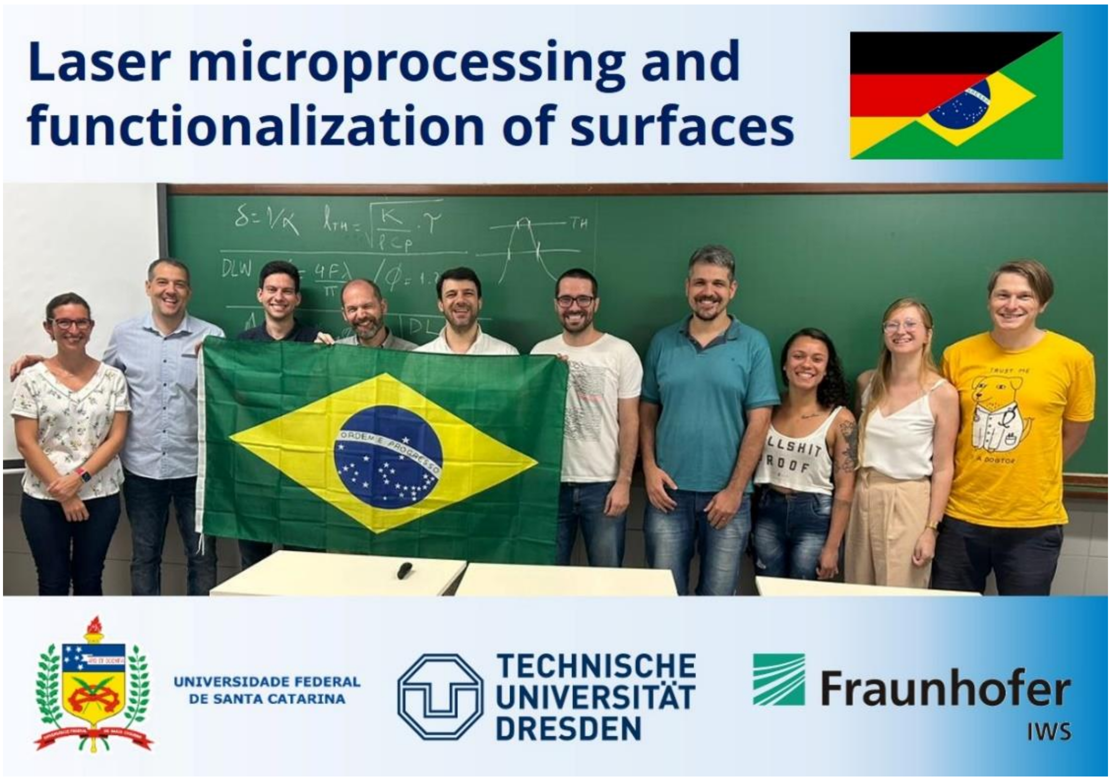
### 11th and 12th International Summer School on “Trends and new developments in laser technology”

In cooperation with the Fraunhofer Institute for Material and Beam Technology (IWS) in Dresden, the Chair of Laser-based Manufacturing held a four-day international summer school in August 29 – September 2, 2022 and in August 28 – September 1, 2023. International PhD students could intensively learn about the basics and applications of laser technology and discuss the latest developments.
The main program consisted of lectures by laser experts and practical training in the laboratories of Fraunhofer IWS. Some of the topics covered by the summer school were surface hardening, high-speed 2D laser cutting, laser welding, additive manufacturing processes and applications of ultra short-pulsed lasers between others.
The exchange of ideas was further promoted by presentations of participants. With its extensive technical equipment, the Fraunhofer IWS Dresden offered excellent conditions for the participants.

Participants from all over the world joined the virtual Summer school, for example from Poland, Canada, Argentina, UK and Italy. Besides the professional exchange, the students had an excellent opportunity for networking. The summer school will be offered again in 2024.

### International Workshop on “Laser microprocessing and functionalization of surfaces “

In cooperation between the TU Dresden and the Universidade Federal de Santa Catarina, the second international course on "Laser Micromachining and Surface Functionalization" took place in September 2023. About 20 students and PhD students from Germany and Brazil participated in the event. The program consisted of lectures by laser experts and practical exercises to introduce the participants to the fundamentals and applications of laser-based technologies. All students who performed the final oral examination at the last day of the course received a certificate of participation, which is recognized as a course credit and as a qualification for PhD programs.




## Symposium-coordinator at EUROMAT, September 2023 (Frankfurt)

In September 2023, Prof. Lasagni coordinated the symposium “Laser-based processing and manufacturing“. EUROMAT is the premier international congress in the field of materials science and technology in Europe.

## Symposium and topic coordinator at MSE, September 2022, Darmstadt, Germany

In September 2022 Prof. Lasagni coordinated the topic F: "Functional Materials, Surfaces and Devices" at the Material Science and Engineering Congress (MSE) in Darmstadt. He also coordinated a Symposium related to “Photonic technologies for surface processing.

## CLASCO Project Kick-off meeting in Dresden

On 18 April, the CLASCO consortium held its first on-site meeting in Dresden, Germany. How can the consortium be even better connected? What are the next important steps? Are there still unseen opportunities for collaboration? Important questions to discuss face-to-face. Thanks to all institutions and companies for participation! ABCircular, Airbus Defence, CATEC, DePuy Synthes Companies, CT-Ingenieros, Deutsche Gesellschaft für Materialkunde e.V., New Infrared Technologies, Plasmo, Steinbeis-Europa-Zentrum, SurFunction, SYLAS, TU Dresden, Z-Prime. And special thanks to TU Dresden for event hosting. In total, 15 (!) countries (Argentina, China, Lithuania, Austria, Portugal, UK, Australia, Colombia, Germany, Iran, Spain, France, Switzerland, Italy, Greece) attended.


## Member of the scientific committee at the Laser-based Micro- and Nano-Processing IX Conference at Photonics West 2022 and 2023 in San Francisco, USA

In February 2022 and 2023, Prof. Lasagni participated as a member of the committee at the "Laser-based Micro- and Nano-Processing IX" conference. The conference was held in San Francisco (USA) and focused on the development of different areas of laser technology.

These include laser-based micro- and nanostructuring, direct laser writing and surface modifications.

## Chair of the "Laser Precision Microfabrication 2022" conference and Member of the scientific committee at the "Laser Precision Microfabrication" conference

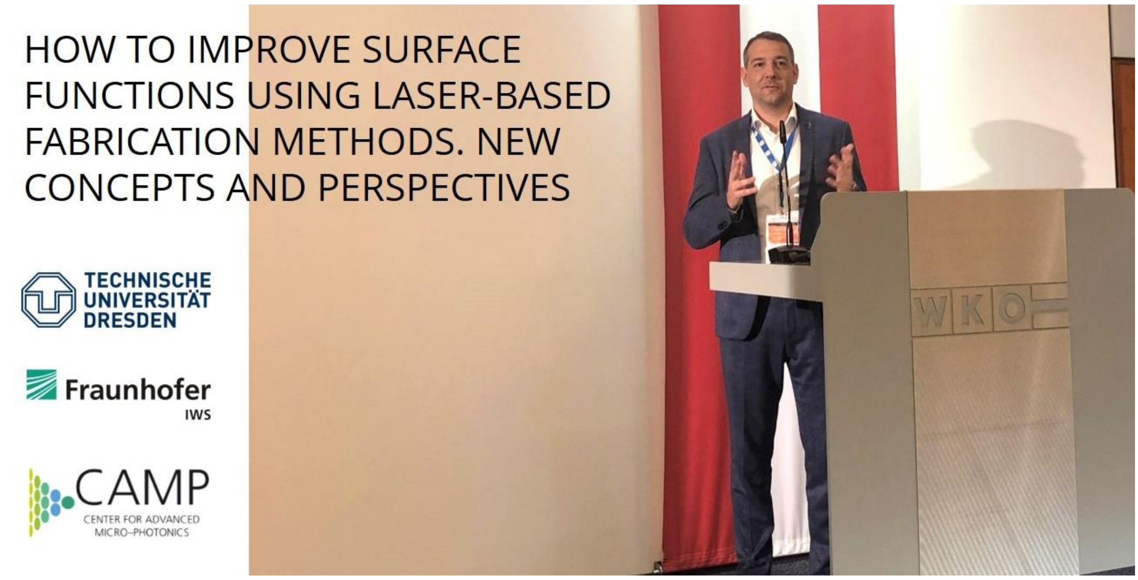
In 2022, Prof. Lasagni was conference chair of "Laser Precision Microfabrication 2022" congress, that was hold in Dresden, Germany. He also participated actively at other committees of the conference, such as the program and steering committees.


## Member of the scientific committee at the Laser Microprocessing Conference at ICALEO, USA

The International Congress on Applications of Lasers & Electro-Optics (ICALEO®) has a 39-year history as a conference where researchers and end users meet to discuss the state of the art and future developments within laser materials processing, laser micro- and nano-processing. In October 2022 and 2023, Prof. Lasagni was a member of the scientific committee of the Laser Macro and Microprocessing Conferences. The subject of the conference is the research of applications, processes and beam sources in laser material processing.

## Plenary talk CICMT 2022

Prof. Lasagni gave a plenary talk at the Ceramic Interconnect and Ceramic Microsystems Technologies (CICMT 2022) conference, in Vienna (Austria), entitled:" How to Improve Surface Functions Using Laser-Based Fabrication Methods". Other plenary speakers were Christophe Moser (from Institut für Elektro- und Mikrotechnik, EPFL) and Martin Letz (SCHOTT AG Mainz).




## CAMP Workshop in Bautzen

In 2023, the first CAMP workshop was performed. The event consisted in a two days workshop, where all PhD students associated in CAMP discussed about their own research, getting insides about different topics related to laser technology.

## Member of the scientific committee at the "Laser Precision Microfabrication 2024" conference

In 2023, Prof. Lasagni participated as a member of the committee at the "Laser Precision Microfabrication" conference (LPM). The theme of the conference was research into applications, processes and beam sources for laser materials micromachining and was held in Japan.

## Member of the scientific committee at the "Lasers in Manufacturing (LiM 2023)" conference, in Munich, Germany

In June 2023, Prof. Lasagni attended the "Lasers in Manufacturing (LiM 2023)" conference as a member of the committee. The LiM focuses on the latest developments and future trends in the field of laser material processing. The conference topics are addressed to all who are interested in the potential of lasers in manufacturing, theory and application.

## 7. Prizes and awards

### Prof. Andrés Lasagni elected member of ACATECH

Durung annual meeting of the National Academy of Science and Engineering (acatech) in 2023, Andrés Lasagni, was elected as a new member of the Academy. Acatech unites more than 600 individuals from science and industry as the national academy and voice of engineering in Germany and on an international level. The members of acatech are admitted to the Academy on the basis of their scientific achievements and reputation. They come from the fields of engineering and sciences, medicine, and humanities and social sciences. Acatech regularly publishes position papers, studies, discussions and more on topics relevant to society and the economy, and also advises the government on policy issues for the future.

### Cover page in Materials Journal (Vol. 15/2022)

The article “Utilizing a Diffractive Focus Beam Shaper to Enhance Pattern Uniformity and Process Throughput during Direct Laser Interference Patterning” was awarded with the title page of the international journal "Materials" (from MDPI). The cover page shows how diffractive fundamental beam-mode shaper (FBS) can be combined with a DLIP optical setup to generate a square-shaped top-hat intensity distribution in the interference volume.


Further information in:
https://doi.org/10.3390/ma15020591

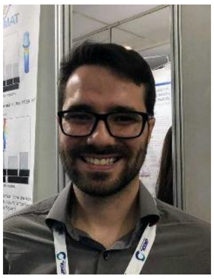
## Best young scientist presentation at LPM 2022 conference

**Fabian Ränke**, from TU Dresden, received the best young scientist presentation - **1st place** - at the 23rd International Symposium on Laser Precision Microfabrication (LPM2022). In addition, **Frederic Schell**, from Fraunhofer IWS received also the **3rd place** award.
For more than two decades, LPM has been one of the most important international conferences in the field of laser material micro processing.

## 8. International cooperation

Prof. Dr. Bruno Henriques
Mechanical Engineering Department, Universidade Federal de Santa Catarina, Brazil
Location: IF, TU Dresden
Duration: from 11/2019 to 06/2022
Program: Alexander von Humboldt Foundation / DAAD-CAPES

Hermann Heffner
Instituto de Química del Sur, Universidad Nacional del Sur, Bahía Blanca, Argentina.
Location: IF, TU Dresden
Duration: from 04/2021 to 02/2023
Program: sandwich DAAD scholarship for PhD students



Fabris Douglas
Universidade Federal de Santa Catarina, Florianopolis, Brazil
Location: IF, TU Dresden
Duration: from 11/2021 to 04/2022
Program: sandwich DAAD scholarship for PhD students

Josefina Dib
Instituto de Física Rosario, IFIR - CCT Rosario – CONICET Rosario, Argentina
Location: IF, TU Dresden
Duration: from 12/2022 to 05/2023
Program: MinCyT scholarship, Argentina

Agustín Esteban Gotte
Universidad Tecnológica Nacional – Regional Paraná, Paraná, Entre Ríos, Argentina
Location: IF, TU Dresden
Duration: from 09/2022 to 10/2022
Program: TUD

Emma Antonia Cuello
Depto. de Química - Universidad Nacional de Río Cuarto, Río Cuarto, Argentina
Location: IF, TU Dresden
Duration: from 05/2022 to 09/2022
Program: DAAD

# 9. Completed thesis

## 9.1 PhD theses

### Florian Kuisat (2022):

### Functionalization of Additively Manufactured Components using Laser-based Techniques

Additive Manufacturing (AM) processes are increasingly crucial for industrial applications, offering advantages over conventional methods. Despite enabling the layer-by-layer fabrication of complex 3D objects from Computer-Aided Design (CAD) models, AM faces limitations in the aerospace industry due to inherent surface roughness. This issue directly affects the mechanical performance of AM components. Consequently, improving the surface finish becomes a critical challenge to meet industry standards. Micro- and nano-scale surface features offer the potential to design novel materials with specific properties, enhancing functionalities like water repellency and antibacterial surfaces. However, a significant knowledge gap exists in the fabrication of specific patterns on rough additively manufactured surfaces. This Ph.D. thesis is dedicated to addressing these challenges by focusing on the enhancement of AM component surfaces using laser radiation. The work encompasses crucial aspects such as determining achievable roughness levels, topographic properties of created surface textures, and their wetting behavior. Laser processing achieves a notable reduction in roughness values (up to 89%), resulting in water contact angles of up to 153° and superhydrophobic surface conditions.

### Björn Michelberger (2023):

### Advanced tribological characterization of surface-functionalized compression rings

The targeted refinement of surfaces through surface functionalization methods opens up a multitude of possibilities to optimize tribotechnical systems such as combustion engines in terms of energy efficiency and durability. In recent years, diamond-like carbon coatings and laser interference microstructurings have come to the forefront in this regard. The study aimed to investigate whether laser interference microstructuring can have a friction-reducing effect compared to a first compression ring with a diamond-like carbon coating without structuring. This was ultimately assessed using a single-cylinder research engine. Additionally, the added value of diamond-like carbon coatings compared to the reference system, consisting of a nitrided compression ring, a 0W-12 engine lubricant, and an arc wire-sprayed cylinder liner, was examined. The study investigated hydrogen-free amorphous carbon coatings (a-C) and tetrahedral hydrogen-free amorphous carbon coatings (ta-C) on compression rings. The Reciprocating High-Frequency Tribometer (RHT) demonstrated superior friction properties and enhanced wear resistance for both variants. Single-cylinder engine tests projected a 0.6% fuel consumption reduction for ta-C and 1% for a-C compared to nitrided rings. RHT underlined its utility for preliminary assessments. DLIP-structured a-C rings showed potential, offering up to 10% friction mean pressure advantage. The study highlights the effectiveness of microstructuring and wear-resistant coatings, indicating potential improvements in engine efficiency.

## 9.2 Master thesis / Diploma works

**Chen Lin (2022):** *Bearbeitung von keramischen Werkstoffen mit Laserstrahlung für den zahnmedizinischen Anwendungsbereich.*

**Maximilian Josef Eckl (2022):** *Entwicklung eines Fügeverfahrens zwischen Lithium-Metallfolien und einer metallischen Ableiterfolie.*

**Julius Zöllner (2022):** *Entwicklung eines Konzepts zur Scanner-Ansteuerung für dreidimensionale Bearbeitungskonturen in der Remote-Lasermaterialbearbeitung.*

**Thomas Litterst (2022):** *Untersuchung des Einflusses verschiedener Parameter des ARC-PVD-Prozesses auf das Schicht-Wachstum an Schneidkanten.*

**Christoph Fischer (2022):** *Analyse von DLIP-strukturierten Metalloberflächen mittels Scatterometrie zur Qualitätssicherung.*

**Franziska Spitz (2022):** *Untersuchung des Korrosionsverhaltens von laserfunktionalisierten Aluminiumoberflächen.*

**Vasco Berl (2022):** *Entwicklung eines Systems zur automatisierten Vermessung und Korrektur von additiv gefertigten Strukturen an Großbauteilen beim Laser-Pulver-Auftragschweißen.*

**Lukas Westecker (2022):** *Unterwasserlaserschneiden mit koaxialem Wasserstrahl in Wasserumgebung.*

**Clarita Muntschick (2023):** *Intelligente Prozesseinrichtung anhand emittierter akustischer Oberflächenwellen für die direkte Laserinterferenzstrukturierung.*

**Andreas Reichel (2023):** *Laserbasierte Methoden zur Erzeugung von Antibeschlag-Oberflächen mit erhöhten Selbstreinigungseigenschaften.*

**Dinh Phongh Doan (2023):** *Untersuchungen zum Hochleistungs-Laser-Auftragschweißen von Gleitlager-werkstoffen mittels eines neuartigen Laser-Multidraht-Auftragschweißkopfes.*

**Paul Neubauer (2023):** *Einfluss von Schichttopografie und Substratmaterial auf das Verschleißverhalten von ta-C-Schichten.*

**Raphael Kern (2023):** *2.5D Oberflächenbearbeitung von Aluminium- und Edelstahllegierungen mit einem Hochleistungs-Pikosekundenlaser zur Beeinflussung des Benetzungsverhaltens.*

**Pavani Katakamsetty (2023):** *Convolutional Neural Network-Based Detection of Surface Homogeneity in Direkt Laser Interfernce Patterning.*

**Joseph Barrios Larranaga (2023):** *Untersuchungen zum Laserstrahlschweißen mit dynamischer Strahlformung.*

**Richard Nicolay Labanda Rios (2023):** *Optimierung der Laserinterferenzstrukturierung durch Vorhersage der resultierenden Oberflächenhomogenität für Anti-Reflexions-Oberflächen.*

**Constantin Schneider (2023):** *Augmented Reality - basierte Qualitätssicherung in der Produkt- und Strukturintegration am Beispiel des BMW Werkes Leipzig.*

## 9.3 Other student reports

**Maximilian Eilert (2022):** *Direkte Laserinterferenzstrukturierung von Edelstahloberflächen mittel Linienförmigem Laserspot.*

**Marvin Uhlig (2022):** *Entwicklung eines Systems zur in-situ-Regelung des Pulvermassestroms beim Laser-Pulver-Auftragschweißen.*

**Paul Neubauer (2022):** *Einfluss von Schichttopografie und Substratmaterial auf das Verschleißverhalten von ta-C-Schichten.*

**Constantin Schneider (2022):** *Erstellung und Anwendung des CAD-Tools `Virtuelle Absicherung` zur frühzeitigen Produktintegration" am Beispiel des BMW Werkes Leipzig.*

**Joseph Barrios Larranaga (2022):** *Untersuchungen zum Laserstrahlschweißen mit dynamischer Strahlformung.*

**Franziska Spitz (2022):** *Untersuchung des Korrosionsverhaltens von laserfunktionalisierten Aluminiumoberflächen.*

**Leonard Günther (2022):** *Konstruktion, Aufbau und Inbetriebnahme einer Laseranlage zur KI-gestützten Mikromaterialbearbeitung.*

**Vincent Weimert (2022):** *Entwicklung und Analyse eines Laser-Schweißprozesses auf einem neuartigen 3D-Multiprozess-Fertigungssystem mit koaxialem Laser-Auftragschweißkopf.*

**Leonard Guenther (2023):** *Inline-Überwachung von LIPSS-strukturierten Metalloberflächen mit Hilfe der Scatterometrie zur Qualitätssicherung.*

**Yuqi Li (2023):** *Influence of process sequence in the generation of hierarchical structures using high-speed optics.*

**Otto Ritter (2023):** *Evaluierung des Einflusses von Substratgegebenheiten auf den Laserabtrag und Ableitung von Abstellmaßnahmen.*

**Nick Müller (2023):** *Prozessentwicklung mit experimenteller Bestimmung von Betriebsparametern für einen automatisierbaren Reinigungsprozess von Stackaufstellflächen einer Hochtemperatur-Elektrolyse-Anlage.*

**Mathias Merkwitz (2023):** *Entwicklung eines laserbasierten Herstellungsverfahrens für Keilzinkenverbindungen*.

# 10. Publications

## Books and book contributions

1. A. F. Lasagni, L. Mulko, M. Soldera (2023): Ultrarapid industrial large area processing using laser interference patterning methods in Ultrafast Laser Nanostructuring - The Pursuit of Extreme Scales, Springer Nature, ed. J. Bonse and R. Stoian, Germany-Great Britain, ISBN: 978-3-031-14751-7.

## Peer-reviewed journals

1. E. Pohl, M. Langer, P. Rauscher, N. Bleil, A. F. Lasagni (2023): Laser In Situ Joining as a Novel Approach for Joining Large-Scale Thermoplastic Carbon Fiber-Reinforced Polymer Aircraft Structures, Adv. Eng. Mater. 2300913.
2. A. Hariharan, P. Goldberg, F. Schell, U. Hempel, F. Striggow, M. Hantusch, M. Medina-Sánchez, A. F. Lasagni, A. Gebert (2023): Single- and Multiscale Laser Patterning of 3D Printed Biomedical Titanium Alloy: Toward an Enhanced Adhesion and Early Differentiation of Human Bone Marrow Stromal Cells, Adv. Funct. Mater. 2310607.
3. B. Henriques, D. Fabris, B. Voisiat, A. R. Boccaccini, A F Lasagni (2023), Direct Laser Interference Patterning of Zirconia Using Infra-Red Picosecond Pulsed Laser: Effect of Laser Processing Parameters on the Surface Topography and Microstructure, Adv. Funct. Mater. 2307894
4. L. G. Zschach, R. Baumann, F. Soldera, C. M. Méndez, S. Apelt, U. Bergmann, A. F. Lasagni (2023): On the Corrosion Properties of Aluminum 2024 Laser-Textured Surfaces with Superhydrophilic and Superhydrophobic Wettability States, Adv. Mater. Interfaces, 2300607.
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9. L. Olawsky, S. Moghtaderifard, C. Kuhn, A. F. Lasagni (2023): Online process monitoring of direct laser interference patterning using an infrared camera system, Materials Letters 350, 134914.
10. B. Henriques, A. F. Lasagni (2023): Structuring surfaces at the speed of light, Biomedical Materials & Devices, https://doi.org/10.1007/s44174-023-00111-x
11. H. Heffner, M. Soldera, A.F. Lasagni (2023): Optoelectronic performance of indium tin oxide thin films structured by sub picosecond direct laser interference patterning, Scientific Reports, 13, 9798.
12. N. Sahoo, O. Carvalho, M. Ozcan, F. Silva, J. C.M. Souza, A. F. Lasagni, B. Henriques (2023): Ultrashort pulse laser patterning of zirconia (3Y-TZP) for enhanced adhesion to resin-matrix cements used in dentistry: An integrative review, Journal of the mechanical behavior of biomedical materials, 143, 105943.
13. P. Goldberg, A. Hariharan, F. Schell, M. Hantusch, M. O. Cichocka, N. Pérez, A. Voß, L. Giebeler, V. Hoffmann, C. Zwahr, A. F. Lasagni, A. Gebert (2023): Fine-tuning effect of Direct Laser Interference Patterning on the surface states and the corrosion behavior of a biomedical additively manufactured beta Ti alloy, Corrosion Science, 219, 111230.

14. L. Krause, K. Skibińska, H. Rox, R. Baumann, M. M. Marzec, X. Yang, G. Mutschke, P. Zabiński, A. F. Lasagni, K. Eckert (2023): Hydrogen Bubble Size Distribution on Nanostructured Ni Surfaces, ACS Applied Materials & Interfaces, 15, 14.
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19. N. Schröder, C. Fischer, M. Soldera, B. Voisiat, A. F. Lasagni (2023): Diffraction-Based Strategy for Monitoring Topographical Features Fabricated by Direct Laser Interference Patterning, Advanced Engineering Materials, 2201889.
20. K. Deng, Q. Zhang, Y. Fu, A. F. Lasagni, H. Reith, K. Nielsch (2023): A Novel PowderMEMS Technique for Fabrication of Low-Cost High-Power-Factor Thermoelectric Films and Micro-Patterns, Advanced Engineering Materials, 2201546.
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22. M. Heinrich, B. Voisiat, A. F. Lasagni, R. Schwarze (2023): Numerical simulation of periodic surface structures created by direct laser interference patterning, PLoS ONE 18(2), e0282266.
23. H. Heffner, M. Soldera, F. Ränke, A. F. Lasagni (2023): Surface Modification of Fluorine-Doped Tin Oxide ThinFilms Using Femtosecond Direct Laser InterferencePatterning, Adv. Eng. Mater. 2201810
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26. C. Zwahr, N. Serey, L. Nitschke, C. Bischoff, U. Rädel, A. Meyer, P. Zhu, W Pfleging (2023): Targeting new ways for large-scale, high-speed surface functionalization using direct laser interference patterning in a roll-to-roll process, Int. J. Extrem. Manuf, 5, 035006
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## Presentations/Conference contributions

1. A. F. Lasagni, Advanced Surface Functionalization using laser-based processes, 3rd International Symposium on Biomedical Materials and Devices, November 2023, Florianopolis, Brazil (invited keynote).
2. A. F. Lasagni, M. Soldera, N. Schröder, T. Steege, C. Muntschick, S. Moghtaderifard, L. Olawsky, C. Kuhn, G. Vergara, C. Zwahr, Sensing Sound and Light for Monitoring Laser Microfabrication Processes, International conference on Lasers and Electro-Optics (ICALEO), October 2023, Chicago, USA (invited)
3. A.F. Lasagni, How to enhance the functionalities of surfaces using laser-based manufacturing methods, Surface Ventures, on-line (invited).
4. A.F. Lasagni, Large area functionalisation of surfaces using Direct Laser Interference Patterning, new approaches and perspectives, Industrial Laser Application Symposium (ILAS 2023), Deventry, UK (plenary talk).
5. A.F. Lasagni, Introduction to laser beam shaping: new trends and developments, Beam Shaping – New solutions for laser material processing workshop, Fraunhofer IWS, March 2023, Dresden, Germany (invited).
6. B. Henriques, B. Voisiat, D. Fabris, A.F. Lasagni, Fabrication of mulri-scale periodic line-like structures on different implant materials using a two-beam interference setup equipped with a picosecond laser source, 27th International Congress of Mechanical Engineering (COBEM 2023), December 2023, Florianopolis, Brazil.
7. D. Fabris, A.F. Lasagni, M.C. Fredel, B. Henriques, Direct Laser Interference Patterning of Ce-TZP-based nanocomposite using nanosecond and picosecond pulsed lasers, 27th International Congress of Mechanical Engineering (COBEM 2023), December 2023, Florianopolis, Brazil.

8. L. G. Zschach, R. Baumann, F. Soldera, C. Méndez, S. Apelt, U. Bergmann, A. F. Lasagni, Estructuración láser como barrera frente a la corrosion, V. Simposio Científico RCAA, November 2023, Berlin, Germany.
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10. F. Ränke, R. Baumann, B. Voisiat, M. Soldera, A. F. Lasagni, High-speed laser surface texturing by combining direct laser interference patterning with polygon scanner technology, 13th Mittweidaer Lasertagung, November 2023, Mittweida, Germany.
11. D. Fabris, M. C. Fredel, L. Gremillard, A. F. Lasagni, B. Henriques, Direct Laser Interference Patterning of Zirconia for Biomedical Applications, 3rd International Symposium on Biomedical Materials and Devices, November 2023, Florianopolis, Brazil.
12. R. Baumann, F. Ränke, B. Voisat, T. Rauscher, C. Bernäcker, C. Zwahr, L. Röntzsch, M. Soldera, T. Weißgärber, A. F. Lasagni, Laser Microstructuring for Improved Electrochemical Performance of 2D and 3D Electrodes, 3rd International Symposium on Biomedical Materials and Devices, November 2023, Florianopolis, Brazil.
13. L. G. Zschach, F. Spitz, R. Baumann, F. Soldera, C. Méndez, S. Apelt, U. Bergmann, A.F. Lasagni, Influencing the corrosion behavior of metal surfaces thought laser processing, 3rd International Symposium on Biomedical Materials and Devices, November 2023, Florianopolis, Brazil.
14. M. Soldera, F. Bouchard, Y. Fu, A. F. Lasagni, Water and Oil Wettability Customization by Tailoring Micro-Structured Polymers, International conference on Lasers and Electro-Optics (ICALEO), October 2023, Chicago, USA.
15. F. Härtwig, S. Makowski, L. Lorenz, R. Baumann, M. Soldera, A. F. Lasagni1, F. Kaulfuß, V. Weihnacht (2023): Improved Tribological Vacuum and Dry Air Performance of ta-C Coatings Modified with Different Process Strategies, 9th International Tribology Conference, September 2023, Fukuoka, Japan.
16. J. Langeheinecke, S. Tutunjian, M. Soldera, A.F. Lasagni (2023): Machine learning-based near real-time process monitoring method for nanosecond pulsed laser functionalization of aluminum surfaces, EUROMAT 2023, September 2023, Frankfurt, Germany.
17. A.F. Lasagni, N. Schröder, T. Steege, M. Soldera, B. Voisiat, C. Zwahr (2023): Monitoring approaches in Laser-based microprocessing, EUROMAT 2023, September 2023, Frankfurt, Germany.
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19. M. Seiler, A. Barz, J. Bliedtner, A.F. Lasagni (2023): Laser-based selective activation for metallization of PBT, EUROMAT 2023, September 2023, Frankfurt, Germany.
20. S. Moghtaderifard, L. Olawsky, F. Ränke, R. Baumann, M. Soldera, C. Kuhn, A.F. Lasagni (2023): Effect of surface roughness on direct laser interference patterning ablation, EUROMAT 2023, September 2023, Frankfurt, Germany.
21. H. Heffner, J. Brunner, A.F. Lasagni, Y. Vaynzof, Y (2023): Dot-like Periodic Patterning of Fluorine-doped Tin Oxide (FTO) Thin Films using Direct Laser Interference Patterning (DLIP) for Photovoltaic Applications, EUROMAT 2023, September 2023, Frankfurt, Germany.
22. T. Wu, B. Voisiat, M. Soldera, A.F. Lasagni (2023): Fabrication of gradual periodic patterns on stainless steel using Direct Laser Interference Patterning, EUROMAT 2023, September 2023, Frankfurt, Germany.

23. D. Obergfell, B. Azarhoushang, A.F. Lasagni (2023): Investigation of Ablation Efficiency of Stainless Steel Using Pulsed Lasers in Burst Mode, EUROMAT 2023, September 2023, Frankfurt, Germany.
24. N. Schröder, F. Nyenhuis, R. Baumann, L. Mulko, T. Kiedrowski, J.A. L'huillier, A.F. Lasagni (2023): Heating influence on the structuring mechanism of hierarchical surface structures fabricated on stainless steel by direct laser interference patterning, EUROMAT 2023, September 2023, Frankfurt, Germany.
25. M. Soldera, F. Bouchard, A.F. Lasagni (2023): Hierarchically micropatterned polymer foils fabricated by laser-texturing and hot embossing for applications as optical diffusers, EUROMAT 2023, September 2023, Frankfurt, Germany.
26. S. Moghtaderifard, L. Olawsky, M. Soldera, F. Ränke, C. Kuhn, A.F. Lasagni (2023): Influence of laser hardening on microstructures using direct laser interference patterning method, EUROMAT 2023, September 2023, Frankfurt, Germany.
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62. A.F. Lasagni, How to improve surface functions using laser-based fabrication methods; new concepts and perspectives, Ceramic Interconnect and Ceramic Microsystems Technologies, July 2022, Vienna, Austria (plenary talk).
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