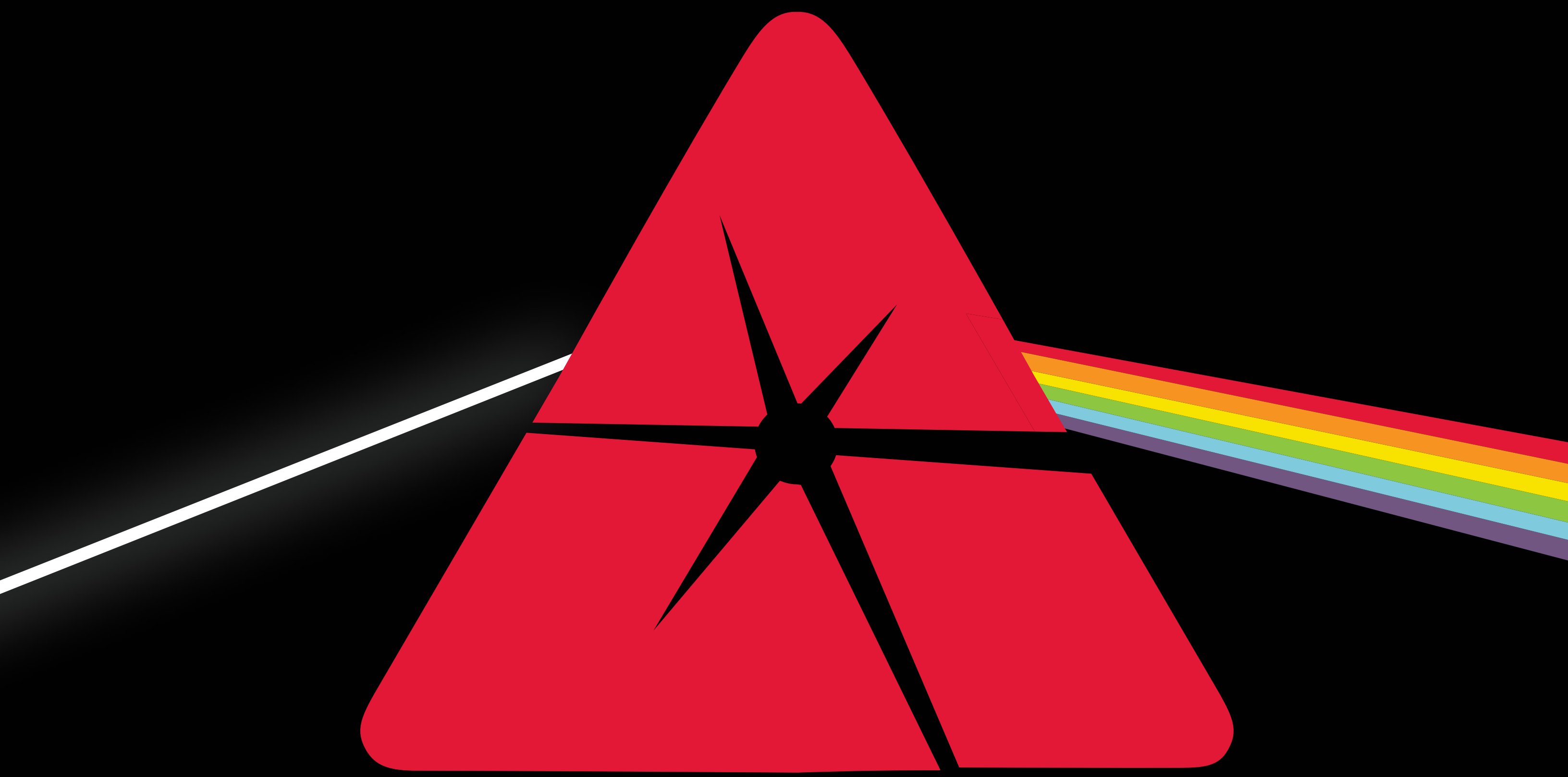
LIA TODAY

Special Edition



ICALEO®

37th INTERNATIONAL CONGRESS ON
APPLICATIONS OF LASERS & ELECTRO-OPTICS

LIA™ | 50 YEARS 1968–2018

LIA TODAY

THE ICALEO 2018 SPECIAL EDITION

This special edition of *LIA TODAY* is your sneak peek into the International Congress on Applications of Lasers & Electro-Optics (ICALEO®), the world's premiere source of technical information in the field.

ICALEO 2017 Articles:

As we look forward to ICALEO 2018, we also look back on ICALEO in years past. David Belforte reflects on the International Laser Processing Conference that preceded the first ever ICALEO, and we take a look at the original announcements from 1981 and 1982. Finally, enjoy select articles from ICALEO 2017, and don't forget to register for 2018!

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Laser Microprocessing Conference (LMF)

SUPERHYDROPHOBIC AND SUPERHYDROPHILIC FUNCTIONALIZATION OF ENGINEERING SURFACES BY LASER TEXTURING

By Suwas Nikumb, Peter Serles, Evgueni Bordatchev

Stainless steel and silicon carbide surfaces were textured in the pursuit of superhydrophobic and superhydrophilic surfaces respectively. The surfaces were created by a picosecond laser texturing in combination with a chemical aging process as dictated by the Cassie-Baxter state. Upon completion of laser texturing, initially the contact angle was decreased to an average value of 70°. However, following a 14-day aging period, the surface reached chemical equilibrium with varied wettability depending on the environment. Read More.

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Laser Materials Processing Conference (LMP)

DESIGN GUIDELINES FOR LASER METAL DEPOSITION OF LIGHTWEIGHT STRUCTURES

By Ake Ewald and Joseph Schlattmann

The additive manufacturing technology laser metal deposition (LMD) serves a high degree of freedom. For an effective industrial application, it is necessary to identify all advantages and disadvantages. A lowering of the introduction barrier can be achieved with design guidelines helping the engineer early in the product development. While LMD is an additive manufacturing process like selective laser melting (SLM), existing manufacturing guidelines cannot be simply adopted. Due to the complex process constraints, a specific design guideline for LMD has been established. Read More.

FOLLOW US!

2018 CONFERENCE CHAIRS

Congress General Chair

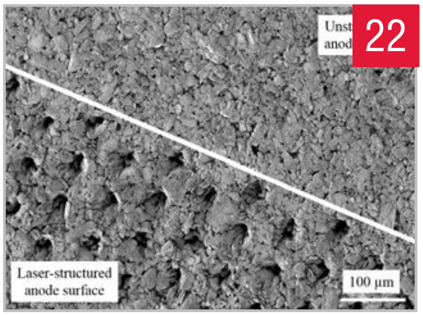
Christoph Leyens
Fraunhofer IWS

Laser Materials Processing

Klaus Kleine
Coherent Inc.

Friedhelm Dorsch
TRUMPF Laser Systems

IN THIS ISSUE:



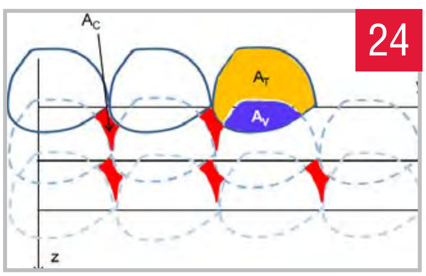
22

Nanomanufacturing Conference (NANO)

FEMTOSECOND LASER STRUCTURING OF GRAPHITE ANODES FOR IMPROVED LITHIUM-ION BATTERIES

By Jan Habedank

Laser structuring of electrodes is a promising approach to enhance the high current capability of lithium-ion batteries by reducing cell internal resistance, as a larger contact area of the active material with the electrolyte solution is created. This is of particular importance for power intensive applications such as automotive use. The electrodes typically consist of microporous coatings comprising active material, binder, and conductive additives which are applied onto metallic current collector foils. In this work, lithium-ion battery anodes were structured by locally ablating small fractions of the coating using femtosecond laser pulses with infrared wavelengths. A guideline is presented which supports potential users in process design and parameter selection. Read More.



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Laser Materials Processing Conference (LMF)

ENERGY EFFICIENCY CONTRIBUTIONS AND LOSSES DURING SLM

By Pragya Mishra

Selective Laser Melting technique, SLM, requires remelting of adjacent tracks to avoid cavities and other imperfections. Usually very conservative process parameters are chosen to avoid imperfections, resulting in a low building rate. The process efficiency relates the energy required for the generation of a new track to the laser beam power. For SLM this efficiency is determined by the process parameters, particularly hatch distance, layer depth and scanning speed, independent of the resulting process mechanisms. . Apart from beam reflection losses of typically 50-60%, significant energy losses result from the remelting of surrounding layers. Further losses originate inevitably from substrate heating. A simplified mathematical model of the track cross section and the corresponding layer overlap geometry has been developed, to analyze the different loss contributions from remelting with respect to the process parameters. The model explains why increasing the hatch distance or the layer depth proportionally increases the process efficiency. However, these increases are limited by cavity formation. Read More.

Laser Microprocessing

Eric Mottay
Amplitude

Robert Braunschweig
LASEA, Inc.

Nanomanufacturing

Yongfeng Lu
Univ. of Nebraska-Lincoln

Business Forum & Panel Discussion

Klaus Loeffler
TRUMPF Laser Systems

Bo Gu
BOS Photonics

ICALEO Agenda*

OCTOBER 14 - 18, 2018

SUNDAY, OCTOBER 14

1:00pm ICALEO Registration Desk Open
4:00pm Welcome Celebration

MONDAY, OCTOBER 15

6:00am LIA Laser Running Club
7:00am ICALEO Registration Desk Open
7:30am Appreciation Breakfast
ICALEO/Rosen Guest Exclusive Breakfast Lounge Open
9:00am Opening Plenary Session
10:10am Morning Break
Lunch on own
1:30pm LMP 1: Sub Plenary
LMF 1: Joint Sub Plenary with Nanomanufacturing
Poster Presentation Gallery Open
3:00pm Afternoon Break
3:30pm LMP 2: Cu- and Al-Welding I
LMP 3: 3D Metal Printing (SLM) I
LMP 5: Welding: Process Control and Monitoring by OCT
LMF 2: Surface Functionalization
Nano 1: Nano Sensing and Characterization
5:00pm President's Reception

TUESDAY, OCTOBER 16

6:00am LIA Laser Running Club
7:30am ICALEO Registration Desk Open
ICALEO/Rosen Guest Exclusive Breakfast Lounge Open
8:00am LMP 6: 3D Metal Printing (SLM) II
LMF 3: Surface Texturing
Nano 2: Fs Laser Processing and Fabrications
Business Forum and Panel Discussion
8:10am LMP 4: Cu- and Al-Welding II
9:20am New Technology Presentations & Panel Discussions
10:10am Morning Break
Lunch on own
1:00pm Laser Industry Exhibitor Showcase
1:30pm LMP 7: Welding
LMP 8: Laser Metal Deposition I
LMF 4: Advanced High Power Microprocessing
Flash Poster Session
4:00pm Vendor Reception & Tabletop Display

WEDNESDAY, OCTOBER 17

6:00am LIA Laser Running Club
7:30am ICALEO Registration Desk Open
ICALEO/Rosen Guest Exclusive Breakfast Lounge Open
8:30am LMP 9: Welding and Brazing
LMP 10: 3D Metal Printing (SLM) III
LMF 6: High Speed Microprocessing
Nano 3: Laser Processing of Battery Materials I
10:10am LMP 11: Lightweight Materials (CFRP)
LMP 12: Laser Metal Deposition II
LMF 5: Special Session: Advanced Laser Technologies for Microelectronics and IC Fabrication
LMF 7: Hard and Dielectric Material Processing
Nano 4: Laser Processing of Battery Materials II
1:30pm LMP 13: Cutting
LMP 14: Laser Metal Deposition III
LMF 8: Beam Shaping
Nano 5: Synthesis and Diagnostics of 2D Materials
2:50pm Poster Gallery Q & A with Authors
5:00pm **LIA Annual Meeting & Awards Gala**

THURSDAY, OCTOBER 18

7:30am ICALEO Registration Desk Open
ICALEO/Rosen Guest Exclusive Breakfast Lounge Open
8:30am LMP 15: Thick Metal and Hybrid Welding
LMP 16: Laser Metal Deposition IV
LMF 9: Biomedical Applications
Nano 6: Fs Laser Nanostructuring
10:10am Morning Break
10:40am LMP 17: Emerging Technologies
LMP 18: Surface Treatment
LMF 10: Micro-joining
Nano 7: Advanced Approaches in Nanoscience and Engineering
Lunch on own
1:30pm Closing Plenary Session
3:30pm Farewell Break and Ice Cream Social

**Program subject to minor changes*

President's Message

As I write this message it is only four weeks until ICALEO 2018, so if you have not registered yet I urge you to do so as soon as possible as this is shaping up to be one of our best ICALEOs. This is especially significant, as we'll also be formally celebrating the 50th year of LIA and laser technology and applications that are the cornerstone of much of what we do as a laser community.

Returning to ICALEO, there are again three conferences: Laser Materials Processing, Laser Microprocessing, Nanomanufacturing, and a Business Forum and Panel Discussion. Christoph Leyens from Fraunhofer IWS Dresden, the General Chair of ICALEO and his conference chairs, Klaus Kleine (Coherent), Friedhelm Dorsch (TRUMPF), Eric Mottay (Amplitude Systemes), Robert Braunschwig (Lasea), Yongfeng Lu (Univ. of Nebraska-Lincoln), Klaus Loeffler (TRUMPF) and Bo Gu (Bos Photonics) have put together a very exciting program. Over 200 papers have been submitted to the ICALEO conferences; 89 of these manuscripts are now going through the second round of the peer review process. Of these submissions those that have been peer reviewed will be featured in the Journal of Laser Applications (JLA). The plenary session titled "Emerging Laser Technologies: a Path to Disruptive Businesses" will feature key industry players, developers and users of laser technology, Islam Salama (Intel Corporation), Jason Eichenholz (Luminar Technologies Inc.) and Milton Chang (Incubic Management LLC). The closing plenary session will feature Andrés Fabian Lasagni (Technical University Dresden), Youping Gao (Castheon), and Eckhard Beyer (Fraunhofer IWS). All in all, this is a great event and opportunity to learn about advances in laser technology and applications while networking with leading global researchers in the field.

Finally, I look forward to seeing and meeting many of you at the President's Reception on Monday, October 15th.

M. Brandt

Milan Brandt
President, LIA

Executive Director's Message

We are rapidly gearing up for the October 14 launch of ICALEO 2018, celebrating LIA's 50th year. The staff, operating as cross functional teams, is covering all bases to make this an outstanding and unique event. We welcome all members to attend and participate in this 50th year anniversary gala. Schawlow award winners, Fellows and past Presidents are invited to participate in panel interviews and presentations throughout the conference, to discuss recollections of LIA's development and its contributions to the international laser community. We will also have presentations discussing current and future LIA initiatives. These presentations will be grouped by decade. We also appreciate any photos you are willing to share, which will be shown throughout the evening. A new special session titled "Advanced Laser Technologies for Microelectronics and Integrated Circuit Fabrication" has been added to the Laser Microprocessing conference. The complete Advance Program for ICALEO was released in late August and is available for download.

We are excited about your participation at ICALEO 2018. Spread the word and we welcome you to Orlando.

Nat

Nat Quick, Executive Director
Laser Institute of America

2018 LIA OFFICERS

President – Milan Brandt
RMIT University

President-Elect – Minlin Zhong
Tsinghua University

Past President – Paul Denney
IPG Photonics

Secretary – Henrikki Pantsar
TRUMPF, Inc.

Treasurer – Gilbert Haas
Haas Laser Technologies, Inc.

ICALEO®

THEN &NOW

The First **ICALEO...**

was held in 1982

had **5** mini-symposia

offered **13** half-day professional advancement courses

1982 ICALEO Conference Presentations included...

- Laser cutting of steel with the revolutionary turbolaser T 1000 CO2 laser
- Laser soldering of micro-electronic chip components to printed circuit boards
- Laser material transformations: an overview
- Safety with surgical lasers
- Laser beam cutting of biological tissue
- A scanning laser microscope for in-process inspection of semiconductor wafers
- Implementation of production laser welding

2018 ICALEO Sessions Will Include...

- 3D Metal Printing
- Laser Metal Deposition
- Welding and Brazing
- Emerging Technologies
- Surface Texturing
- Beam Shaping
- Fs Laser Processing and Fabrications
- Synthesis and Diagnostics of 2D Materials
- And more!

SCHAWLOW WINNERS

1982 - 2018

1982 - Dr. Arthur Schawlow*
1983 - Dr. Arthur H. Guenther*
1984 - Dr. Kumar N. Patel
1985 - Mr. Leon Goldman*
1986 - Prof. William Bridges
1987 - Mr. Sidney Charschan*
1988 - Prof. Francis L'Esperance
1989 - Dr. Milton Chang
1990 - Mr. Herbert Dwight
1991 - Prof. Anthony Siegman
1992 - Dr. Yoshiaki Arata
1993 - Dr. James L. Hobart
1994 - Dr. Rocco Lobraico*
1995 - Mr. David Belforte
1996 - Prof. William M. Steen
1997 - Mr. Conrad Banas
1998 - Prof. Robert L. Byer
1999 - Dr. William Schwartz*
2000 - Prof. Theodor W. Hänsch
2001 - Prof. Walter W. Duley
2002 - Prof. Akira Matsunawa*
2003 - Prof. Jyotirmoy Mazumder
2004 - Dr. Helmut Hügel
2005 - Dr. David Sliney
2006 - Dr. Edward Metzbower
2007 - Dr. Marshall G. Jones
2008 - Dr. Eckhard Beyer
2009 - Dr. Valentin Gapontsev
2010 - Dr. Steven Chu
2011 - Prof. Berthold Leibinger
2012 - Prof. Isamu Miyamoto
2013 - Prof. Ursula Keller
2014 - Prof. Reinhart Poprawe
2015 - Dr. Keming Du
2016 - Prof. Yongfeng Lu
2017 - Dr. Paul Seiler
2018 - Dr. Don Scifres

*deceased

ICALEO 2017

19 countries &

200 organizations

represented

over **350**

attendees

OVER 180

presentations

Laying the Groundwork For ICALEO

THE YEAR OF THE INTERNATIONAL LASER PROCESSING CONFERENCE

BY DAVID BELFORTE

It was a bright November day in 1979 and I was on my way to a meeting at the Tokyo Hilton Hotel that would lead to a defining moment in the history of LIA.

First, a little framework is in order. Back in the day, Japan was arguably the world leader in industrial laser material processing, mainly as a result of government funding for research and development programs at leading technical universities. Metal fabricating shops in Japan had advanced laser sheet metal cutting to industry acceptability, positioning Japan as the preeminent market for this technology.

With a background in laser metal cutting, I was intrigued by this success in Japan, so in 1976, I arranged a fact-finding trip to the country to look into business opportunities for the Avco Everett Metalworking Lasers company where I was employed. This trip, arranged by the two trading companies representing my employer—Marubeni and Japan Lasers—took me on a two-week journey to most of the laser material processing hot spots in the country.

In the course of this and subsequent trips, I gained a unique view of the laser processing technology advances being made in Japan. In doing so, I met with and established relationships with most of the leading developers of laser cutting and welding technology in the country. They opened my eyes to a wealth of laser process technology that had advanced metal processing but was relatively unknown outside Japan.

With this knowledge, it occurred to me, as the 1978 LIA president, that the advances made in Japan deserved wider dissemination outside the country. I broached an idea on how to do this with Sid Charschan (Western Electric), Chairman of LIA's Material Processing committee, and the Executive Committee of the LIA Board of Directors. Out of this came LIA approval to open discussions with leading Japanese laser processing organizations with a goal of presenting an international conference on the subject.

I outlined plans for a joint conference to my company's representatives in Japan and briefed them on actions they should initiate. Shortly thereafter I received a wake-up call—the leaders of the organizations I proposed as conference partners were cautious about teaming up with LIA, and they were not receptive to partnering with each other.

I won't go into the details behind this, except to say many organizations in Japan were competing for laser processing development funding from the same government agencies, creating tense relationships. To a degree, this engendered personality clashes that closed down communications channels.

For several months, using contacts I had established in my travels, I was able to direct the LIA's conference proposition to leaders of the Japan Laser Processing Society and the Japan Society for Laser Technology, who agreed to meet in Tokyo to discuss the LIA's proposal. And that takes us to where I started this story.

My local representatives had arranged for the meeting in a corner of the Hilton's lobby, which had several couches set in a circle. The invited guests from each organization staked out seats as far from each other as possible, so I took my seat between them, where I could be a referee if necessary.

Acting as a moderator and backed by an interpreter, I attempted to assuage any strong feelings by suggesting a conciliatory idea—the conference would be a joint U.S./Japan event to be known as the first International Laser Processing Conference (ILPC). Each organization would be responsible for providing technical papers and speakers from a list of well-known authors on various aspects of the technology.

The International Laser Processing Conference (ILPC) early 80's

David Whitehouse, President of LIA presents the Honored Speaker Award to Herbert M Dwight, Jr. at the ILPC in 1981

An extensive dialogue exchange followed, and after an hour we arrived at a consensus. The ILPC was born, and it was to be held in 1981 at a convenient date and location in the U.S., with me as the General Chairman.

As the meeting drew to a close, I shook hands with each leader, setting an example that they reluctantly followed. Departing the hotel, I noticed the leaders of each group communicating with each other in an amiable fashion, even deep bowing, a sign of great respect. My local representative gave me a thumbs up and a large smile and said, “We didn’t believe you could pull this off.”

The conference was set for November 16-17, 1981, in Anaheim, California, with a program with 33 juried papers from Japan and the U.S.

The event, held at the Marriott Hotel in Anaheim, was a great success, drawing more than 150 attendees. Included was a large contingent of post-grads from Germany, who later became leaders of laser technology in that country, surpassing the technical prowess in Japan.

Later, David Whitehouse, then LIA President, disclosed that the LIA Education Committee had decided to take the ILPC model to the next level as part of the newly created International Congress on Applications of Lasers & Electro-Optics (ICALEO), a conglomeration of 5 symposia on laser applications. The first such event would be held in Boston on September 20-23, 1982. As part of the first ICALEO, an LIA Material Processing Symposium was scheduled. Organized under Chairperson Michael Bass, in cooperation with 14 organizations (two of which were the Japanese Societies that had first made their international appearance at the ILPC event the previous year), a modest 23 papers drew a small but enthusiastic audience.

Dave Whitehouse (right) receiving the President’s Award for outstanding service to the LIA, from Myron Wolbarsht (left). 1983 LIA President

Dave Belforte, chairman of the ILPC conference presents an award to Professor Dr. Y. Arata, President of the Japan Laser Processing Society

Over the years, ICALEO has become an internationally recognized laser material processing event, drawing a larger audience each year as the LIA has moved the event around the U.S. to attract an increased foreign audience. This year, the 37th ICALEO, now focused exclusively on laser material processing, will move back home to Orlando on October 14-18.

On the 50th Anniversary of the LIA, it is appropriate to look back at the beginnings of this immensely important and highly regarded ICALEO series and recall its more humble origins when a group of technically autogenous yet socially disparate Japanese laser process developers cast aside differences to join with an ambitious young society from the U.S. to plant the seeds for one of the world’s most respected international advanced laser material processing conferences. ■

David Belforte is Editor-in-Chief of Industrial Laser Solutions.

Exhibitors’ displays provide conference attendees glimpses of state-of-the-art equipment available in the laser industry (1983)

INDUSTRY GOVERNMENT LIA EDUCATION

Newsletter

NEWS AND COMMENTS FROM THE
LASER INSTITUTE OF AMERICA

VOLUME 3. NO. 2 PUBLISHED SIX TIMES A YEAR SEPTEMBER 1981

The Laser Institute of America Invites You to It's First International Laser Processing Conference

A unique international forum, focusing specifically on Laser/Material Interaction, is being jointly sponsored by the Laser Institute of America (LIA) and the Laser Institute of Japan (LIJ). The conference will be held at the Convention Center in Anaheim, CA, with headquarters at the Marriott Hotel on November 16 & 17, 1981. An outstanding group of U.S. and Japanese scientists, and engineers will review the diverse areas of laser processing from the laboratory, through to industry, and into tomorrow. Thirty-four presentations are committed by world renown experts to this all inclusive meeting devoted exclusively to laser processing.

In the United States the technical program chairman is Sidney S. Charschan, Past President of the LIA, and two eminent co-chairmen, Dr. John F. Ready of the Honeywell Corporate Technology Center, and Dr. Michael Bass of the University of California. The Japanese co-chairmen are Dr. Yoshiaki Arata, President, Japan Laser Processing Society and Professor Dr. Hiromichi Kawasumi, Chairman Japan Society for Laser Technology. All papers are invited by the program committee to carry through on the theme of Past — with review papers, Present — with current technology presentations, and Future — with a view of emerging technologies by the experts in the field.

Presentations by Drs. Ready, Arata and Bass set the tone and the standards of the conference at the Plenary Session Monday morning. The two Review Sessions (II & III) cover such diverse topics as Laser Heat Treating, Pulsed YAG Material Processing, Basic Study on Laser Welding, Laser Induced Chemistry, Electronic Material Processing with Lasers, and Laser Machining and Welding of Ceramics. Noted experts of both universities and industry will speak on these topics.

Current Technology (Sessions IV & V) subjects are described by invited speakers who represent a cross section of industrial giants such as AVCO, Toshiba, Western Electric, Nippon Electric, and the Ford Motor Co., etc. as well as other companies with specialities in the field of laser processing. The diverse material covers cutting steel products with a multikilowatt CO_2 laser, computer aided laser welding of titanium, laser marking and serializing, laser drilling of glass as well as high resolution mask repair for VLSI.

Emerging Technologies (Session VI & VII) give exciting previews of developments on the horizon. Material transformations, alloying, laser chemistry, isotope technology, and laser possibilities for VLSI devices offer vistas of things to come.

These presentations, all by noted contributors, are to be compiled in a complete set of Proceedings available in advance of the Conference to early registrants.

The registration fee of $325 will include admission to all conference sessions, a copy of the Proceedings, welcoming reception, admission to the trade exhibit, and a discount on Electro Optics/Laser 81 Conference fees. Registration fee for LIA members is reduced 10% to $295. LIA Student Members from an authorized LIA Student Chapter can attend single day sessions for $25. Registration may be accomplished by completing the registration form on the back of this page and sending the form and your check to the US/Japan Conference Committee.

Newsletter

NEWS AND COMMENTS FROM THE
LASER INSTITUTE OF AMERICA

VOLUME 4, NO. 1 | PUBLISHED SIX TIMES A YEAR | JANUARY, 1982

FIRST INTERNATIONAL CONGRESS ON APPLICATIONS OF LASERS & ELECTRO-OPTICS

September 21-23, 1982
Hynes Auditorium
Boston, MA

SCOPE OF THE MEETING

The 1st International Congress on Applications of Lasers & Electro/Optics will provide a forum for indepth symposia on each of the specified fields of applications listed below. Whereas a high level of interchange will take place in each of the symposium, the congress will be structured to permit each access to all symposia, and to promote the flow of information and ideas among the disciplines. Contributed papers are being sought for original work of recent origin or heretofore unpublished results in the R & D of applications to common use. Invited Papers on important contributions will also be presented. Descriptions of the contents of the Symposia are given below.

Materials Processing Symposium

A comprehensive Symposium will be presented covering the mechanism of laser material processing, the adaptation of these interactions to the manufacturing process and the equipment and facilities required. Research reviews will be presented and papers describing current research activities in this field are sought. The applications of laser processing such as cutting, welding, drilling and heat treating will be reviewed and reports of specific manufacturing processes will be presented. Papers describing the properties of laser materials processing hardware, and design considerations will also be presented. Papers concerning laser processing of metals, semiconductors, ceramics, plastics, and other non-metals are all a part of this Symposium.

Inspection, Measurement and Control Symposium

This Symposium will review state of the art developments employing laser-electro optic techniques for inspection, measurement and control. Individual sessions will include, but are not limited to, scanning laser microscopy, machine perception and image analysis, optical monitoring, gaging and process control. Emphasis, where possible, will be placed on state of the art developments, applications, and technological directions.

Medicine & Biology Symposium

The growing acceptance by physicians and biological field workers of laser techniques has led to great changes in the types of lasers and associated instrumentation that is needed and available. One of the largest changes is in the field of surgery where almost all the specialty branches have evolved with particular requirements and apparatus. Surgery and materials processing share a common scientific basis; however, the engineering development work and the industrial use of lasers in materials processing has largely been ignored. There are many lessons to be learned from the fields of industrial material processing for the development of new surgical uses and instrumentation. One session of this Symposium will present the background discussions for interface between material processing experts and surgeons to acquaint surgeons with solutions that are available and engineers with the surgical problems. In other areas of biological medicine similar disjunction exists between the life scientists who have problems and technical experts who have solutions. The purpose of this overall group of sessions will be to examine specific problem areas with both invited and contributed papers.

Con't. page 2

Published bi-monthly by the Business Office of the Laser Institute of America to enhance the transfer of information and education within the laser community. News contributions are solicited and will be published at the discretion of the Editor. Comments are always welcome. All views and opinions expressed in this newsletter are those of the contributors or the Editor and do not necessarily represent the views of the LIA. Information has been gathered from sources considered to be reliable; however, their accuracy cannot be guaranteed.

Con't. from page 1

Optical Communications Symposium

This Symposium will cover all aspects of optical fiber communication with both invited and contributed papers. Contributed papers will emphasize applications of the technology, with the objective of presenting a user oriented program. General topics will include optical fibers, cabling, characterization, splicing and systems. The following topics will be considered for contributed talks. In the fiber and cable field: Waveguide Materials and Design, Fabrication Techniques, Cable Design, Coupling, Splicing, Single Mode Fibers, Long Wavelength Fibers, Measurement Techniques and Quality Control Methods. In the Device Field: Semiconductor Lasers, LED's, Amplifiers, Switches, Multiplexes, Connectors and Detectors. Systems and Applications Area: Transmitters, Receivers, Data Links, Communication Networks, System Performance, Military Applications and Reliability. A minimum of seven sessions are anticipated.

Lasers and Electro Optics Symposium

This symposium addresses Laser and Electro-Optical Devices and Systems with emphasis on their applications to: 1) Ring Laser and Optical Fiber Gyroscopes; 2) Optical Recording, Data Storage, and Signal Processing; 3) Photochemistry and Spectroscopy; an 4) UV, Visible and Infrared laser technology.

Preparation of Abstract & Summary

Authors are requested to submit a fifty word abstract and a separate 500 word summary. The fifty word abstract should be on a separate page and should include the Title, the Authors name, telephone number, and address. The summaries should also contain the above information and should be no more that two pages in length including figures. Figures should be suitable for journal publication. The author's name and paper's title should appear on the top of each summary page. Abstracts and summaries which exceed these limits may be arbitrarily shortened by the Program Committee. If the paper is accepted the Summary including illustrations will be reproduced in the Congress technical Digest directly from the material presented.

Submission of Papers

All Abstracts and Summaries must be received before May 14, 1982, and should be sent to Haynes Lee, care of the LIA Business office, 5151 Monroe Street, Toledo, Ohio, 43623. Authors will be notified by June 15, 1982, whether their papers have been accepted. Notification will be sent to the authors listed first on the paper. Full papers will then be requested for submission by September 1, 1982. They will be incorporated in a published Proceedings which will be available shortly after the Congress.

Professional Advancement Courses

PAC will be presented in each field of specialization both at the fundamental and advanced levels.

Exhibits

The Congress will be held in conjunction with the Fourteenth Annual Electro Optics/Laser '82 Exposition sponsored by EOSD Magazine and The Cahners Exhibition Group.

Registration

Registration for the Congress includes admission to all Symposia sessions and exhibits as well as a copy of the Technical Digest. Admission to PAC is by a separate registration. Special rates will be available for students.

"STIMULATED EMISSIONS"

TECHNOLOGY TRANSFER INSTITUTE, in cooperation with the Manufacturing Productivity Center of the Illinois Institute of Technology Research Institute (IITRI) will head a 16 day study mission to Japan on "Laser Technology" departing from Los Angeles on February 13, 1982. Mr. F. D. Seaman, Manager of the Laser Center at IITRI is heading the mission. For more information contact Nancy Dyer, TTI Project Manager (212) 947-2648.

CLINT HARPER, at MOORPARK COLLEGE reports the LEOT program has grown to 100 freshmen students and 20 sophomores. The support from private industry and an NSF ISEP grant is much appreciated. Top salary for the one year degree graduate is $25K.

The Los Alamos Chapter of the LIA in conjunction with the Society of Applied Spectroscopy and the Los Alamos National Laboratory is co-sponsoring a one-day mini-conference entitled "TECHNIQUES IN MODERN SPECTROCHEMISTRY". The Conference of six papers plus discussion will be held in Los Alamos on February 19, 1982. For further information contact Lee Radziemski (505) 667-748 (or 7121) or Charles Apel (505) 667-5875.

Congress Organizing Committee

General Chairperson:	David R. Whitehouse Raytheon Company
Program Chairperson:	Sidney S. Charschan Western Electric Company
Professional Advancement Courses:	James T. Luxon General Motors Institute
Treasurer:	James F. Smith IBM Corporation
Publicity:	Burton Bernard General Photonics
Intersociety Liaison:	David A. Belforte AVCO — Everett

Symposium Chairpersons

Materials Processing —	Michael Bass
Medicine & Biology —	Myron L. Wolbarsht
Inspection, Measurement & Control —	Vince J. Zaleckas
Laser & Electro Optics —	Peter B. Mumola
Optical Communication —	Raymond Jaeger

Newsletter

News and Comments from The Laser Institute of America

VOLUME 4, NO. 5 PUBLISHED SIX TIMES A YEAR NOVEMBER, 1982

Banquet Highlights

LIA President Jack Aldridge presents Schawlow Medal to Arthur Schawlow, its first recipient.

Schawlow Medal and Award

Your Executive Committee and Board of Directors voted in November 1981 to establish an Arthur L. Schawlow Award to recognize distinguished contributions toward applications of lasers in science, industry, or education. The award, to be presented annually, consists of a silver medal with a rendition of Dr. Shawlow on one side, and the LIA logo and inscription on the other side. The award also includes a $1000 honorarium.

Dr. Schawlow was the first recipient of the award at the ICALEO Banquet in Boston on September 22, 1982. Dr. Schawlow is widely acclaimed for his pioneering work especially in spectroscopy, for which he shared a Nobel Prize in Physics in 1981. The award also recognizes his significant contributions to education in laser science and applications through numerous public lectures, as well as through teaching and advising a generation of undergraduate and graduate physics students. Following the award, Dr. Schawlow delivered the 1982 LIA Honored Speaker address on the subject "Laser Applications."

Sidney Charschan receives the President's Award at ICALEO '82.

President's Award

LIA President Jack Aldridge instituted a new award at the LIA Banquet on September 22, 1982. The President's Award will be awarded at the discretion of the President to recognize outstanding contributions furthering the goals of the LIA. 1982 recipient of the award is Sidney Charschan, a Past President, member of the Executive Committee, Chairman of the Financial Affairs Committee, Chairman of the Administrative Committee, and Program Chairman of ICALEO '82. Sid is also responsible for reviving the Laser History Project.

In a letter expressing appreciation for the award, Sid expressed his thanks to his wife Lillian, to Western Electric and hordes of others for the support extended to his activities, and to the President and members of the LIA who have honored him with this award

SUPERHYDROPHOBIC AND SUPERHYDROPHILIC FUNCTIONALIZATION OF ENGINEERING SURFACES BY LASER TEXTURING

BY SUWAS NIKUMB, PETER SERLES, EVGUENI BORDATCHEV

Figure 1. Water droplet on a superhydrophobic surface.

Nature is a bountiful source of inspiration to advance innovative surface functionalities, processes, and technologies for engineering materials. For example, the super-hydrophobic surface characteristic of the lotus leaf can be recreated by mimicking the microstructure and surface energy on stainless steels. This super-hydrophobic behavior, which causes water to roll off the lotus leaf while collecting dust particles, enables the self-cleaning of the leaf surface and is primarily due to the hierarchical conical structures, as well as the wax layer present on the leaf surface. A good understanding of the surface topography of the microstructures, water droplet contact angle, and surface chemical composition provides the important clues necessary for the creation of artificial super-hydrophobic or superhydrophilic surfaces and using state-of-the-art ultrafast laser ablation treatment.

Controlling the wettability of a material surface for superhydrophobic or superhydrophilic performance has been an interesting area where numerous different methods are being pursued. While many coatings and thin-films are able to achieve extremely high or low wettability, their endurance life, chemical compatibility, and large area scalability make them less attractive for manufacturing environments. Meanwhile, ultrafast pulsed lasers with several megahertz pulse repetition rates can tune the wettability of a surface without changing its chemical composition and offers higher endurance lives. This is accomplished by instant vaporization (laser ablation) of the material in specific micro-scale patterns thus creating structures that changes the way the surface topography interacts with water.

A superhydrophobic surface is characterized by its ability to repel water using structures that are akin to a bed of nails allowing the water droplet to rest only on the peaks using surface tension and therefore repel from the surface (see Fig.1). Contrarily, a superhydrophilic surface is characterized by its ability to attract and spread the water so features a series of channels that trap water and wick it away using micro-capillary forces. Such surface functionalization techniques have been developed at Canada's National Research Council for stainless steel (304 SS) and Silicon Carbide (SiC) surfaces respectively to demonstrate the effectiveness of laser texturing technology for wettability control of common engineering surfaces. Fig.2 depicts superhydrophobic performance of a bouncing water droplet at ~5° tilt on 3x3 cm^2 textured area.

Experimentally, a 10 W picosecond pulsed laser operating at 1 MHz frequency was focused to a tiny spot of 25 μm diameter. The samples were mounted on a CNC motion system equipped with argon gas protective environment. The optimization of laser structuring process included varying each of the laser parameters, e.g. power, frequency, feed rate, grid pitch, etc. and evaluating the water droplet contact angle using the standard drop-shape analysis method. For the 304 SS superhydrophobic surface, a laser beam fluence of 2.61 J/cm^2 was used to promote narrower, shallower features by material redistribution rather than complete vaporization, while the SiC superhydrophilic surface was realized using a much higher fluence of 10.7 J/cm^2 to create thicker and deeper channels for the water to impregnate. Both surfaces were machined using the five-axis CNC micromachining system to texture grid patterns, ensuring an even distribution of micro-structures.

The superhydrophobicity of 304 SS surface was highly dependent on post-processing conditions in order to tune the wettability. Specifically, the chemical nature of the surface was reactive for 14 days after laser processing due to high-power interaction with the material which excites the chemical state. The samples were thus stored in different environments and exhibited vastly different contact angles. Most notably, the sample which was submerged in deionized water showed hydrophilic tendencies while the sample kept in extremely dry (<8% relative humidity) air was highly

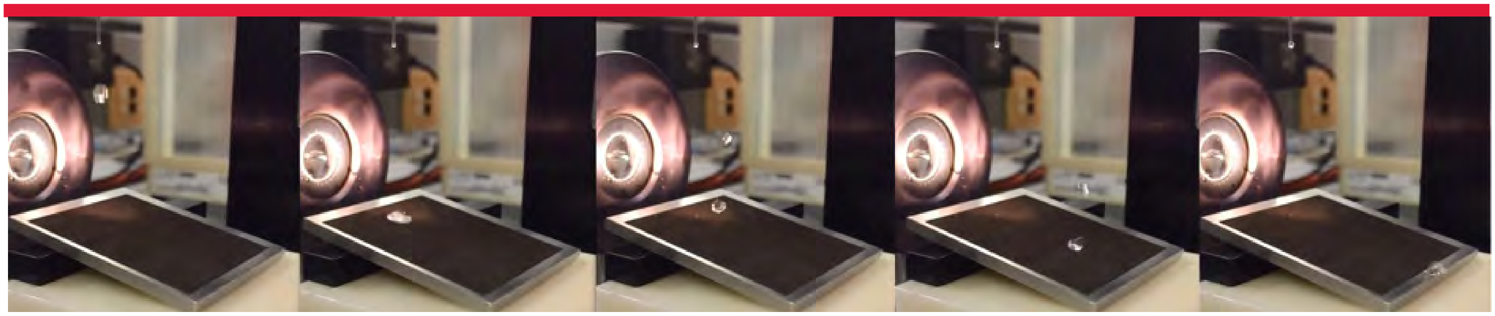

Figure 2. Superhydrophobic performance of a bouncing water droplet at ~5° tilt.

superhydrophobic with a contact angle of 152°. Following this two week period, the sample attained stable chemical equilibrium and the wettability was unchanged regardless of environment.

The superhydrophilic SiC surface on the other hand was not as reactive and therefore showed a contact angle of 0° immediately after processing. As aforementioned this sample was intended to have wider and deeper channels to hold and wick the water away from the contact point. The micro-capillary forces that are responsible for spreading the water across the surface were strong enough even to counter gravity; Figure 3 shown below depicts a time-lapse of a 3x3 cm^2 textured area placed vertically with the bottom edge in water. Within a 10-second span, the entire surface was wet by the micro-capillary forces pulling water vertically against the force of gravity.

The potential for laser texturing technologies spans many applications in manufacturing industries. Superhydrophobic surfaces have been proposed as a method to mitigate many fluid problems; by decreasing the interaction between a pipe wall and the fluid, the drag experienced by the fluid has been shown to decrease significantly in both laminar and turbulent flows. Thus far, only superhydrophobic coatings and thin-films have been tested for this application however they remain plagued by rapid wear and very short lifetimes. The robustness of the laser texturing process to achieve superhydrophobicity therefore presents exciting new opportunities. As well as water repellency of superhydrophobic surfaces, longer freezing times of water droplets and lower adhesion strength of ice to the surface are characteristics of these high contact angle surfaces and thus present an iceophobic surface property. This enables applications for machinery that operate in colder climates such as wind turbines and airplane wings and engines.

Applications for superhydrophilic surfaces are commonly based on the micro-capillary forces demonstrated as the rapid dispersion creates a thin film of water on the surface. This thin film allows for an increased rate of evaporation from the surface opening doors for anti-fogging applications or greatly increased rates of heat transfer. Other applications manipulate the thickness of the film formed which can provide antireflection ability for surfaces such as solar cells. Superhydrophilic textured surfaces also exhibit increased adhesion strength with the liquid due to the impregnation of the liquid into the surface, therefore providing applications for improvement in bonding strength of joints between different material surfaces.

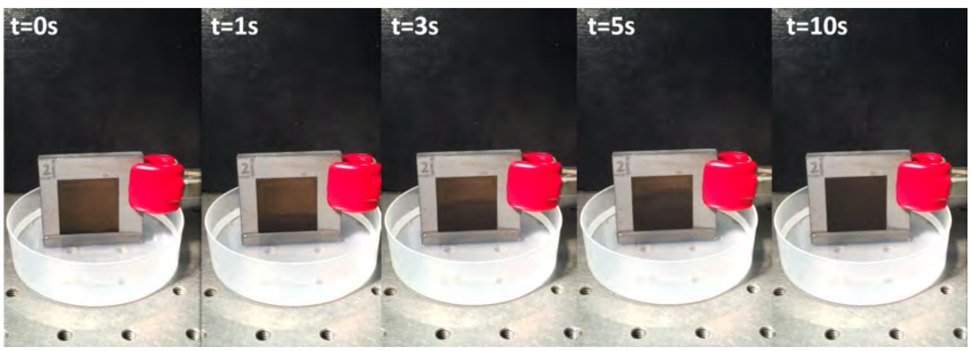

Figure 3. Superhydrophilic surface pulling water vertically.

The wettability control functionalization on engineering surfaces opens the door for new applications with both superhydrophobic and superhydrophilic surfaces. The robust nature of laser surface texturing technologies in combination with chemical compatibility and industrial scalability makes this method unique and most promising to deploy a wide range of functions in manufacturing products. While this technology has already provided solutions to several significant industrial tasks, many more applications are currently being explored at NRC.

LEARN MORE

More details on this topic can be found on YouTube:

Combined Wettability Control (https://youtu.be/7IW2aC_rkjw) Super-hydrophobic Bouncing (https://youtu.be/b1vXDuvf3aQ) Super-hydrophilic Ceramic (https://youtu.be/9ZCcW4cOccw)

Further details on these studies can be found in Ref: Superhydrophobic and Superhydrophilic Functionalized Surfaces by Picosecond Laser Texturing, ICALEO 2017, Paper # 0058 0087 000137

DESIGN GUIDELINES FOR LASER METAL DEPOSITION OF LIGHTWEIGHT STRUCTURES

BY AKE EWALD & JOSEF SCHLATTMANN

Weight critical applications, like parts in the aerospace industry, are driven by lightweight design. Titanium alloys have great potential in lightweight design of structural parts due to their excellent specific mechanical properties. Today, structural parts are manufactured in conventional milling processes. Titanium parts are characterized by poor milling behaviour as well as high material waste rates up to 95 % [1]. The Laser Metal Deposition (LMD) is a layer wise manufacturing process for the production of three-dimensional complex parts [2].

LMD builds parts based on a nozzle-fed powder which is solidified by a laser. The process can be used for surface cladding, repair and build-up of parts. For an effective industrial application, it is necessary to identify all advantages and disadvantages. A lowering of the introduction barrier can be achieved by design guidelines helping the engineer early in the product development. With LMD like Selective Laser Melting (SLM), existing manufacturing guidelines cannot be simply adopted. Due to the complex process constraints, a design guideline for LMD has been established.

Complex parts often share simple geometries as a basis. These shapes were identified and used to evaluate the applicability and effectiveness of LMD. Following established lightweight design guidelines, the presented guideline focuses on fine structures. In addition to the manufacturability, the building accuracy and the surface roughness have been investigated, since both have a significant influence on the product quality and the necessity of post-processing towards the final shape of a part.

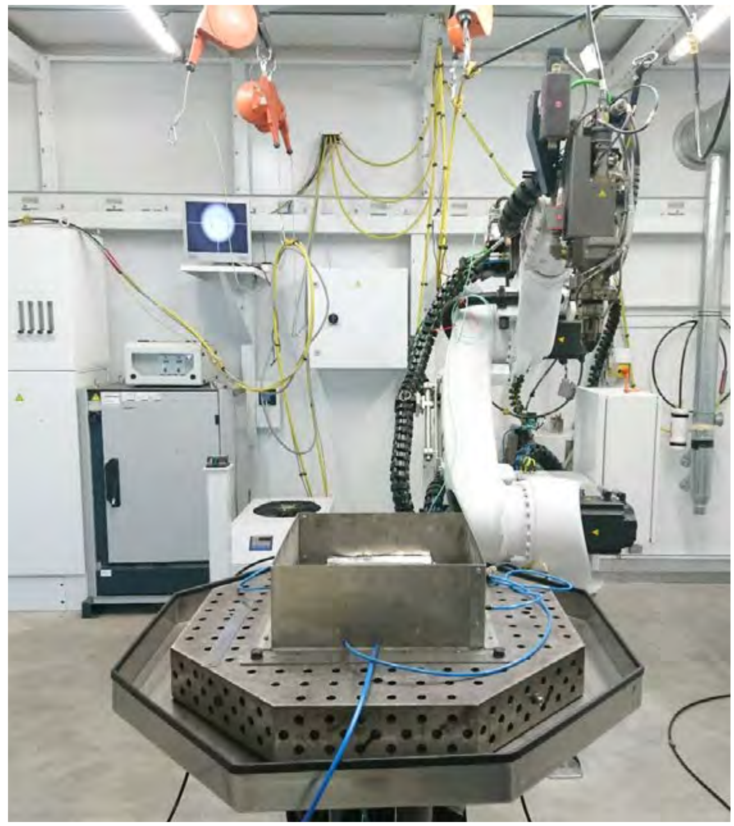

Figure 1. Robot cell (TruLaserRobot).

INVESTIGATION OF PROCESS CONSTRAINTS

The investigations are performed with a Trumpf TruDisk 6001 multi-mode continuous wave disk laser with a laser power of 6 kW at a wavelength of 1.03 μm. A three nozzle processing head is used with a rotational table feeder (Fig. 1). The used Ti-6Al-4V powder is spherical and sieved to a fraction less than 80 μm.

Three different building strategies have been identified in a preliminary design guideline by Möller et al., 2016 [3]. Figure 2 shows the different building strategies. In S1 an inclination is achieved by a stepwise offset (a) between the layers ($\alpha = \beta = 0°$). S2 rotates the platform to reach the inclination. The structure is manufactured vertically without an offset between the layers. S3 rotates the machine head to the inclination angle of the structure. The structure can be manufactured without an offset. Besides the three single building strategies, combinations of these are possible, which are not considered at this point. The preliminary guideline published by Möller et al. (2016) showed a high potential in the degree of freedom of building strategy S2 and S3 [3]. For this reason, these strategies were further investigated.

The mentioned fine structures have been classified to thin walls, curved walls, congregating and aggregating structures. The width of the manufactured structures has been set to a single layer width. The length has been set to 50 mm.

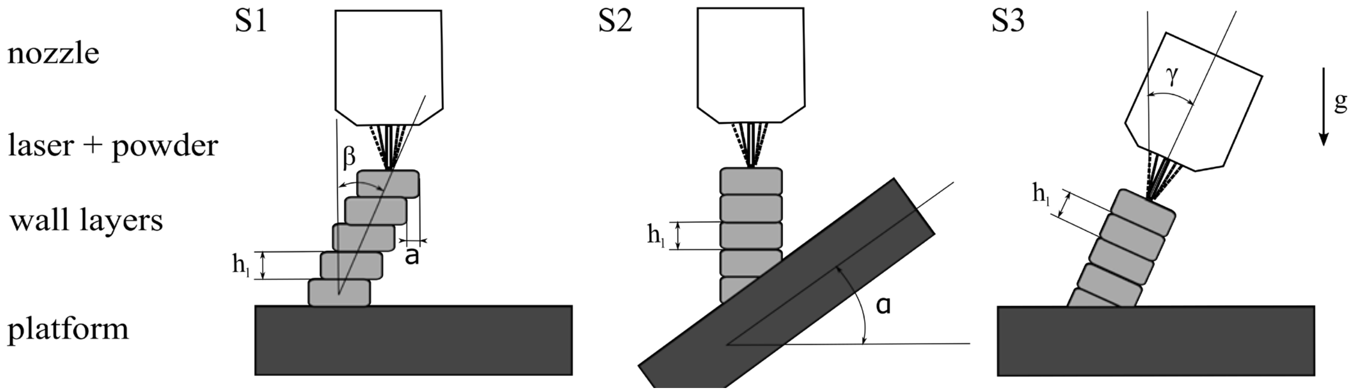

Figure 2. S1: horizontal offset between layer, S2: rotation of platform, S3: rotation of machine head

THIN WALLS

The build-up of inclined thin walls has been made to investigate

- the connection towards the platform
- the influence of the gravitation
- the building accuracy
- the influence on the wall surface

Both strategies produce a constant and comparable wall thickness under (see Fig.3). It varies due to the surface roughness of about 150 μm. The variation of the measured angle is less than 1°.

The surface quality of a part has an influence on the appearance, the buy to fly ratio in case of a post-processing, and the fatigue strength. The mean values of the surface roughness remain constant with rising inclination angles. The surface roughness of S3 is about 15 μm higher than with S2.

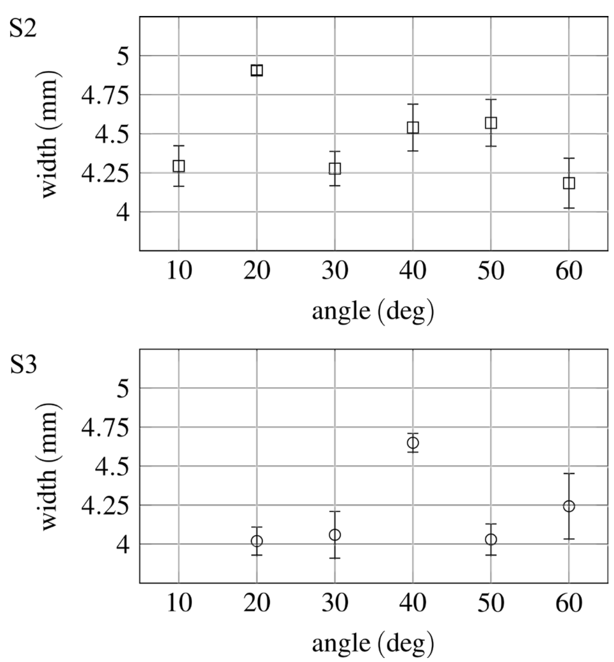

Figure 3. Measured wall thickness of the inclined walls manufactured with S2 and S3.

CURVED WALLS

Curved walls can vary in radius and angle. Curved walls can be divided into curves with their rotational axis parallel, and perpendicular to the building direction (z-axis, Fig. 4). For the vertical built up of the curved walls with different radii can be seen in fig. 5.

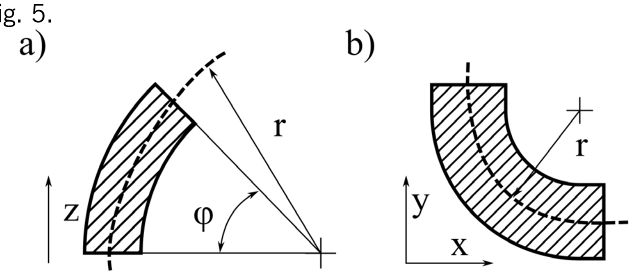

Figure 4. Sketch of curved elements perpendicular (a) to the building direction and (b) parallel to the building direction.

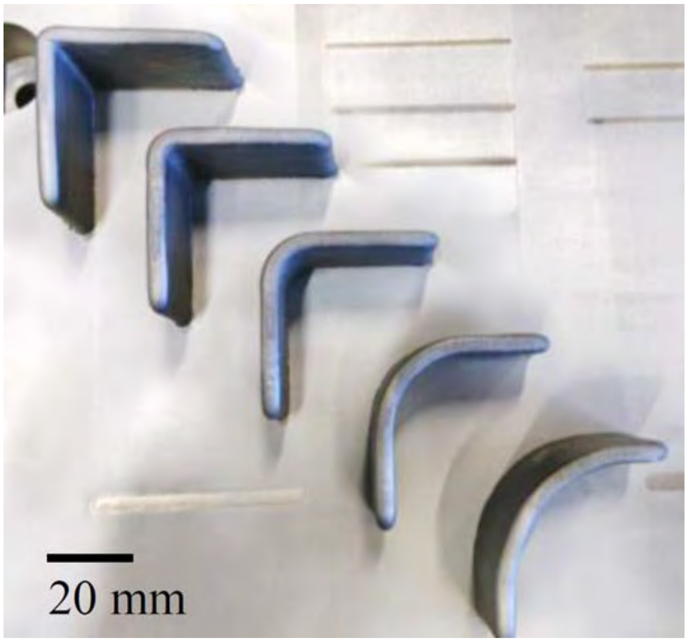

Figure 5. Set of manufactured parallel curved elements with radius of 0 mm (left) to 30 mm (right).

The radii of the built walls are 0.15 mm to 0.4 mm smaller than expected. An intended vertical edge (radius of 0 mm) produces an outer radius of 3.58 mm. Without post processing edges should be designed to allow a radius up to the layer width. The radius independent deviation allows the manufacturing in reproducible tolerance fields.

CONGREGATING AND DIVIDING STRUCTURES

The separation in congregating and dividing structures is based on the necessity of different manufacturing strategies and constraints in LMD (Fig. 6).

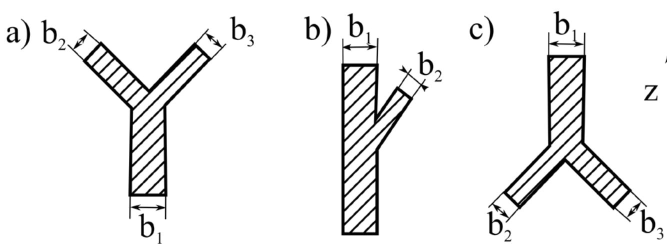

Figure 6. Sketch of the three defined congregating and dividing structures with building direction in z: (a) Y-branch, (b) overhang and (c) reversed Y-branch.

The manufacturing of regular and reversed Y-branches was realised by using S3. To achieve good results, binding on alternating branch sides is recommend (Fig. 7).

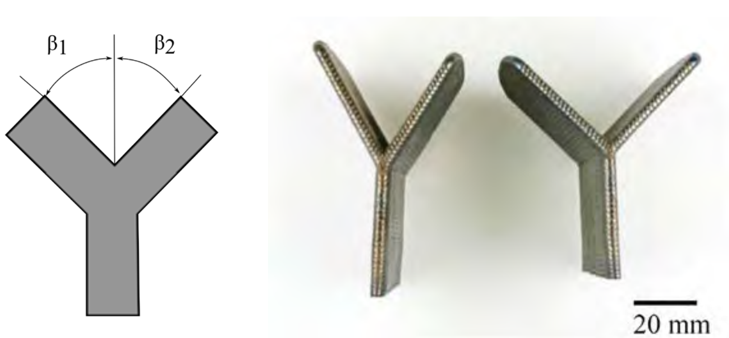

Figure 7. Sketch of the Y-branch (left), manufactured Y-branches with the angles $\beta_1 = \beta_2 = 30°$ and $\beta_1 = \beta_2 = 45°$ (right).

Additionally, overhangs were built on the manufactured vertical wall (Fig. 8) to evaluate

- the connection between a thin rough wall and a manufactured wall
- the building accuracy
- the boundary constraints

The measured angles of the overhangs have an angle deviation of less than 1° up to a manufacturing angle square to the gravity (Tab. 1). This is comparable to the inclined walls. Overhangs show that overhangs with the same or smaller width can be manufactured on thin walls.

Figure 8. Manufactured overhangs with inclination angles from 30° to 90°.

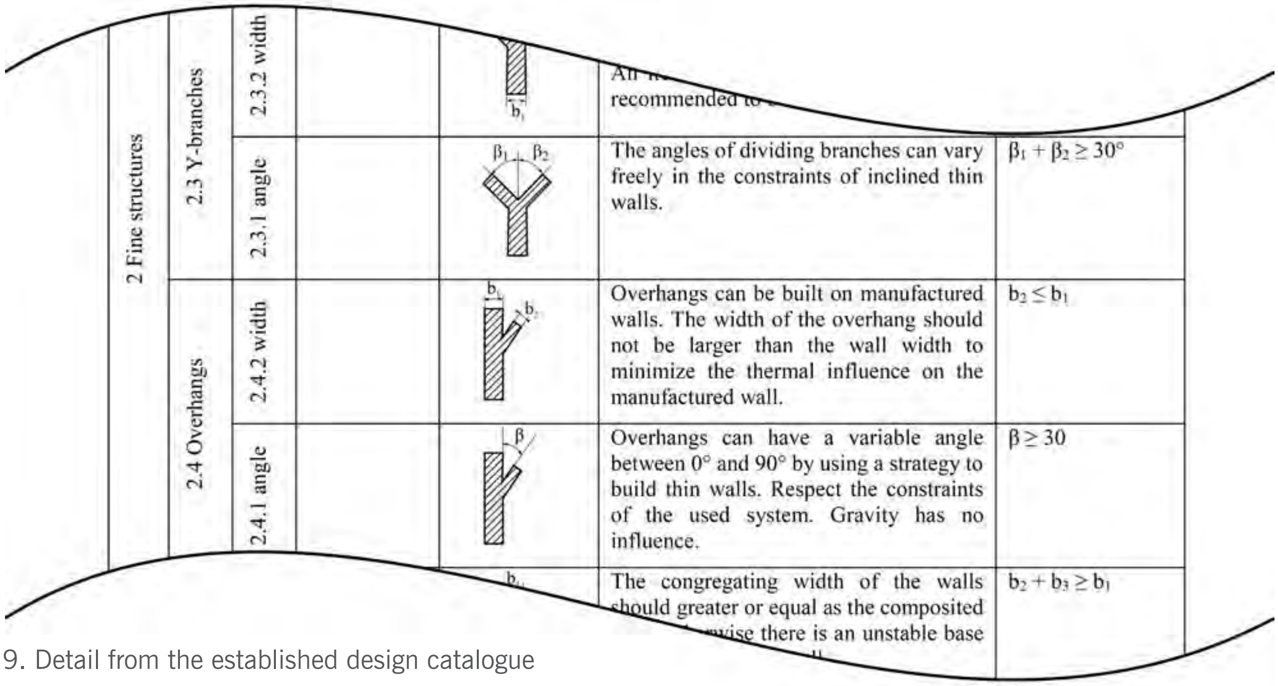

Figure 9. Detail from the established design catalogue

	30°	45°	60°	90°
Measured angle	30.40°	45.50°	60.51°	89.88°

Table 1. Measured inclination angles of the manufactured overhangs

The guidelines derived from the experimental investigation have been collected in a design catalogue according to the VDI 2222 in extracts shown in the figure 9.

CONCLUSION AND OUTLOOK

LMD offers a high degree of freedom in the design of parts. Lightweight parts can benefit from this flexibility. An industrial application can be achieved by design guidelines helping engineers to take the advantages and disadvantages of the LMD process into account during the design process.

The experimental investigation points out that structures based on the basic shapes are producible with constant geometric and surface tolerances, which allows reliable final machining. This is the basis for a successful design process. The building strategy S2 and S3 can be applied. The comparable results of S2 and S3 allow to choose the better fitting strategy for a specific use case.

By focusing on lightweight application, the following aspects have been achieved:

- Investigation and manufacturing of basic shapes
- Determination of process constraints
- Draft of a design guideline.

The developed design catalogue builds a first step towards a comprehensive design guideline for LMD.

ABOUT THE AUTHORS

M.Sc. Ake Ewald is research assistant in the workgroup System Technologies and Engineering Design Methodology at the Hamburg University of Technology since 2013. He works in the methodical product development where he researches the methodical design of hybrid manufactured structural parts using LMD.

Josef Schlattmann is Univ.-Professor at the Hamburg University of Technology. He leads the workgroup System Technologies and Engineering Design Methodology.

REFERENCES

[1] Allen, J. (2006) An Investigation into the Comparative Costs of Additive Manufacture vs. Machine from Solid for Aero Engine Parts, Rolls-Royce PLC Derby, UK.

[2] Ravi, G.A., Hao, X.J., Wain, N., Wu, X., Attallah, M.M. (2013) Direct laser fabrication of three dimensional components using SC420 stainless steel, Materials & Design, Vol. 47, 731-736.

[3] Möller, M., Baramsky, N., Ewald, A., Emmelmann, C., Schlattmann, J., (2016) Evolutionary-based Design and Control of Geometry Aims for AMD-manufacturing of Ti-6Al-4V Parts, Laser Assisted Net Shape Engineering 9 International Conference on Photonic Technologies Proceedings of the LANE 2016, S. 733–742, DOI: 10.1016/j.phpro.2016.08.075.

ICALEO 2018 Highlighted Sessions & Events

Welcome Celebration

Sunday, October 14 | 4:00pm

ICALEO®'s welcome celebration is always a memorably festive affair that brings together longtime and new attendees for an evening of snacks, beverages and live entertainment by the Beer's Law band, featuring Ron Schaeffer, Henrikki Pantsar and special guest musicians. Staged at the ICALEO venue, this gathering of old and new friends will also feature a raffle comprised of exciting door prizes. Don't miss out on this opportunity to socialize with the ICALEO gang in this informal setting.

LIA's Laser Running Club

Monday - Wednesday, October 15 - 17 | 6:00am

LIA'S LASER RUNNING CLUB

Meet with your colleagues for our traditional sunrise run. Enjoy three days of running through beautiful Orlando while catching up with your fellow early risers. A tradition begun by former LIA President Klaus Loeffler, the LIA Laser Running Club keeps you energized during the conference. Meet us in the hotel lobby with your Laser Running Club shirt on! If you are a newcomer, we will provide you with a shirt. Learn more about how to participate at the ICALEO registration desk.

Opening Plenary

Monday, October 15
9:00am

The ICALEO® Opening Plenary session is designed to enthrall you. Kicking off days of informative technical sessions, three renowned speakers will present on new advances in lasers and photonics, and offer insight into the challenges and rewards of launching a new laser business. You won't want to miss this enlightening plenary session!

ABOUT THE SPEAKERS

Keynote: Dr. Islam Salama | *Intel Corporation*

Islam Salama is a Senior Director with Intel Corporation responsible for packaging substrate Pathfinding of the high density interconnect across Intel products. Salama has a Ph.D. in laser materials processing from the College of Optics and Photonics (CREOL), UCF, and has been with Intel since 2003. Salama has authored over 30 technical papers, was awarded more than 70 international patents in the fields of HDI substrate technology, laser technology, materials processing and semiconductor fabrication. Islam is a member of the steering committee with the International Technology Manufacturing Initiative (iNEMI), and a board member of Applicote Associates LLC.

Dr. Jason Eichenholz | *Luminar Technologies, Inc.*

Jason Eichenholz is the co-founder and CTO of Luminar, a sensing technology company that will become the core platform to enable safe fully autonomous vehicles. As CTO, Eichenholz is responsible for research and development of new products, product roadmap and bringing Luminar's technology to to market. Before joining Luminar, Eichenholz was the CEO and founder of Open Photonics, an open innovation company dedicated to the commercialization of optics and photonics technologies. Eichenholz is a fellow of SPIE and of OSA. He holds more than twenty U.S. patents on new types of lasers and photonic devices.

Dr. Milton Chang | *Incubic Management LLC*

Milton Chang is a past president of the LIA and OSA, and a Fellow of LIA, OSA, and IEEE. He is a trustee of Caltech and is currently on the boards of two companies. He was CEO of Newport Corporation and New Focus, which he took public. His book "Toward Entrepreneurship" sharing his experience in starting and building companies is well-received. Check out the reviews at www.miltonchang.com and more about his current activities at www.incubic.com.

President's Reception

Monday, October 15 | 5:00pm

Mingle with your colleagues in a fun and relaxed environment at ICALEO's premier networking event. Hosted by LIA President Milan Brandt, the President's Reception is the perfect place to interact with the LIA Executive Committee, Board of Directors, ICALEO Congress General Chair Christoph Leyens and Conference Chairs Klaus Kleine, Friedhelm Dorsch, Eric Mottay, Robert Braunschweig and Yongfeng Lu.

Business Forum & Panel Discussion:

The Global Laser Market and Its Future Development

Tuesday, October 16 | 8:10am

Laser market specialists from around the world provide exclusive information about the development and future trends in the different regions. Topics like the following will be discusses: China has installed more than 60,000 laser systems last year. Is this a opportunity or a threat for the non-Chinese laser businesses? Be part of the discussion: The forum is open for all attendees. This will also help to show you where your professional career might lead you to. Be part of the exciting network and exchange ideas with the speakers and attendees during the round table discussions.

LIA Annual Meeting & Awards Gala featuring the Arthur L. Schawlow Award Presentation

Wednesday, October 17 | 5:00pm

LIA™ 50 YEARS 1968–2018

Celebrate the 50th Anniversary of LIA!

Join your fellow ICALEO 2018 attendees, conference chairs, and LIA staff in commemorating the 50th anniversary of the Laser Institute of America. Don't miss this once-in-a-lifetime event, as we honor our history and look to the future of the laser industry!

About the Arthur L. Schawlow Award

One of LIA's most prestigious honors, the Arthur L. Schawlow Award recognizes outstanding, career-long contributions to basic and applied research in laser science and engineering, leading to fundamental understanding of laser materials interaction and/or transfer of laser technology for increased application in industry, medicine and daily life.

The Schawlow honoree is acknowledged at the traditional LIA Awards Gala, during which the recipient gives an address that is always a memorable, must-see ICALEO moment.

NANO MANUFACTURING CONFERENCE 2017

FEMTOSECOND LASER STRUCTURING OF GRAPHITE ANODES FOR IMPROVED LITHIUM-ION BATTERIES

BY JAN HABEDANK

The demand for lithium-ion batteries is rapidly increasing, making advancements in battery technology more important than ever before, especially for electric mass mobility. Material processing lasers have been used for a wide range of applications in battery production, from cutting of the electrode sheets to welding of the cell cases and conductive connections. The electrodes are the key components of the battery cells, substantially influencing many cell properties such as fast charging and discharging capability, energy density and life time. However, especially high energy electrodes struggle to deliver high power during operation. Internal resistances caused by the complex and porous material structure of the electrodes hinder the ion movement within the battery cell. This results in efficiency losses, heat generation and a limitation of energy delivery, especially at high discharge current. Laser structuring of electrodes is a promising approach to overcome these drawbacks. By precisely removing a small fraction of the anode material (today mostly graphite) with femtosecond laser pulses, artificial micro pores are created, which are later filled with liquid electrolyte in cell assembly. Figuratively speaking, these channels serve as ion-shortcuts through the electrodes, reducing the effective transport pathways from the anode, through the separator, to the cathode.

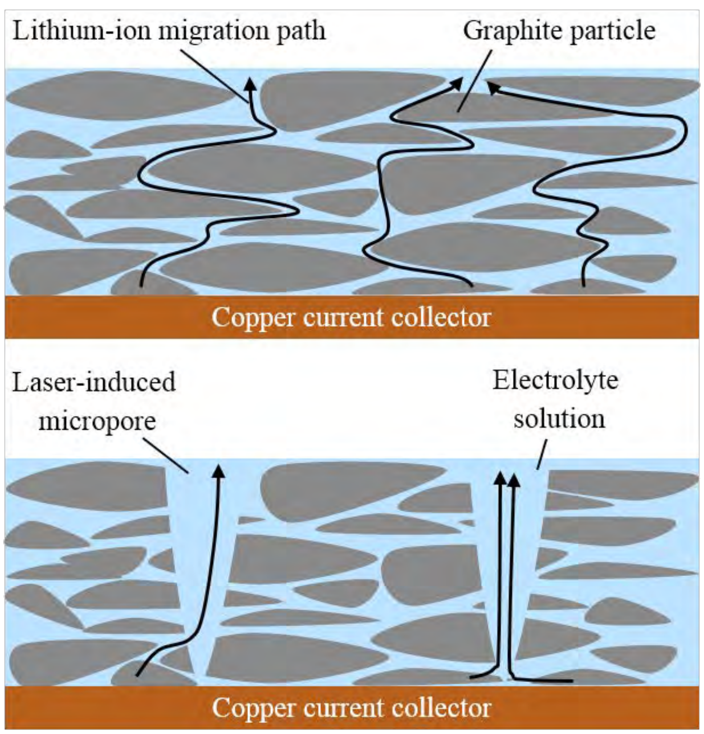

Figure 1: Illustration of the lithium-ion flow through a graphite anode, top: unstructured electrode with long ion transport paths, bottom: laser structured electrode with short and direct ion transport paths.

In Figure 1, a schematic sectional view of a graphite anode is displayed, illustrating the facilitated diffusion process through the electrode by laser structuring.

As state-of-the-art electrodes are just 50 to 100 μm thick, the induced structures have to be very small in order to not remove excessive amounts of the active material. Mechanical processes are either not precise enough or too slow for the fabrication of the structures. Laser technology provides the unique possibility to create structures with diameters smaller than 50 μm with a reasonable processing speed of hundreds of structures per second. An image of the electrode surface, structured and unstructured, is presented in Figure 2. Separate holes with a distance of 70 μm and a structure diameter of approx. 25 μm were created and evenly distributed in a hexagonal pattern to keep the removal of active material at a minimum while increasing the active surface area substantially.

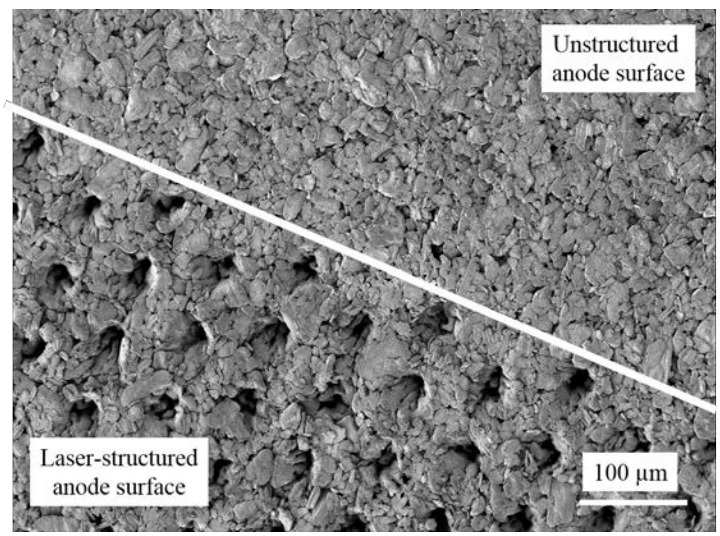

Figure 2: SEM-image of a laser structured and an unstructured graphite anode surface.

Laser structuring was performed using a pulsed femtosecond laser with a pulse duration of 400 fs and an infrared wavelength of 1040 nm. The beam was focused on the electrode surface with a focus diameter of only 17 μm. In order to speed up the process, a study on ablation efficiency was performed. It was shown, that high pulse energy is essential for an effective material removal process. Also it was found, that high pulse repetition rates onto the same spot impede an effective ablation process, as ablation products and plasma of the previous pulse act as a shield for the subsequent pulse. These insights can work as a guideline for process design in the industrialization of laser structuring of electrodes. Additionally, different electrode compositions were evaluated. It could be shown, that the material removal process becomes far less effective the more binder the electrodes contain. This offers the possibility of designing and tuning the electrode properties for an efficient laser structuring process.

To evaluate the effect of structured graphite anodes on the electrochemical properties of lithium-ion batteries, test cells with structured and conventional anodes were manufactured and cycled at different current rates. The delivered capacities for the different current rates were tracked and normalized with respect to the theoretical capacity of the batteries. A C-rate of C/10 represents a current that discharges the full capacity of a cell in ten hours. Higher C-rates are a multiple of this current. As cathodes, NMC was used which is standard for most electric vehicles on the market. For each C-rate, three charging and discharging cycles were applied. The resulting discharge capacities are displayed in Figure 3.

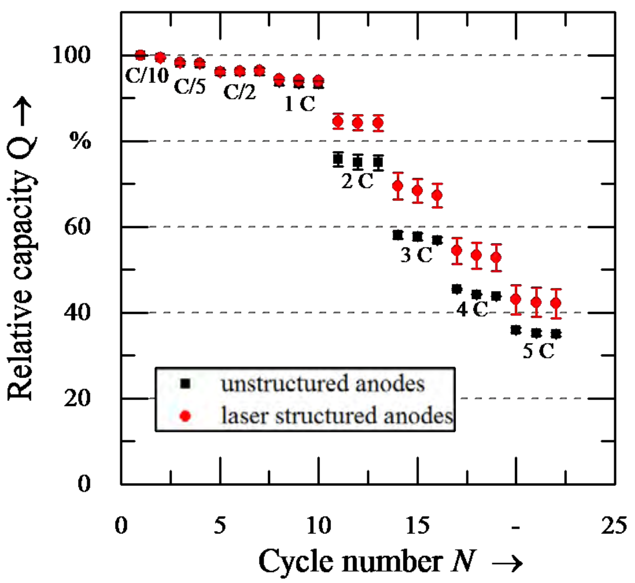

Figure 3: Normalized discharge capacities and standard deviations of li-ion (C/NMC) full cells with laser structured and unstructured anodes

The test showed significant and substantial improvements in discharge capacity of approx. 20 % for the cells with laser structured anodes compared to conventional anodes for C-rates between 2 C and 5 C. At C-rates below 1 C, the conventional cells and the cells with laser structured anodes showed almost equal performance, indicating that no notable damage was done to the surrounding active material particles by laser structuring, e.g. by creating a significant heat affected zone. The improvements in the discharge characteristics of test cells with laser structured anodes can be attributed to reduced resistances and thereby decreased electrode polarization during discharge. Especially the flake-like form of the graphite particles has repeatedly been suspected to slow down ion transport at high C-rates due to highly tortuous paths through the electrode's microstructure. This issue is partially overcome by laser structuring of the anodes making the process highly interesting for all high-power applications of lithium-ion batteries. The laser process may also contribute to the introduction of ultra-high energy density cells with very thick electrodes, as a satisfactory C-rate capability is likely to be maintained, solving the conflicting goals of high power and high energy density.

The author will continue to work on optimizing structure design by electrochemical simulations, on experimental validation and also on the process scale up to prove the adaptability of the laser structuring process for large format lithium-ion batteries.

ACKNOWLEDGEMENTS

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ABOUT THE AUTHOR

Jan Bernd Habedank is working as a research assistant and doctoral candidate at the Institute for Machine Tools and Industrial Management (IWB). He studied mechanical engineering at the Technical University of Munich and the Technical University of Darmstadt. Within his research, he focuses on improving lithium-ion batteries with laser-based processes.

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ENERGY EFFICIENCY CONTRIBUTIONS AND LOSSES DURING SLM

BY PRAGYA MISHRA

Selective Laser Melting technique, SLM, requires remelting of adjacent tracks to avoid cavities and other imperfections. The process efficiency relates the energy required for the generation of a new track to the laser beam power. For SLM this efficiency is determined by the process parameters, specifically hatch distance, layer depth and scanning speed, independent of the resulting process mechanisms. For SLM the process efficiency often very low, typically 2-20%. Apart from beam reflection losses of normally 50-60%, significant energy losses result from the remelting of surrounding layers. Some areas can even experience multiple remelting cycles. Further losses originate inevitably from substrate heating.

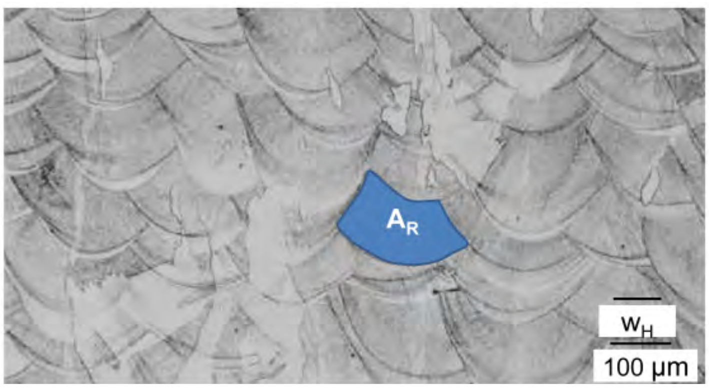

Figure 1. Macrograph of typical track cross sections from SLM

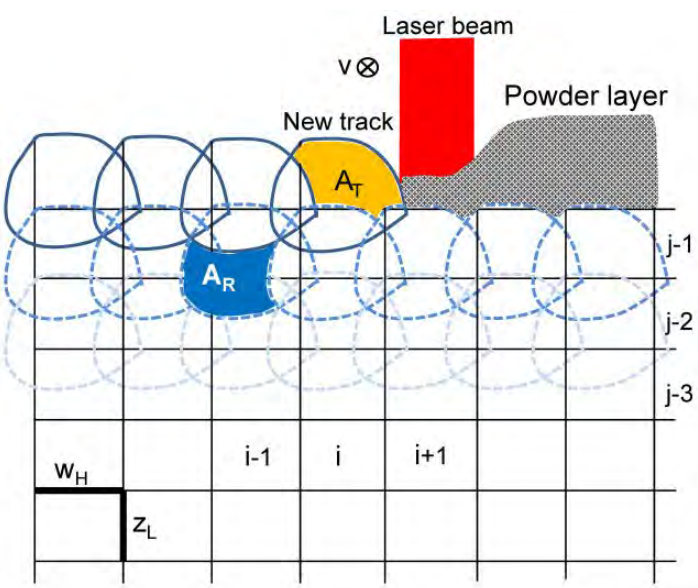

Figure 2. Illustration of the sequence of tracks i and layers j placed during SLM.

A simplified mathematical model of the track cross section and the corresponding layer overlap geometry has been developed, to analyse the different loss contributions from remelting with respect to the process parameters. The cross section of the overlapping tracks generated by SLM can be regarded as an experimental fingerprint linked to the process conditions. The track cross section geometries can significantly fluctuate, in terms of area and coordinate position. The fluctuations require additional reduction of the hatch distance or layer depth, to ensure robust, cavity-free processing. Examples are presented for stainless steel where a 180 W laser beam has led to a process efficiency of 5-11%, proportional to a hatch distance that was increased from 50 to 110 μm, for 40 μm powder layer depth, at a speed of 50 m/min.

Figure 1 shows a typical cross section of tracks generated by SLM, highlighting the visible area AR after processing. In Figure 2 the sequence of tracks and layers is visualized. Repetitive remelting of the same material and track contributes to losses of the laser beam energy. During SLM a large amount of energy is wasted and usually only a rather small amount is used to generate a new track A_T, which is the valuable contribution envisaged.

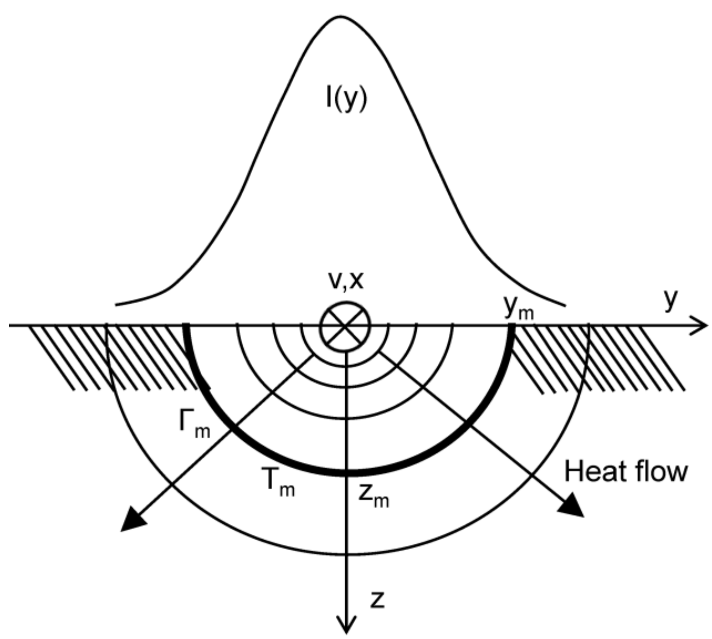

Figure 3. Model of a moving Gaussian beam to calculate the melt shape $\Gamma_m(y,z)$ of a single track.

The process efficiency, η_p, by the energy (per unit time) required to melt a track during SLM in relation to the energy of the laser beam, the laser beam power P_L:

$$\eta_p = \frac{v A_T [\rho c_p (T_m - T_a) + L_m]}{P_L}$$

The energy per unit time to melt a track results from multiplying the scanning speed, v, with the specific energy of melting per unit volume, e_m,[J/m^3] and the track cross section area, $A_T=w_H \cdot z_L$, i.e. the product of hatch distance w_H and layer depth z_L. Other properties are the specific mass density ρ, specific heat capacity c_p, melting temperature T_m, ambient temperature T_a and latent heat of melting L_m. The here defined process efficiency expresses the percentage of the laser beam power that is used to generate a track while all other beam power are losses. The losses can be divided into beam reflection losses and into heating of the material, except the above considered melting of the generated track A_T.

In Figure 3 shows the moving Gaussian source of heat of a single track. The resulting melting cross section has a circular-like shape Γ_m, of width $2y_m$ and depth z_m.

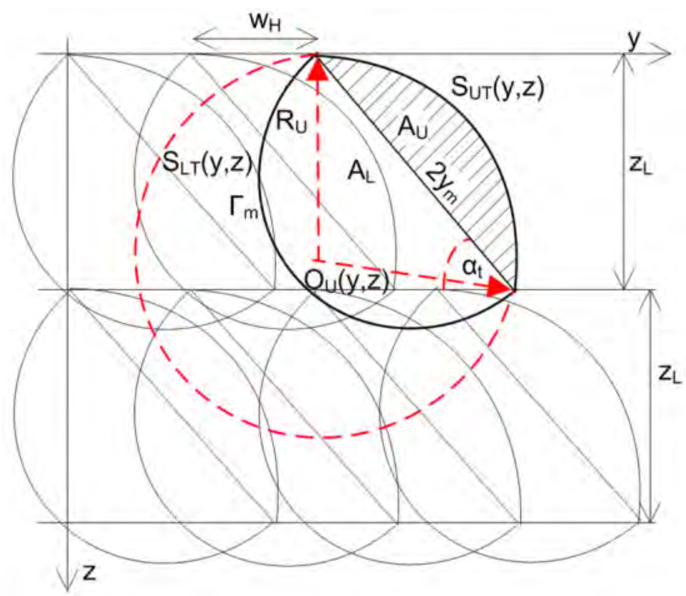

Figure 4. Model to tilted cross section by $\Delta z=z_L$

As a next step, the cross section shape Γ_m is tilted, see Figure 4 to an extent (angle α_t) that the height of the left end of the melt pool, at $-y_m$, is one layer depth, z_L, higher than at the right end, $+y_m$. This new, tilted shape of the lower part of the track is denominated $S_{LT}(y,z)$. The upper shape of the track, $S_{UT}(y,z)$, is approximated by a circle. The radius R_U (and centre coordinates $O_U(x,y)$) of the circle is chosen such that it sufficiently matches the mass balance. The calculations turned out to have little sensitivity to this radius. Overlapping of the tracks is modelled by duplication of this track shape, by displacing the shape by multiples of the hatch distance w_H and layer depth z_L, respectively.

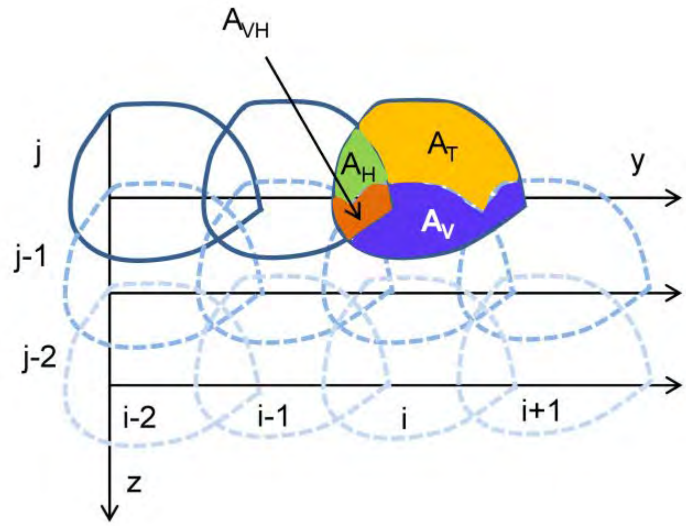

Figure 5. Highlighted areas of the track cross-section

The model was programmed in MatLab software. The main purpose of the model is to analyse the SLM-process through these overlapping shapes. While the basic cross section of a single track is simple, overlapping becomes rapidly complex, as visualized in Figure 5.

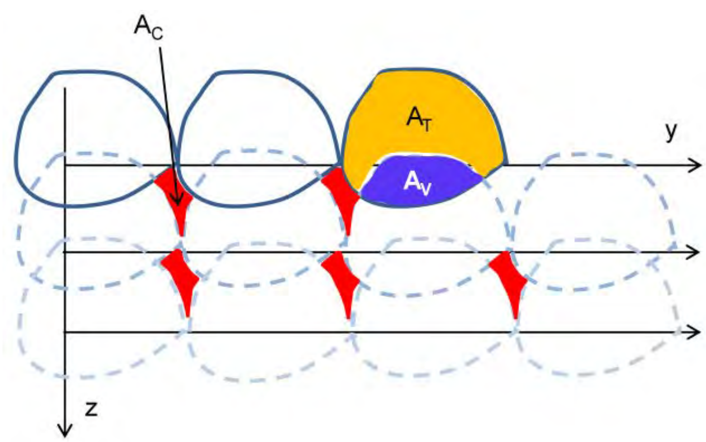

Figure 6. The case of cavity formation A_C.

The newest track generated has an area A_T, which is equal to the reference area, $A_T=w_H \cdot z_L$. The much larger area from the melt pool shape S_{LT} causes remelting of previous layers, which can be subdivided into three categories, namely vertical, A_V, horizontal, A_H and combined remelting (losses), A_{VH}. Beyond a limit of increasing layer depth or, as in Figure 6, hatch width, cavities of growing area A_C form between the tracks.

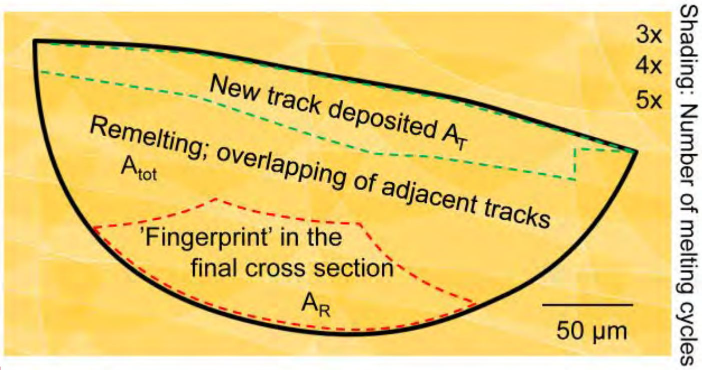

Figure 7. Remelting cross section A_{tot}

The calculated cross section of a melt track generated during SLM is shown in Figure 7, here for w_H=80 μm and z_L=40 μm. When this melt track was formed, only the most upper part was melting powder and generating a new track, of area A_T. The larger lower part of this section has remelted previous tracks, beside or underneath. In this case 24% of the melted area contributed to generate the new track (A_T=3200 μm^2) while 76% were remelting losses. Figure 7 also shows how the finally visible track AR forms (note: A_R=A_T). The overlapping tracks explain why this "fingerprint" results. The different levels of yellow shades correspond to the number of remelting per subdomain. The shades in the elements right up can be used as reference. Here every element is at least melted a second time, some elements experience five times melting (including the initial melting to generate the new track).

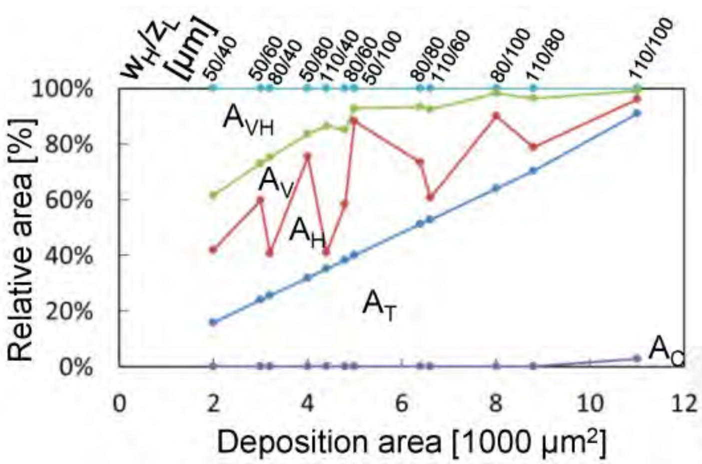

Figure 8. Calculated remelting contributions

A relative to the total melting area A_{tot}, as a function of deposition area A_T (which results from the combinations of three hatch distances w_H and three layer depths z_L)The percentage of vertical and horizontal remelting areas relative to the whole melted track shown in figure 8.

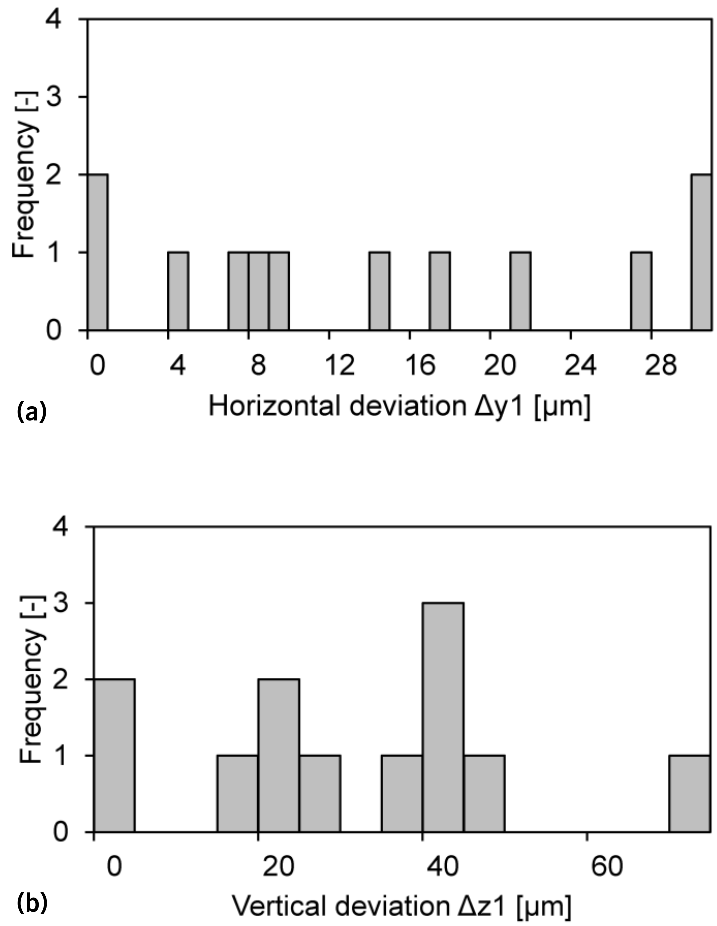

Figure 9 Histograms of statistical variations of the experimental track cross sections (a) horizontal coordinate deviation $\Delta y1$ (b) vertical deviation $\Delta z1$

In Figure. 9(a), (b), compared to the ideal regular matrix of track placement. The horizontal coordinate fluctuations range up to 30 μm, which is significant when related to a beam diameter of 70 μm and a hatch width of here 80 μm. The vertical coordinate deviation, typically up to 50 μm, becomes the order of magnitude of the layer depth, here 40 μm.

The process efficiency of SLM is very low, 2-20%. Losses of the complex, asymmetric process geometry in SLM can be divided into reflection, remelting and bulk heating. A simplified mathematical model for the cross section shapes can explain fingerprint and can estimate the loss contributions through different remelting areas; the same location is likely to experience multiple melting, here up to five times. The safe parameters (slow, small hatch width and layer depth) required to avoid cavities, though causing low efficiency; higher repeatability of track geometries is therefore a promising goal.

ABOUT THE AUTHOR

Pragya Mishra is currently completing PhD study in the research topic engineering materials at the division of material science, Luleå University of Technology, Sweden.

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