The International Academy for Production Engineering

NEWSLETTER

N° 47 – November 2013

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From the President

My Dear Colleagues and Friends,

First of all, I would like to thank you for your trust that you found me appropriate to act as the President of our distinguished Academy, CIRP! My presidency started in Copenhagen at an extremely successful General Assembly. I am convinced that on behalf of all of us I may express our gratitude to our colleagues Leo Alting and Hans Hansen who made the this year's GA unforgettable for the participants.

I express thanks to all the past presidents of our Academy, and especially to Marco Santochi, so that I could take over the leadership of an Academy which is in a very good shape from many points of view. Naturally, in this respect, I owe thanks to the Secretariat, to Didier, Chantal and Ágnes, too.

The favourable condition, however, does not mean that we have chances to rest in the coming years! One of the most important tasks is, while keeping our 10 STCs as cornerstones of our activities to be open towards new, emerging areas, in other words to be responsive to novel challenges, and cooperative with leading scientists of other disciplines.

Reacting on the rush industrial development in countries which are underrepresented in our Academy, we must strengthen our efforts to involve the top level representatives of our fields from these countries into our activities. Thanks to the endeavours of our members, CIRP is gaining more and more recognition and influencing power in the circles of industrial policy makers, especially in Europe. I really think that our international Academy has the power to play a liaison role between different regions, fostering this way sustainable, but simultaneously competitive production, world-wide.

Another important issue is to continue the successful research affiliates programme, and to find the ways of long-term relations with them, independently of the fact whether they have started industrial or academic carriers. Coming back to the presidency, thank you all for your trust, which I try to deserve posteriorly by serving you in the coming year!

Looking forward to meet you in Paris in 2014.

With warm regards

László Monostori
President of CIRP
2013-2014

News about Members

Leibniz prize for Prof. Dr.-Ing. Marion Merklein

Marion Merklein is the youngest of the new Leibniz prizewinners. At 39 years of age, she is recognized as an outstanding engineer at the interface between materials science and manufacturing technology. Her more than 300 research works cover a broad spectrum of topics, although primary interests include: design and optimization of lightweight sheet metal structures, hot sheet metal forming (press hardening), and sheet metal massive forming. In many cases, Merklein succeeds in bridging the gap between materials science and manufacturing technology, commonly addressing important questions relevant for industrial applications. In doing so, she has already contributed greatly to the ever-increasing importance of forming as a resource- and energy-saving technology for manufacturing applications. This is especially true for high-value products that can be formed very close to their final contours.

Merklein's research career is tied closely to the University of Erlangen-Nürnberg (FAU), where she studied materials science, earned her doctorate, worked as chief engineer and research group director, and also completed her habilitation. Her chair for Manufacturing Engineering is considered to be one of the internationally leading centers in its field with outstanding contacts in science and industry. Merklein also pursues her research in her role as spokesperson for major cooperative research networks, including a DFG Research Unit and a Collaborative Research Centre/Transregio. As early as 2004 Merklein received the Heinz Maier-Leibnitz Prize from the DFG and BMBF, the most important award for early career researchers in Germany. Additional prizes followed. Merklein is also deeply involved with academic instruction and self-administration.

Professor Hendrik van Brussel Honorary member of the Hungarian Academy of Sciences

Hendrik van Brussel, Emeritus Professor at the Catholic University of Leuven, is one of the highly acknowledged researchers who became Honorary Member of the Hungarian Academy of Sciences (MTA) at the election held on the first day of the General Assembly. According to the Statutes of MTA, members can be elected from among scientists who hold Doctor of the Academy or other equivalent scientific degrees and

"who cultivate their fields of science on a well-recognized, extremely high and creative level."

He held his inauguration lecture on 10 October 2013 in presence of some 15 CIRP members. The title of his speech was “A systems approach to manufacturing science”

Prof van Brussel is an International Member of the Advisory Board of *MTA's Institute for Computer Science and Control.* Main fields of research: cutting dynamics, structural dynamics, robotics, mechatronics, c*omputer-integrated* manufacture (CIM), holonic manufacturing systems, micro and precision engineering.

Professor Hoda ElMaraghy received an Honorary Doctorate

Professor Hoda ElMaraghy received an Honorary Doctorate Degree awarded by Chalmers University of Technology in Gothenburg, Sweden in recognition of her "distinguished contributions to knowledge, research and industry in the field of Manufacturing Systems Engineering, and strong international eminence in the area of production engineering". The degree was conferred during the University convocation ceremony held on 1 June 2013 at Gothenburg Concert Hall.

Chalmers Technical University is highly ranked in Sweden and worldwide. Professor Hoda ElMaraghy has over the years served as an international evaluator of the Swedish Strategic Research Foundation (SSF) national research program ProViking in which research groups from all of Sweden compete for funding of major research projects and Centers of Excellence. She is a member of the International Scientific Advisory Board of Chalmers' Wingquist Laboratory VINN Excellence Center for Efficient Product Realization since 2007.

Dr. Hoda A. ElMaraghy is a Professor of Industrial & Manufacturing Systems Engineering and the founding Director of the Intelligent Manufacturing Systems (IMS) Centre at the University of Windsor. She holds a prestigious Tier I Canada Research Chair (CRC) in Manufacturing Systems since 2002. She obtained a Master and PhD degrees in Mechanical Engineering from McMaster University where she became a Professor and founding Director of its Flexible Manufacturing R&D Centre until she moved to the University of Windsor in 1994 to become the first woman Dean of Engineering in Canada.

Professor ElMaraghy is a Fellow of the International Academy of Production Research (CIRP). She became the first woman CIRP member since its inception. She was elected soon after as a CIRP Fellow in 1990 and was later elected a member of the CIRP Council. Professor Hoda ElMaraghy is also a Fellow of the Society of Manufacturing Engineers (SME), Canadian Society of Mechanical Engineers (CSME) and a senior Member of the American Society of Mechanical Engineers (ASME). She received numerous honors and awards including the Professional Engineers Ontario Research Medal. She serves on several national and international advisory boards and is a member of 4 Editorial Boards of high impact international journals. Her areas of research interests include: Manufacturing Systems Flexibility, Reconfiguration and Changeability, Products and Production Systems Co-Evolution, Systems Complexity, Variety management in products and manufacturing systems, Process and Production Planning, Rapid Products Development, Assembly, and Robotics.

Dr. Hoda ElMaraghy is author and co-author of six frequently cited CIRP Keynote papers, and has over 380 publications to her credit including 2 edited books on changeable, reconfigurable and sustainable manufacturing systems and 20 Chapters in Books. She has contributed to the training of more than 100 highly qualified personnel including 2 CIRP Fellows and 4 CIRP Research Affiliates.

Professor Lin Li elected to Fellow Royal Academy of Engineering

Professor Lin Li, Director of Laser Processing Research Centre and Head of Manufacturing Research Grooup, Director of Research in School of Mechanical, Aerospace and Civil Engineering at The University of Manchester, UK has recently been elected to ***Fellow of Royal Academy of Engineering*** for the recognition of his outstanding contributions to the advancement of science, technology and engineering applications of laser based advanced manufacturing. The Royal Academy of Engineering is UK's national academy for engineering that brings together the country's most eminent engineers from all disciplines to promote excellence in the science, art and practice of engineering. (http://www.raeng.org.uk/).

Professor Lin Li received Sir Frank Whittle Medal from Royal Academy of Engineering

Professor Lin Li, CIRP Fellow, Head of Manufacturing Research Group at The Univeristy of Manchester, UK, received the 2013 ***Sir Frank Whittle Medal*** from the Royal Academy of Engineering for the recognition of his "*outstanding and sustained research achievements for engineering innovations in manufacturing that have directly benefitted the UK economy*". http://www.raeng.org.uk/prizes/whittle/default.htm

The Sir Frank Whittle Medal is named affer Sir Frank Whittle, father of the jet propulsion engine. Previous recipients of the medal (one per year) include Professor Tim Burners-Lee (2001) who created the World Wide Web and Professor Ian Young (2004) who invented the (MRI – magnetic resonance imaging).

Professor's Li achievements include the pioneering of new manufacturing technologies, supported with sciences, that have been practically implemented in wide industrial sectors including aerospace (e.g. laser cleaning for aero engine production), automotive (e.g. diesel fuel injection nozzle manufacture and the use of non-conventional laser beam geometry for brazing), medical (e.g. water assisted fibre laser machining of coronary stents) and security (e.g. laser demetallisation of imbedded metallic threads between polymers for banknote security printing). He is also an inventor of one of the world's most powerful optical microscopes based on virtual microsphere imaging that allows nano-scale structures, beyond the optical diffraction limit, to be captured.

Professor Ajay Malshe honored by the R&D 100 Award

NanoMech's TuffTek® has been announced as a winner of the coveted R&D 100 Award, the "Oscar of Technology". Dr. Ajay Malshe, Chief Technology Officer and Founder, was honored by the award and immediately thought of those with whom he has worked. "NanoMech could not have received this prestigious award without the tireless work of our world-class team of scientists at the Nano Materials Science and Engineering Institute (Mechanical Engineering) at the University of Arkansas, the National Science Foundation and the Environmental Protection Agency.

TuffTek® is a ground-breaking product that is manufactured using Atomically Precise Manufacturing (APM). When applied to cutting tools, it dramatically increases the tool's precision cutting performance, durability and sustainability while significantly decreasing the company's costs to manufacture.

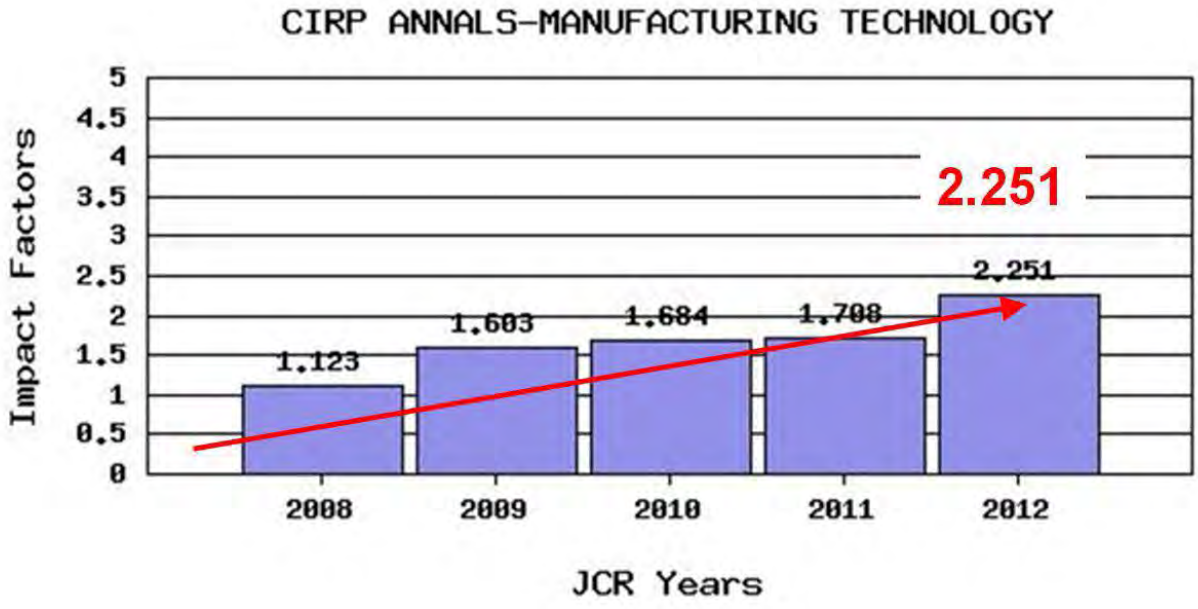
NanoMech is the only Arkansas company on the 2013 Top 100 list. The R&D Top 100 list was established in 1963 and over the past 51 years has recognized such revolutionary products as the flashcube (1965), the automated teller machine (1973), the halogen lamp (1974), the fax machine (1975), the liquid crystal display (1980), the Kodak Photo CD (1991), Taxol anticancer drug (1993), lab on a chip (1996), and HDTV (1998). More recent breakthroughs that have earned R&D 100 Awards include next-generation magnetic resonance imaging machines, laser-based metal-forming tools, and the building blocks for fusion experiments.

Ajay's business, technology transfer and commercialization experience in the past ten years spans multiple roles including successfully translating breakthrough nanotechnologies from table-top -to- factory floor, building a team of people with complementary and compatible skills for accelerating tech transfer and commercialization in record time; assembling winning grant proposals and teams for successful completion; executive leadership; synergistic tech and public networking and outreach for business, work with skilled and unskilled associates with diversity in disciplines and cultures.

Due to his science and technology contributions, he has received more than 30 national and international awards and recognitions. He is also the Distinguished Professor of Mechanical Engineering as well as the 21st Century Endowed Chair Professor of Materials, Manufacturing and Integrated Systems at the University of Arkansas at Fayetteville.

Notes from the Editorial Committee

Once again the continuous actions to improve the quality of our Annals have paid off by a newly increased impact factor. For the 2012 edition of our Annals it has gone up to the new record value of **2.251**. The 5 years impact factor has also reached its highest value so far with 2.659.



We could also see major improvements in another segment of attention. The self- citations went significantly down from 35% in 2011 to **25%** in 2012, which is a good sign and indicates that the impact factor of this year is the result of citations from competitor journals in the field. Thus our efforts to make the CIRP annals visible all over the world and establish them as top ranking publication show again very good results. If the observed trend continues we will most likely approach download numbers beyond 450.000 per year for our annals, which is even from Elsevier's point of view an extremely impressive result.

Together with the team of Elsevier the Editorial Committee is continuously working to further reduce any formatting issues regarding the annals. Problems with equations and paper lengths were drastically reduced. However Elsevier is going to launch a complete new software package for paper handling soon, which should solve all remaining problems.

Following my proposals from April 2013 the General Assembly 2013 in Copenhagen has decided to give up the discussion cards in the individual STC sessions, which was already tested in Copenhagen and positively received by all members. Furthermore the requested enlargement of the number of Editorial committee members by 2 more fellows (from 12 including Chair and Vice-Chair to 14) was approved. Thus our team is ready to face the challenges of the future and the hopefully further rising number of excellent paper submissions to be considered for our annals.

Bernhard Karpuschewski
EC-Chairman

From the Research Affiliates

From startup to steady state

The precise reader may notice that I started the previous newsletter also with this section title. However, seeing the constant evolvement the RA network is under, I opted to leave it there. As the RA program started in 2007, this year the 6-year RA membership would expire for the first time. In fact, we had to say goodbye to 24 RAs who were with us from the very beginning: a sad thing. This year also 25 new RAs are admitted to the program and we can happily notice that the number of in- and outgoing members match. The total number of RAs is now 103 representing 24 different countries. The fact that about 25% of our network rejuvenated this year, really shows the strength of our network: a group of young outstanding researchers, (still) open minded, looking to bring in new ideas and explore unexplored fields of research free from pre-established concepts (quoting our CIRP president).

RA agenda

Looking ahead, this spring two interesting events are planned:

- 3rd CIRP Web Conference (CIRPe2014) on June 3-5, 2014.

  After the second successful web conference, the third is already in the making. To accommodate more outstanding papers this time a third day is added to the conference schedule. The abstract deadline is November 15 (2013), so you can still join us and submit your work. For more information visit: http://www.cirpe2014.unina.it/
- CIRP RA annual workshop, June 16-17, 2014 in Gjøvik University College, Norway.

  Rhythm Wadhwa has offered to organize the annual workshop in Norway. An excellent opportunity for the new 25% and the established RAs to meet and share ideas. To kick start the ideation process also this time a mini-workshop will be part of the schedule. The central topic for this will be decided in the January meeting in Paris.

Looking forward to seeing you in Paris.
Wessel Wits (CIRP RA Chairman)

Research Affiliates at the CIRP General Assembly, Copenhagen, August 2013.

From the STC's

Two STC's have presented their research program to the Corporate Members Meeting in Copenhagen. Here a short impression:

STC "E" presented by prof. Bert LAUWERS

STC E deals with research into material removal processes of a physical and/or chemical nature, such as electro-discharge machining (EDM), electrochemical machining (ECM) and the use of high energy laser, electron and ion beams.

There is a broad range of domains:

- RPM domain
- Aerospace
- Mould & Die Making
- Micro and nano engineering
- Medical applications
- General Engineering

- Meso, micro and nano scales machining of advanced materials
- ceramics,
- aerospace materials,
- materials for medical and chemical applications
- depositing noble metals

The STC actively participates in other groups like collaborative Working Groups on

- Bio manufacturing
- Hybrid Processes
- Additive Manufacturing
- Combined key-note papers
- Other collaborations world wide

The STC organizes every three years the CIRP conference on Electro Physical and Chemical Machining (ISEM), this year, Leuven with 150 participants (international) from academia and industry.

Further involvement in other conferences like:

- Lane (Germany)
- Bio-manufacturing
- High performance cutting
- Other conferences
- VRAP (Portugal)
- Solid Freeform Fabrication Symposium (SFFS)

Corporate members actively present and discuss their research work within this STC. Examples are:

- "Extending the field of applications of Electric Discharge Surface Modification", by R. Perez, M. Boccadoro (AGIE-Charmilles)
- "Precision ECM of High Pressure Common Rail Diesel Fuel System Component Mini-Features", by M.B. Grant (Caterpillar), H.J. Konietzni

Participation of corporate members is of significant importance, resulting in:

- Better understanding and knowledge of the industrial needs
- Industry can bring forward scientific questions
- Academic results can be discussed with industry members
- Set-up of academic-industry collaborations

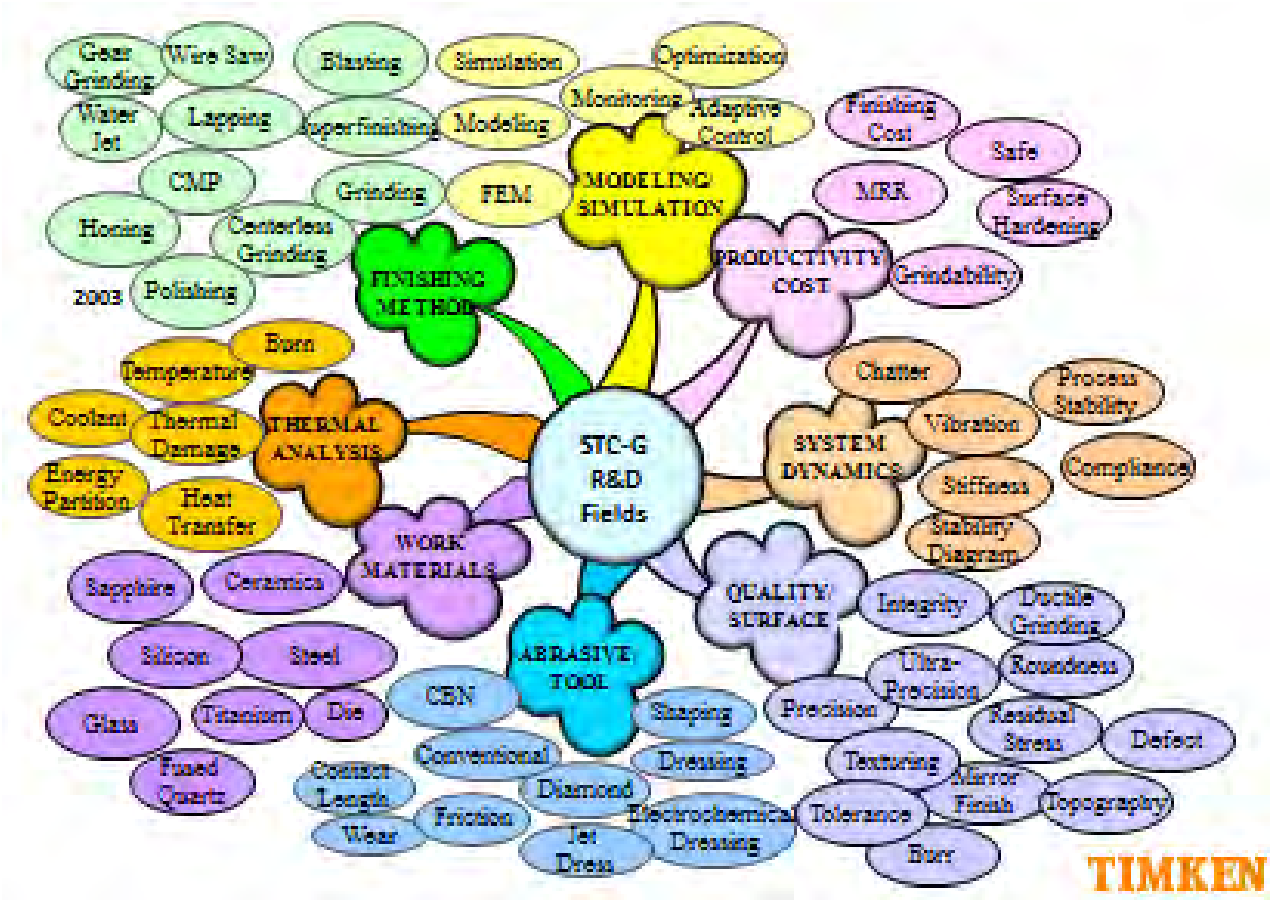
STC “G” presented by prof. Fukuo Hashimoto

Study and research into material removal processes using abrasive grains including grinding, lapping, polishing, superfinishing, jet finishing, mass finishing, etc. The research largely focuses on fundamentals of finishing processes, the integrity of finished surfaces and the economics of abrasive processes.

Main research topics are:

- Theoretical and experimental research in abrasive finishing processes
- Innovation and development of finishing technologies with fixed abrasive, free abrasive and flow abrasive tools
- Modeling, simulation and verification of abrasive finishing processes
- Optimization of technical and economic performance of the processes

A coherent figure of the expertise is given in the next figure

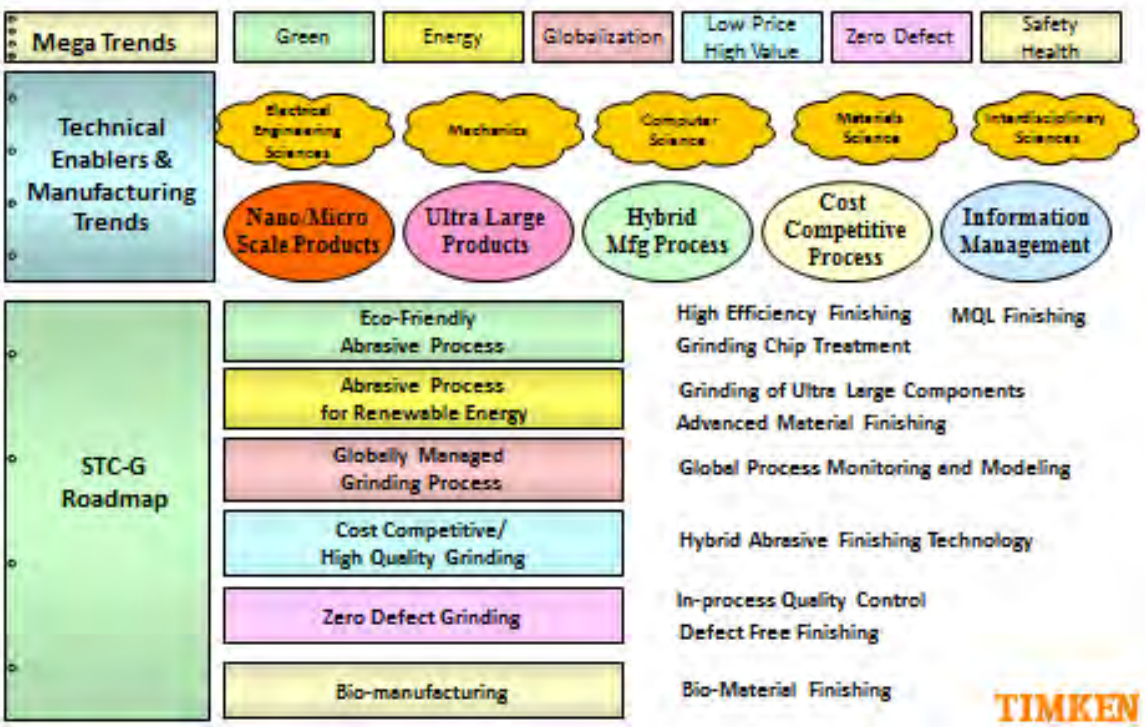


Requests to Corporate Members:

- STC-G needs more inputs/advices from corporate members
- STC-G looks for more participants from corporate members
- Corporate members can give the presentation about abrasive finishing technology or laboratory in their company at STC-G meeting

- STC-G needs to have keynote contributions from corporate members in Productivity/ Costs, Quality, Materials and the total manufacturing system
- STC-G needs to have more collaborative work with corporate members
- Corporate members should challenge CIRP colleagues to future R&D requirements

The STC G roadmap for the coming years is given below



Our Conferences

For the **most recent overview** of our coming conferences (CIRP conferences and CIRP sponsored conferences go to: http://www.cirp.net/meetings-conferences/view-cat/year.listevents/2013/10/31/-.html
A report of a conference held in March is given below:

23rd CIRP Design Conference 'Smart Product Engineering' - An excellent comeback of the CIRP Design Conference to Europe

After two editions in Asia (Daejeon 2011 and Bangalore 2012), the 23rd CIRP Design Conference has been held March 11th-13th, 2013 at the Ruhr-Universität Bochum (RUB), Germany. Conference chairmen were Mr. Prof. Abramovici (RUB) and Mr. Prof. Stark (TU

Berlin). Thanks to the participation of 170 academic and industrial delegates from 21 nations, this conference has been an unforgettable success.

Prof. M. Abramovici and Prof. R. Stark at opening ceremony (left), organizing committee presenting the conference proceedings (middle), and Prof. Bernard during Keynote presentation

A total of 98 papers have been chosen from over 160 proposals, presented during the conference in 28 sessions, and published in the conference proceedings. Particularly attractive have been the 9 keynotes presentations, thereof 7 from world-renowned companies (Contact Software, Dassault Systemes, Ford, Jaguar/Landrover, PTC, Shenyang Machine Tool, and Siemens), 1 from the European commission and 1 from the CIRP STC Dn chairman Mr. Prof. A. Bernard. The contribution of industrial partners as well as of the German Academic Society for Product Development (WiGeP) as co-sponsor has been crucial for the success of the conference. In addition to keynotes and sessions, a permanent industrial exhibition has been organized as meeting and exchange platform for academic and industrial delegates. Besides the formal conference program, world-class social events have been organized to promote discussions and networking between participants.

The conference topic - Smart Product Engineering - addressed two major aspects of modern product creation: the development of intelligent (‘smart’) products as well as the new (‘smart’) approach of engineering, explicitly taking into account consistent systems integration. Smart Product Engineering requires tremendous changes of both industrial products and engineering processes and is therefore a major driver for the 4th industrial revolution.

The next CIRP Design Conference, the 24th, will be held in Milano, Italy, on April 14th-16th, 2014. It will be co-organized by Politecnico di Milano – Mechanical Engineering Department (Prof. G. Moroni) and National Research Center of Italy – Institute of Industrial Technologies and Automation (Prof. T. Tolio). Thanks to the patronage of Lombardy Region, it will be hosted at the new Lombardy Region Palace, awarded by the CTBUH of Chicago in 2012 as the best European skyscraper for its design, sustainability and innovation. All the information on the conference, whose main topic will be “Mass Customization and Personalization”, may be found at www.cirpdesign-2014.it

August 2013, Bochum/Berlin, Germany and Milano, Italy.

Future Keynotes Papers

Our keynote papers are the result of an intensive collaboration between specialists working together during several years within an STC. They are important state of the art papers on important (new) technological areas. CIRP members who are willing to contribute are invited to contact the coordinator.

2014 Keynote Papers in preparation

STC	Proposed title	Coordinator/ first author	Contact
”A”	Grasping Devices and Methods in Automated Production Processes	M. Santochil	santochi@ing.unipi.it
“C”	Cutting Edge Micro Geometries	B. Denkena	denkena@ifw.uni-hannover.de
“Dn”	Tools & Techniques for Product Design	D. Lutters	e.lutters@utwente.nl
“E”	Turbo Machinery Component Manufacture by application of Chemical , Electrical, Physical & Photonic Processes	F. Klocke	f.klocke@wzl.rwth-aachen.de
“F”	Testing and Modelling of Material Behaviour and Formability in Sheet Metal Forming Processes	S. Bruschi	stefania.bruschi@unipd.it
“G”	High Energy Fluid Jet Machining	D.A. Axinte	dragos.axinte@nottingham.ac.uk
“M”	No Keynote in 2014		
“O”	Design and Management of Manufacturing Systen for Production Quality	T. Tolio	direzione.itia@itia.cnr.it
“P”	Industrial Applications of Computed Tomography	L. De Chiffre	ldch@mek.dtu.dk
“S”	Role of Surfaces and Interfaces in Solar Cell Manufacturing	A. Chandra	achandra@iastate.edu
Track	Hybrid Processes	B. Lauwers	bert.lauwers@mech.kuleuven.be

2015 Keynote Papers in preparation

STC	Proposed title	First authors	Contact
“A”	Automated Processes for joining of Dissimilar Materials	K. Martinsen	Kristian.Martinsen@sintef.no
“C”	High Performance Cutting of Advanced Aerospace Materials	R. M’Saoubi	rachid.msaoubi@secotools.com
“Dn”	Automating Design with Intelligent Human-Machine Integration	Yue H. Yin	alain.bernard@irccyn.ec-nantes.fr
“E”	Additive micro manufacturing using short laser pulses	A. Huis in't Veld	bert.huisintveld@tno.nl
“F”	Predicting and Controlling Product Properties in Metal Forming Processes	A.E. Tekkaya	erman.tekkaya@udo.edu
“G”	Abrasive Machining of Advanced Aerospace Alloys and Composites	F. Klocke	f.klocke@wzl.rwth-aachen.de
“M”	Materials in Machine Structures (internal)	H.C. Möhring	hc.moehring@ovgu.de
“M”	Virtual Machining (external)	Y. Altintas	altintas@mech.ubc.ca
“O”	Prognosis for cloud manufacturing	R. Gao	rgao@engr.uconn.edu
“P”	Measurement Technologies for Precision Positioning	W. Gao	gaowei@cc.mech.tohoku.ac.jp
“S”	Calibration and Verification of areal texture measuring instruments	R. Leach	richard.leach@npl.co.uk
Track	Metalworking Fluids – Mechanisms and Performance	E. Brinksmeier	brinksmeier@iwt.uni-bremen.de
Track	Virtual Machining of Parts	Y. Altintas	altintas@mech.ubc.ca

From the CIRP Office

Chantal Timar-Schubert

Annals papers/keynote papers submission process, CIRP meetings, the Website, candidatures for Membership, Internal Regulations and any internal information.

Agnès Chelet

Financial aspects: accountancy, membership fees, page charges, conferences sponsorships, January registration + Agendas & Minutes of the scientific meetings.

Don't forget to register online before January 13th (with your guest if any) if you intend to attend the next January meetings.

Fellows, Honorary and Emeritus Fellows can propose new candidates for Associate and Fellow membership, as well as nominations for the General Nicolau Award up to December 1st. Fellows can propose new Research Affiliates up to December 1st

Future CIRP Meetings

January meetings	**General Assemblies**
22-24 January 2014, Paris	24-30 August 2014, Nantes, France
21-23 January 2015, Paris	23-29 August 2015, Cape Town, South Africa
	21-27 August 2016, Guimaraes, Portugal

Changes in the I.R. voted last August 2013:

- The Discussion Cards for the paper presentations of the Annals have been cancelled.
- In front of the high number of papers proposed for the CIRP Annals, the GA has approved to raise the number of the Editorial Committee to 14 CIRP Fellows.

- Research Affiliates who will enter CIRP from next January 2014 will have to pay a small annual CIRP fee
- Taylor Medal: a complete nomination stating the qualifications of the candidate and indicating the scientific interest and practical value of the work should be sent to the CIRP Office by **May 1st** of the year of presentation of the candidate's paper.

EU-Japan Newsletter

CIRP regularly receives the EU-Japan Newsletter which might be of interest for our members. The October issue contains:

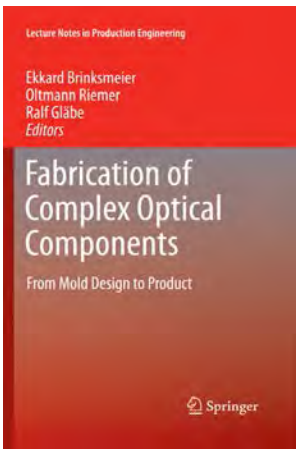
- EU-Japan Centre's news
- Training opportunities in Japan and in the EU
- New information platform on Japan for EU companies
- European Union Authorities news
- Japanese Authorities news
- EU & Japan business-related news
- Experts' corner
- Enterprise Europe Network - Japan news
- EU-Japan partnering opportunities
- News in brief
- Event calendar

For those who are interested please use the link to the latest issue: http://www.eu-japan.eu/sites/eu-japan.eu/files/october13.pdf

New Books

Fabrication of Complex Optical Components - From Mold Design to Product

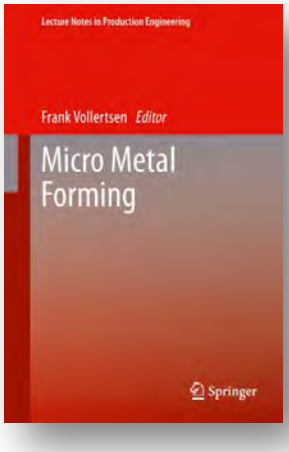
Edited by Ekkard Brinksmeier, Oltmann Riemer, and Ralf Gläbe



Photonics is a key enabling technology for many high-tech products serving large markets like consumer products. Optical components e.g., in video projectors, in digital cameras and in illumination optics are mostly fabricated by replication processes, as this is the most cost-effective way to produce complex optics in large quantities. In this field the Universities at Aachen, Bremen and Stillwater have pursued focused research on the manufacture of complex optics over a period of eleven years. The goal of this research effort was to combine the emerging technologies of optical mold making and glass or plastic replication processes on a broad basis. For obtaining a holistic view of the production process, these technologies were connected with integral optics design, a comprehensive metrology framework and quality management. The sum of all developed and investigated methods and processes, as well as the holistic view on all process chain relevant impacts, provides a fundamental step towards a deterministic process chain.
The book summarizes the major achievements gained within this concerted effort of research. It is organized according to the framework of process chains, process steps, technologies, and classification of optical surfaces.

Micro Metal Forming

Edited by F. Vollertsen



Micro Metal Forming, i. e. forming of parts and features with dimensions below 1 mm, is a young area of research in the wide field of metal forming technologies, expanding the limits for applying metal forming towards micro technology. In order to enable potential users like students, scientists and engineers in industry who already have a background in metal forming and like to expand their knowledge towards miniaturization, information about the following topics are given. All topics are discussed with respect to the questions relevant to micro metal forming:

- tribological behavior: friction between tool and work piece as well as tool wear
- mechanical behavior: strength and formability of the work piece material, durability of the work pieces
- size effects: basic description of effects occurring due to the fact, that the quantitative relation between different features changes with decreasing size
- process windows and limits for forming processes
- tool making methods
- numerical modeling of processes and process chains
- quality assurance and metrology.