21st CIRP CONFERENCE
ON ELECTRO PHYSICAL AND CHEMICAL MACHINING

Final Program

14th – 16th June 2022, Zurich Switzerland

www.isemxxi.ethz.ch
ISEM XXI happens in Zurich, and this time we are able to meet in person at our University and in the city of Zurich. We are very glad that we got this second chance, but anyway have still been forced by pandemic boundary conditions to at least open the possibility of online participation for presenters and attendants making ISEM XXI a hybrid conference with strong personal participation. We cordially welcome you now to the 21st CIRP Conference on Electro Physical and Chemical Machining, may it be online or personal. We have the honour and pride to present to you industries, our institute, ETH Zürich and the wonderful city of Zurich, which is despite being not the capital the economical and cultural center of Switzerland. Zurich is embedded in the scenic landscape of the alps, which offers the possibility for impressive tours into the mountains. This was and still is one of the important challenges of the Swiss population. Since centuries Swiss people carved holes into the mountains to connect to each other and to create an infrastructure that enables to connect the north to the south. The latest major step in this infrastructural master plan was the inauguration of the Gotthard Basistunnel in 2016, which was at that time with 55 km the longest tunnel of the world.

Switzerland today is a major manufacturing country, besides hosting also important banks. Having been the poorest country in Europe in the beginning of the 19th century Switzerland’s wealth is based on manufacturing. It is by that an archetype society for demonstrating the role of manufacturing for fulfilling sustainable development goals of the UNO. Thus, today comparing countries by value of produced machine tools per capita and year Switzerland leads by far. In a wider sense the region around the Alps is Europe’s machine tool area, within which approximately one fourth of the world’s machine tool production takes place, and Zurich is in its center. From here major machine tool companies as well as manufacturers of all different kinds of goods can easily be reached.

Switzerland played and still plays a major role in the development of one of ISEM’s major topics, electrodischarge machining. After invention in Russia it were the two Swiss companies Charmilles Technologies S.A. in Geneva and AGIE S.A. in Losone, now united under the roof of GF Machining Solutions, who made the major developments towards industrialization of this technology. Also in the production of laser machining systems Switzerland plays an important role, hosting two of the world class players in this field. All non-conventional manufacturing technologies existing today are applied here in this vital manufacturing environment. Innovativeness in manufacturing is the key asset of Switzerland enabling manufacturing in one of the most expensive countries worldwide.
Today it is mostly the non-conventional technologies that produce completely new manufacturing routes. Non-conventional manufacturing technologies typically are considered to overcome weaknesses of conventional technologies mostly in terms of materials, geometries, quality and surface integrity and even productivity. Research in this field therefore aims to further develop the strengths and overcome weaknesses of the individual technologies, which unites these technologies in trends beyond the everlasting tasks in manufacturing research of increase of productivity, quality, reliability, scope of eligible materials and reduction of ecologic footprint. Characteristic for these non-mechanical technologies is that tools are defined not by their geometry, but by differential field equations, where the boundary conditions are the geometry of the work piece. Concentrating power to the process zone requires extreme gradients of state variables. Therefore, process understanding, process modelling and process observability becomes much more difficult and even simplifying meta models for the daily use in industry are lacking. Thus, process modelling, process observation are major targets of actual ongoing research. These topics are not self-sufficient but aimed for a better control of the processes. Here also the re-discovered capabilities of artificial intelligence will complement and cooperate with physical modelling in future. This indicates the next trend of Industry 4.0 at the same time challenge and opportunity. Digital twins for machines, processes and workpieces will be combined not only for a better understanding of manufacturing systems but to gain an overview in daily manufacturing practice. And it also needs to be mentioned that the non-conventional processes need to prove their justification in the metrics of sustainability.

A vital role plays the cooperation between industry and academia in this area of process technologies. To promote and deepen this collaboration is one of the most important goals of the ISEM XXI conference. We are proud of a strong industrial participation despite the adversities of present times and very much appreciate the generous sponsoring of Georg Fischer Machining Solutions, DMG Mori, Agathon, Posalux, Sarix, IBAM, Oerlikon, 6c-tools, Swiss Photonics, Swissmem, and inspire.

We would like to sincerely thank the CIRP conformance committee, international advisory and scientific committee and all contributors to the conference.

ISEM has set the benchmark for online conferences in COVID19 times. We nevertheless go back to the traditional way of conferencing to the benefit of networking and cross fertilization which is so important especially for the ISEM technologies dealing all with similar topics. But we keep some elements of the online way of life. It is a ridge walk to not jeopardize the presence conference and at the same time offer the opportunities of cyber conferences. We will synchronously provide the presentations on the conference platform, and we allow also some presentations being given via internet. We hope that we can by this at best serve the community’s wishes.

Konrad Wegener

Conference Chairman ISEM XXI

On behalf of the local organizing committee
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3D MICRO EDM MACHINING
https://www.sarix.com/en/

SWISS PHOTONICS
https://www.swissphotonics.net/home

IBAM
https://ibam.swiss/de/home-2-main-de/

6C
https://6c-tools.ch/en/

Oerlikon
https://www.oerlikon.com/metco/de/
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### International Scientific Committee

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<td>Marco Boccadoro</td>
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### International Advisory Board

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<td>Wansheng Zhao</td>
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VENUE

ETH Zürich

In 1855, the Swiss Federal Institute of Technology (ETH) was founded mainly as a school for engineers, but also as a compensation to Zurich for not being the capital city of Switzerland. Between 1861 and 1864, the impressive main building was created by Gottfried Semper. Ever since it was first founded, ETH Zurich has been a driving force behind Swiss industry, whose innovative products and services are in demand worldwide. In the history of ETH, many well-known scientists and 21 Nobel prize winners are associated with this school. 21,400 students, including 4,180 doctoral students, from over 120 countries are matriculated in 16 departments of all technical and scientific disciplines.

The City of Zurich

More than 2000 years ago Zurich was founded by the Romans as a fortress. Today Zurich has about 400'000 inhabitants and is the largest city in Switzerland. Zurich is the main town of a canton also named Zurich. The city has a picturesque downtown with many tourist attractions and is located at the end of the Lake of Zurich. Zurich is not only important for its universities but is also the commercial centre of Switzerland and a platform for international trade.

Switzerland

Switzerland is well known for its food (especially chocolate and cheese), skiing in Zermatt, Gstaad, St. Moritz and many other famous places in the alps, hiking in the Engadin or watching the mountain panorama out of the Glacier-Express train. Many famous places of interest are very close to Zurich and easy to reach by train. Enjoy some days before or after the conference at the Lake of Lucerne, on the Jungfraujoch, the Rheinfall of Schaffhausen or at many other beautiful landmarks.
# PROGRAM OVERVIEW

<table>
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<tr>
<th>Day</th>
<th>Monday 13.06.2022</th>
<th>Tuesday 14.06.2022</th>
<th>Wednesday 15.06.2022</th>
<th>Thursday 16.06.2022</th>
<th>Friday 17.06.2022</th>
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<td>Morning Program</td>
<td>OPENING Keynote Presentations</td>
<td>Parallel Sessions</td>
<td>Lunch Break</td>
<td>IWF Lab Visit @ ETH Zürich</td>
<td>Company Visits: Inspire AG MAN Energy @ Technopark</td>
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<tr>
<td>Afternoon Program</td>
<td>Lunch Break</td>
<td>Parallel Sessions</td>
<td>Lunch Break</td>
<td>Company Visit: SUNCAR HK @ Technopark</td>
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<td>Evening Program</td>
<td>Welcome Reception @ ETH Zürich</td>
<td>Gala Dinner @ Haus z. Rüden</td>
<td>Networking Event @ ETH Zürich</td>
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WELCOME RECEPTION

The Welcome Reception is held the evening before the conference start to welcome the participants at ETH Zürich. It is a casual event with barbecue and drinks taking place at the “Alumni Pavillon” on Polyterrasse, from where there is a magnificent view over the city and the mountain landscape.

Location: Alumni Pavillon, Polyterrasse, ETH Zürich
Connection: Polybahn to “Polyterrasse” or Tram 6 or 10 to “ETH/Universitätsspital”
Parking: Parking places in the close proximity: “Parkplatz USZ Süd” and “Rämibühl”
When: 13.06.2022, 6 PM
GALA DINNER

The “Haus zum Rüden” (house of the hound) was built in 1348. An association of noblemen built a tavern in which the Council occasionally met with approximately two hundred members between 1348 and 1400. The impressive feature of this tavern is the magnificent, eleven meter-wide curved wooden ceiling with the carved timber heads, which is today the “Gothic Room” Restaurant. The “Haus zum Rüden” is situated in the heart of the old town close to Bahnhofstrasse and Paradeplatz and offers a beautiful view on the Limmat river.

Homepage: haus-zum-rueden.ch
Location: Limmatquai 42, 8001 Zürich
Connection: Tram 4 or 15, to “Rathaus” or “Helmhaus”.
Parking: Parking garages in the close proximity: “Hohe Promenade” and “Urania”
When: 14.06.2022, 7 PM
NETWORKING EVENT

The ETH Faculty Restaurant (“Dozentenfoyer”) is located in the main building of ETH Zurich, which was built from 1858 to 1864 under Gustav Zeuner; the architect was Gottfried Semper, who was a professor of architecture at ETH Zurich at the time and one of the most important architectural writers and theorists of the age. The rooftop of the “Dozentenfoyer” is an ideal place for networking while watching the sunset at the end of a conference day.

Homepage: ethz.ch/staffnet/en/service/events/dozentenfoyer.html

Location: Dozentenfoyer, Main Building (K-Floor), ETH Zürich

Connection: Tram 6 or 10 to “ETH/Universitätsspital”

Parking: Parking places in the close proximity: “Parkplatz USZ Süd” and “Rämibühl”

When: 15.06.2022, 7 PM
LOCATION OVERVIEW

The conference is held in the historical main building (Hauptgebäude) of ETH Zürich, located less than 1 kilometer from the train station in the city center and about 10 kilometers from Zurich airport (ZHR). Tram 10 directly connects ETH Zürich with both the airport (Flughafen) and the main train station through “Bahnhofplatz/HB”.

To reach the other event locations, Tram 4 departs from “Central” to “Technopark” for the company visits as well as to “Rathaus” for the gala dinner.
COMPANY VISITS

The company visit starts on the 17.06.22 at 8.30 AM at ETH Zürich CLA A5 with a tour through the labs of the Institute of Machine Tools and Manufacturing (IWF). The meeting point is the entrance of the CLA building in Tannenstrasse (MAP I). For the following visits, the participants may use public transport to get to Technopark (MAP II). It is recommended to use Tram 4 from “Central” (direction: “Altstetten”) to “Technopark”. The first company to visit here is inspire AG. As a strategic partner of ETH Zürich, inspire AG is the leading Swiss competence center for technology transfer to the mechanical, electrical and metal (MEM) industries. From there, MAN Energy Solutions will be visited. In the heart of Zurich, MAN Energy Solutions produces both axial as well as centrifugal compressors, mainly for the oil and gas industry. Lunch will be served back in Technopark and afterwards the SUNCAR HK will be visited. SUNCAR HK specializes in the electrification of construction machines, utility and municipal vehicles.
## SESSION OVERVIEW

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<td>Keynote 4</td>
<td>Keynote 5</td>
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<td>Coffe Break</td>
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<td>15:00-15:15 Coffe Break</td>
<td>15:15 Closing remarks</td>
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- **HG E5**
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- **HG F30**

- **ECM/ECDM**
- **AM**
- **EDM**
- **ST**
- **LMP**
KEYNOTE ABSTRACTS

Authors: Umang Maradia, Moritz Wiessner, Marco Boccadoro

Title: Evolution of EDM through technology push and application pull

EDM is a key material removal process utilized in the manufacturing of molds, dies, punches, parts in practically all fields of technology. EDM as manufacturing technology is driven by requirements such as material removal, accuracy, and geometry complexity, ease of use, reliability and cost of ownership.

The evolutionary steps in EDM have always been driven by the market challenges (market pull) on the one hand and through new available technologies, creating solutions to reply to the market needs (technology push) on the other hand. In the early days of EDM, innovations were mainly dominated by mechanical improvements and developments in CNC technology to improve automation and geometric accuracy. In recent decades, EDM technology has benefited greatly from the innovation and growth of the semiconductor industry and power electronics, as electrical components are at the heart of the process to generate and control discharges. The tremendous advances in technology have made new industrial applications possible. Digitization, machine learning combined with real-time data analysis will shape the innovations and trends of the future to meet market demands for "first time right parts" and unmanned production shifts.

Author: Adam Clare

Title: The electrolyte jet - a tool for machining and measurement

Electro-physical techniques allow for complex energy delivery methods which do not rely on shear alone in order to liberate material. In this talk we will explore the innovations made in enhancing the use of electrochemical jets from the perspective of precision and material removal but also its use as an analytical tool. Focus will also be given to emergent applications for this nascent technology.
This builds upon three innovative techniques developed within our team over the last 10 years. In addition the use of electrolyte jet processing for self-diagnosis and metrology will be discussed.

Through electro-physical modification of the electrode gap in electro-chemical jet techniques, precision has been shown to be greatly increased. Repeatable kerf widths approaching the diameter of the nozzle are demonstrated and the individual contributing effects are quantified across energy density and length scales. This allows the feature resolution achievable through electrochemical jet processing to be comparable to other surface structuring techniques, albeit with zero thermal loading of the surface. This is applied to demonstrate the machining of complex geometric features, not previously produced by electrolyte jet techniques. The talk will conclude by highlighting recent developments in this area and highlight industrial case studies.

**Author:** Eckart Uhlmann

**Title:** Novel advances in machine tools, tool electrodes and processes for high-performance and high-precision EDM

High-performance electrical discharge machining (EDM) is a key technology for manufacturing high-precision components in a broad range of industrially relevant applications. Formation of debris in the working gap leads to electric arcs and short circuits on the surface and related inaccuracies and process instabilities. Despite decades of research in the field of EDM excessive tool wear and limited process performance are still challenging. In order to overcome highly complex state of the art challenges dedicated processes, machine tools, peripheral systems, software, tool electrodes and technologies for the application of alternative dielectric fluids have been developed. Within this work novel advances in the development of a sophisticated dry-ED milling machine tool including generator and process control technology based on open architecture, open source software and commonly available machine tool components are shown. Solutions for challenges regarding remaining debris and gas bubbles as well as related electric arcs and short circuits in sinking EDM are presented by new flushing methods, technologies and devices. A new system for inverse pressure flushing of the dielectric fluid in ED-drilling
enables a removal of the debris and gas bubbles through the interior channels of the tool electrode with high efficiency. A new multi-fluidic ED-drilling spindle system provides the ability of using performance and material related application of gaseous, near-dry and liquid dielectric fluids sequentially within a single machining process. Recent advances in tool electrode design, tool electrode material application, modification and production led to essential process improvements. A helical tool electrode design improved flushing conditions and related material removal rate in ED-drilling significantly. Modification of ED-drilling tool electrode surfaces by thermal oxidation of copper shows a promising approach for decreased occurrence of ineffective discharges. The application of a specific mesophase-pitch carbon fibre with a diameter of \( df = 10 \mu m \) using a new process and handling technology enabled drilling holes with a diameter of \( dh = 25 \mu m \). Next to the shown advances in EDM, efficient development of new process technologies could be enabled by using a specially adapted natural analogue algorithm software tool.

Authors: Andreas Schubert, Viet D. Buia, Ingo Schaarlschmidt, Thomas Berger, André Martin

Title: Developments in Powder Mixed EDM and its perspective Application for targeted Surface Modification

Although widely studied over the few decades, there are conflicting theories on the discharge mechanisms of powder mixed electrical discharge machining (PMEDM). Additionally, the dielectric flow plays a vital role in the distribution of powder particles in the machining gap, which significantly affects the powder deposition to the modified surface. This study aims to verify the separation mechanism of a single discharge in PMEDM. To do so, single discharge investigations have been performed when silver nano-powder is mixed into the hydrocarbon-based dielectric fluid to modify Ti6Al4V surfaces. Surface topography, chemical composition as well as the deposited silver content and distribution over the crater surface when using positive and negative polarities are analyzed and discussed. Current and voltage waveforms of PMEDM and EDM without powder at varying discharge energies as well as with and without ultrasonic vibration assistance are recorded and analyzed. For the transfer of fundamental results to a perspective application, CFD simulation is used to calculate the flow field of the dielectric fluid and analyze the velocity and
distribution of the nano-powder within the working gap of a setup with internal flushing. The results show that PMEDM is a potential technology for machining medical devices with simultaneous antibacterial surface modification.

**Authors:** Johannes Henrich Schleifenbaum

**Title:** Rapid alloy development

Additive Manufacturing (AM) technologies offer the possibility of manufacturing complex parts which cannot be manufactured using conventional manufacturing technologies. AM technologies such as Laser Powder Bed Fusion (LPBF) feature unique processing conditions which are characterized by small melt pool sizes and high cooling rates up to 107 K/s. Despite these differences to conventional manufacturing technologies, mostly well-established conventional alloys are applied which are not adapted to AM process particularities. There are only a handful of alloys such as Scalmalloy® specifically designed for AM processes. Alloy development is a time and resource consuming process without a guarantee for success. In addition, no other conventional manufacturing technology can reproduce the unique processing conditions of LPBF which makes the targeted development of new materials even harder. A possible solution to overcome these challenges are rapid alloy development (RAD) approaches. Integrated Computational Materials Engineering (ICME) employs thermodynamical simulations of expected phases and solidification simulations to gain further insight into the microstructure (e.g. cell size, dendrite arm spacing) and resulting properties. Promising alloys are then further tested experimentally in the AM process, usually in a first step by dry mixing of multiple elemental or pre-alloyed powders. The third step of the process uses custom pre-alloyed powders for a final alloy characterization.

**Author:** Markus Bambach

**Title:** AM+X: potentials of combining additive and die-based manufacturing processes

Additive manufacturing (AM) processes are often praised for their unique cost structure. Compared to die-based manufacturing processes, they are claimed to allow for individualization, lightweighting and complexity for free. In spite of these advantages, their industrial take up in the field of
metallic components is still relatively slow due to the fact that AM suffers from a rather high cost level. Especially in small batch and one-off production, engineering costs and lead times keep cost per part at a high level. Likewise, large parts and large lot sizes are expensive to produce by AM processes. One may hence wonder whether, in the space spanned by part complexity, part size and lot size, combinations of AM with die-based processes such as forming or casting (referred to as X below) are more cost-efficient, and, almost equally important, easier to plan and qualify than AM processes alone. This keynote gives an overview of recent developments in hybrid AM processes that combine die-based metal forming and dieless AM processes. Two types of process chains are analyzed, (1) chains in which the preforms are made by forming and intricate part features are made by directed energy deposition, and (2) combinations in which AM preforms are formed to reduce porosity and to convert the microstructure in order to increase part performance. At the example of aerospace titanium parts it is shown where AM+X offers advantages compared to AM in terms of cost and part properties.
# SESSION CONTRIBUTIONS

**Tuesday 14.06.2022**

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* keynote lectures
### Keynote session: Tuesday 09:00-10:30 in HG F30

**U. Maradia, M. Wiessner**  
Evolution of EDM through technology push and application pull

**M. Boccadoro:**  
The electrolyte jet – a tool for machining and measurement

### Tuesday Sessions 10:45-12:15

#### Session EDM 1 in HG F30

- **PROCIR-D-21-01338** Kai Oßwald  
  White Layer Thickness Variation in Die Sinking EDM

- **PROCIR-D-22-00007** Georg Wälder  
  Active Corrosion Control in Wire EDM of carbide punches

- **PROCIR-D-21-01250** Dalibor Drzajic  
  Virtual Operators with Self and Transfer Learning Ability in EDM

#### Session AM 1 in HG E7

- **PROCIR-D-21-01284** Clemens Maucher  
  Investigation on anisotropic behavior of additively manufactured maraging steel during orthogonal cutting

- **PROCIR-D-22-00027** Indira Dey  
  CA single track simulation of laser conduction welding with stainless steel 316L (1.4404)

- **PROCIR-D-21-00504** Mohammad Rabiei  
  Ultrasonic-Assisted Laser Metal Deposition (LMD) of Steel 316L

#### Session ECM/ECDM 1 in HG E5

- **PROCIR-D-21-01256** Muhammad Hazak Arshad  
  Experimental Investigations into Machining Characteristics of Niobium Carbide Cermet with μECM / hybrid laser-μECM.

- **PROCIR-D-21-01279** Elio Tchoupe  
  Towards in-process evaluation of the precise electrochemical machining (PECM)

- **PROCIR-D-21-01260** Florian Sous (pres. by Lukas Heidemanns)  
  Experimental analysis on the accuracy of two dimensional curved cuts in wire ECM

#### Session AM 4 in HG E33.1

- **PROCIR-D-21-01339** Julia Förster  
  Electrophotographic Powder Application for Metal Powder bed based Additive Manufacturing (Online)

- **PROCIR-D-21-00501** Mikel Madarieta Churrucu  
  Geometrical study of 5356 aluminium alloy by means of a concentric wire laser metal deposition (LMD) (Online)

- **PROCIR-D-21-00497** Menghua Wu (pres. by Shengyuan Yu)  
  Research on "slice" layer height and width additive manufacturing by maskless localized electrodeposition method (Online)
Tuesday 13:15-15:15

**Session: EDM 2 in HG F30**

- PROCIR-D-21-01255  Ugur Küpper (pres. by Elio Tchoupe)  Prediction of Geometrical Accuracy in Wire EDM by Analyzing Process Data
- PROCIR-D-21-01258  Lukas Welschof  Influence of the WEDM rim zone on material specific thermo-physical properties
- PROCIR-D-21-01232  Masanori Kunieda  Simulation of Wire EDM Combined with Measurements of Discharge Locations and Wire Displacement
- PROCIR-D-21-01257  Raphael Hess  Simulation based derivation of rim zone properties caused by thermal loadings during EDM process

**Session: AM 2 in HG E7**

- PROCIR-D-21-00541  Daniel Knüttel  Height prediction in Directed Metal Deposition with Artificial Neural Networks
- PROCIR-D-21-00488  Hiroya Kobayashi  Synergy Effect of Abrasive Blasting and Large-area EB Irradiation on Surface Finishing of AMed Titanium Alloy
- PROCIR-D-21-00537  Daniel Kirkman  Process Development for the Freeform Deposition of a Glass Fiber Reinforced Photopolymer
- PROCIR-D-21-00517  Rico Weber  In-situ integration of piezoelectric stacks with laser-based powder bed fusion

**Session: ECM/ECDM 2 in HG E5**

- PROCIR-D-21-01243  Lukas Heidemanns  Thermographic in-situ investigation of precise electrochemical machining
- PROCIR-D-21-01247  Ming Wu  Profile prediction in ECM using machine learning
- PROCIR-D-21-01283  Elio Tchoupe  Experimental setup for the investigation of the transport of different gas bubble sizes during electrochemical machining based on similarity theory using particle image velocimetry
- PROCIR-D-21-00532  Sei Nakano  Wire electrochemical finishing of wire electrical discharge machined surfaces on the same machine
### Session: EDM 4 in HG E33.1

<table>
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<tr>
<th>Paper ID</th>
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<tbody>
<tr>
<td>PROCIR-D-21-00552</td>
<td>Mikhail Kliuev</td>
<td>Novel method of multi-axis EDM machining of thin-walled Al-Mn parabolic reflector for aerospace applications (Online)</td>
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<tr>
<td>PROCIR-D-21-00545</td>
<td>Xiaodong Yang</td>
<td>Study on discharge state detection of micro-EDM based on wavelet transform method (Online)</td>
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<tr>
<td>PROCIR-D-21-00540</td>
<td>Shinya Hayakawa</td>
<td>Influence of Working Surface Temperature on Area Effect in Electrical Discharge Machining Process (Online)</td>
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<td>PROCIR-D-21-00531</td>
<td>Yuangang Wang</td>
<td>Segmented manufacturing of micro-electrode based on EDM and its performance evaluation (Online)</td>
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**Tuesday 15:30-17:00**

### Session: EDM 3 in HG F30

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<tr>
<td>PROCIR-D-21-01229</td>
<td>Long Ye</td>
<td>Experimental investigations on micro-EDM milling of niobium carbide-nickel based cermet using statistical and empirical techniques</td>
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<tr>
<td>PROCIR-D-21-01246</td>
<td>Marcel Olivier</td>
<td>Influence of Electrical and Thermal Conductivity of Cemented Carbides on the Wire EDM Process</td>
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<tr>
<td>PROCIR-D-21-01262</td>
<td>Lisa Marie Rickerts.</td>
<td>Electrical discharge machining of dental implants in ultrasonic stimulated dielectric (Online)</td>
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### Session: AM 3 in HG E7

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<tr>
<td>PROCIR-D-21-01238</td>
<td>Eleonora Ferraris</td>
<td>Development of a free-form piezo-resistive pressure sensor using advanced printing methods</td>
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<td>PROCIR-D-21-00533</td>
<td>Johannes Alois Vetter</td>
<td>Development of a Material Extrusion Additive Manufacturing Process of 1.2083 steel comprising FFF Printing, Solvent and Thermal Debinding and Sintering</td>
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<tr>
<td>PROCIR-D-22-00032</td>
<td>Jodok Weixler</td>
<td>Picosecond pulsed laser machining of hardened martensitic stainless steel drive shaft</td>
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### Session: ECM/ECDM 3 in HG E5

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<tr>
<td>PROCIR-D-21-00522</td>
<td>Murali Sundaram, (pres. by Yu-Jen Chen)</td>
<td>Predicting the sparks occurrence in electrochemical discharge machining by machine learning using convolutional neural networks (Online)</td>
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<tr>
<td>PROCIR-D-21-00496</td>
<td>EGASHIRA Kai</td>
<td>Electrochemical machining of microrods using a self-drilled hole (Online)</td>
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<tr>
<td>PROCIR-D-21-00507</td>
<td>Shuhei Kodama</td>
<td>Fabrication of nanostructure and deposition of metal particles by femtosecond laser ablation in electrolyte (Online)</td>
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<tr>
<td>PROCIR-D-21-00677</td>
<td>Observation of EDM gap phenomena of single pulse discharge under different environments (Online)</td>
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<td>Xiaodong Yang</td>
<td>(pres. by Qi Li)</td>
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<td>PROCIR-D-21-00530</td>
<td>Experimental study on hybrid electrical discharge and mechanical truing of coarse diamond grinding wheel V-tip (Online)</td>
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<td>Yanjun Lu</td>
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<tr>
<td>PROCIR-D-21-00536</td>
<td>Significant Improvements of Machined Surface Qualities by Electrical Multi-channel Discharging in Precision Manufacturing (Online)</td>
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<td>Ming Zhou</td>
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## Keynote Session

**Wednesday 15.06.2022**

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<td>E. Uhlmann*</td>
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<td>A. Schubert*</td>
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*keynote lectures

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**Keynote Session:** Wednesday 08:15-09:45 in HG F30

- **E. Uhlmann**
  - Novel advances in machine tools, tool electrodes, and processes for high-performance and high-precision EDM

- **A. Schubert**
  - Viet D. Buia,
  - I. Schaarschmidt
  - T. Berger
  - A. Martin
  - Developments in Powder Mixed EDM and its perspective Application for targeted Surface Modification

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Wednesday Sessions 10:00-12:00

**Session: EDM 6 in HG F30**

- **PROCIR-D-21-00495** Marco Corrado Boccadoro - About a new method to enhance the productivity of die sinking EDM
- **PROCIR-D-21-01228** Robert Bolz - Validation of different tungsten carbide-cobalt grades as tool electrode material for sinking EDM
- **PROCIR-D-21-00549** Izaro Ayesta (pres. by Jun Wang) - Study on the influence of the actual industrial constrains during WEDM roughing of Fir Trees on Inconel 718 disks
- **PROCIR-D-21-01241** Tomohiro Sawada - Development of WEDM Simulation with Parameters Adaptively Changed using Wire Electrode Displacement Sensor

**Session: ECM/ECDM 4 in HG E7**

- **PROCIR-D-21-01230** Krishna Kumar Saxena - A ‘virtual sensing’ framework for μECM/hybrid laser-μECM for monitoring interelectrode gap conditions
- **PROCIR-D-21-00679** Wataru Natsu - Influence of electrolyte flow on transfer characteristics of electrochemical machining for micro-hole
- **PROCIR-D-21-00493** Scott Sneddon - Precision improvements in ECM via tool insert development by 3D printing
- **PROCIR-D-21-00550** Thomas Van Riel - Exploratory study of wire based ECM finishing of 316L stainless steel, implemented within a hybrid wire EDM-ECM platform

**Session: ST 1 in HG E5**

- **PROCIR-D-21-00534** Yifei Yang - Experimental study of processing γ-TiAl by blasting erosion arc machining (Online)
- **PROCIR-D-21-00547** Kelin Li - Study on Residual Stress of Blasting Erosion Arc Machined Ti6Al4V and TiAl Alloys (Online)
- **PROCIR-D-21-00553** Mikhail Kliuev - Hybrid method of stainless steel machining by Ti-Al-N coated tool in electrical discharge ionised gas (Online)
- **PROCIR-D-21-00544** Ming Pingmei - Fabricating Ultrahigh Strength and High Accuracy Nanostructured Microcomponents Using Ultrafine-anode Scanning Through-mask Electrodeposition (Online)
**Session: EDM 8 in HG E33.1**

PROCIR-D-22-00029 Jian Wang  
Experimental study of EDM milling of 3D-shaped diffuser for film cooling holes on turbine blades  
(Online)

PROCIR-D-21-00529 Zuyuan Yu  
Influence of the punch with concave cutting-edge on the blanking force in micro punching process  
(Online)

PROCIR-D-21-01251 Min Zhang  
Measurement of Axial Orientation of Film Cooling Holes by EDM Based on a Laser Sensor  
(Online)

PROCIR-D-22-00029 Jicheng Bai  
The Electrode Wear and Effective Energy Detection in Micro-EDM Drilling of Micro-hole Array  
(Online)

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**Wednesday Sessions 13:00-15:00**

**Session: EDM 7 in HG F30**

PROCIR-D-21-00528 Adriano Nasciuti  
Data-driven statistical analysis for discharge position prediction on Wire EDM

PROCIR-D-21-00518 Shogo Kimura  
Influence of Nozzle Jet Flushing in Wire EDM of Workpiece with Stepped Thickness

PROCIR-D-21-00521 Masahiro Yoshida  
Study on Slicing of Conductivity SiC Ingot by Oil and Water type WEDM

**Session: ST 2 in HG E7**

PROCIR-D-21-01261 Mohammad Dadgar (pres. by Timm Herrig)  
Effect of a Single Particle in Abrasive Waterjet Machining on 42CrMo4 Modifications

PROCIR-D-22-00026 Cedric Bessire (pres. by Alexander Küenzi)  
Jet Application of Plasma Electrolyte Polishing

PROCIR-D-21-01244 Uroš Hudomalj  
Effect of particle size distribution width on repeatability of coating characteristics in atmospheric plasma spraying

PROCIR-D-21-00680 Wataru Natsu  
Simulation investigation of influence of particle focusing on the machined surface of ECM process  
(Online)
Session: ST 3 in HG E5
PROCIR-D-21-00489  Togo Shinonaga  Study on Smoothing of Hole Wall Surface by Electron Beam Polishing under Control of Magnetic Field
PROCIR-D-21-00500  Noah Fredrick Graff  Modelling, Simulation and Control of Roll-to-Roll Physical Vapor Deposition Processes
PROCIR-D-21-00520  Menghua Wu (pres. by Yuqing Xiao)  Effect of process parameters on growth pattern of micro-nickel column in mask-less localized electrodeposition (Online)
PROCIR-D-21-00394  Xiangyu Zhang  High-speed cutting titanium alloys with increasing tool life and increasing compressive residual stresses by ultrasonic vibration cutting (Online)

Session: EDM 9 in HG E33.1
PROCIR-D-21-01234  Ling Qin  Characterization of plasma discharge channel in EDM using photography and spectroscopy (Online)
PROCIR-D-21-01235  Qiang Gao  Kinematic Modeling and Error Analysis of Cradle-type WEDM (Online)
PROCIR-D-21-00543  Yonghong Liu (pres. by Xinlei Wu)  Research on green dielectric fluids of high-efficient electrical discharge assisted arc milling (Online)

Wednesday Sessions 15:15-16:45
Session: LMP 1 in HG F30
PROCIR-D-21-00524  Amarachi F. Obilor  Laser Processing of Polymers for Surface Energy Control of Biomedical Implants
PROCIR-D-21-00506  Nikita Levichev  Experimental validation of a machine learning algorithm for roughness quantification in laser cutting
PROCIR-D-21-01336  Nicola Giandomenico  Development of an OCT system for measuring machining defects on a texturing laser machine

Session: AM 5 in HG E7
PROCIR-D-22-00025  Maicol Fabbri  Preliminary investigation of a fast temperature prediction approach for simple thin-walled parts produced with Wire Arc Additive Manufacturing
PROCIR-D-21-01237  Zhen Zhang  Numerical and experimental study on wettability of Ti6Al4V micro-nano structure surface fabricated by laser induced plasma micro-machining (Online)
**Session: ECM/ECDM 5 in HG E5**

- **PROCIR-D-21-01242** Hongping Luo
  - Bipolar nano-second pulse power supply for electrochemical micromachining of tungsten carbide without tool wear (Online)

- **PROCIR-D-21-01252** Feng Wang
  - Experimental Research on Chemical Polishing of Metal Capillary Inner wall for Laser-Assisted Electrochemical Machining (Online)

- **PROCIR-D-21-01263** Yongwei Zhu
  - Mechanism and Experiment Study on Multi-dimensions Rotary Ultrasonic Composite Electrochemical Evolution Machining (Online)

**Session: EDM 10 in HG E33.1**

- **PROCIR-D-21-01240** Jicheng Bai
  - Study on overlap rate of discharge craters based on finite-continuous pulse discharges (Online)

- **PROCIR-D-21-01240** Jingyu Pei
  - Experiment study on low stiffness electrode vibration in air under the impact of discharge (Online)

- **PROCIR-D-21-00494** Bin Xu
  - Applying micro-EDM in the drilling process of PCB micro hole to eliminate the hole nail head (Online)
Thursday 16.06.2022

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<td>M. Bambach*</td>
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* keynote lectures
** chairman

Keynote session: Tuesday 08:15-09:45 in HG F30

J.-H. Schleifenbaum  Rapid alloy development

M. Bambach  AM+X; potentials of combining additive and die-based manufacturing processes
Thursday Sessions 10:00-12:00

**Session: LMP 2 in HG F30**
- PROCIR-D-21-01245 Balasubramanian Nagarajan: Femtosecond laser processing of cemented carbide for selective removal of cobalt
- PROCIR-D-21-01248 Manuel Müller: Software-based setpoint optimization methods for laser cutting machine tools
- PROCIR-D-21-01236 Alexander Wittmann: Laser-based coating process of PEEK powder on stainless steel substrates by using a thulium-doped fiber laser
- PROCIR-D-22-00030 Haider Butt: Printing Nanostructure Holograms on Contact Lenses via Direct Laser Ablation

**Session: EDM 11 in HG E7**
- PROCIR-D-21-01254 Timm Petersen: Size and speed of ejected particles from different cemented carbide grades machined with sinking EDM
- PROCIR-D-21-01231 Mirsad Osmanovic: Comparing the performance of a nested to a continuous evolution strategy with covariance matrix adaption for optimization of drilling EDM
- PROCIR-D-22-00028 Lin Jiang, Masanori Kunieda: Investigation of Influential Discharge Parameters on Machining Characteristics Generated by the LC Pulse Generator
- PROCIR-D-22-00033 Paulo Matheus Borges Esteves: Single crater dimensions and wire diameter influence on Wire-EDM

**Session: ECM/ECDM 6 in HG E5**
- PROCIR-D-21-00525 Koki Matsuzawa: Electrochemical machining using the circulation of machining fluid in an electrode (Online)
- PROCIR-D-21-00519 Peixuan Chen: Investigation on the electrochemical etching of tungsten in alkaline electrolyte (Online)
- PROCIR-D-21-00515 Ningsong Qu: Optimizing the Cathode Structure in Electrochemical Milling (Online)
- PROCIR-D-21-00516 Ze-Xiang Liu: Research on the Influence of RCUECM on Side Clearance of Micro-small Holes (Online)
### Thursday Sessions 13:00-15:00

**Session: EDM 14 in HG F30**
- **PROCIR-D-21-00678** Wenting Gu: Relationship between Discharge Reaction Force and Bubble Behavior in Wire Electrical Discharge Machining
- **PROCIR-D-21-00539** Jun Wang: Insight on Relation between Discharge Delay Time and Machining Parameters in Wire EDM

**Session: LMP 3 in HG F30**
- **PROCIR-D-21-00505** Manuela Pacella: Functionalised polycrystalline boron nitride materials via laser surface engineering
- **PROCIR-D-21-01233** Jide Han: Influence of material composition on nanosecond pulsed laser micromachining of zirconia-alumina composites

**Session: EDM 12 in HG E7**
- **PROCIR-D-21-00523** Shixian Liu: Optimization of Dielectric Oil Viscosity for High-precision Wire EDM
- **PROCIR-D-21-00527** Ryoji Kitada: Influence of surface roughness of die sinking EDM on mold releasability in compression molding of thermosetting phenol resin
- **PROCIR-D-21-01249** Haoyu Chu: Observation of molten material and recast layer distribution of fast EDM drilling on inclined surface (Online)
- **PROCIR-D-21-00538** Xiaodong Yang: Study on characteristics of EDM using pulse power supply with active high-frequency oscillation (Online)

**Session: EDM 13 in HG E5**
- **PROCIR-D-21-00681** Atsutoshi Hirao: Effect of Electrode Shape on High Aspect Ratio Deep Hole Drilling by EDM (Online)
- **PROCIR-D-21-00682** Chenxue Wang: Observation of Bubbles Behavior in EDM with Ultrasonic Vibration (Online)
- **PROCIR-D-21-00542** Tomohiro Koyano: Measurement of Wire Electrode Temperature in Wire Electrical Discharge Machining by Two-color Pyrometer with Optical Fiber (Online)
- **PROCIR-D-21-00859** Yan-Xin Sun: Spatial Planetary Movements for Multi-Axis EDM (Online)
With the **new high-end CUT X series**, GF Machining Solutions makes use of its over 100 years of experience in wire-cutting EDM. The new CUT X series in the **Pininfarina design**, which includes the CUT X 350 and the CUT X 500 machines, features **new technologies that significantly increase operating precision**. The machines are capable of holding extreme pitch positioning and contouring capabilities for superb part quality, making them suited for stamping, molding and micro-machining applications in the electronic components (EC), medical and automotive markets.

For further information visit [www.gfms.com](http://www.gfms.com)
IWF RESEARCH GROUPS

**Abrasive Processes**

**Sawing and Grinding**

- **Glass grinding**
  A new process for edge grinding of glass with min. 50% increase in feed rate will be developed. With a holistic approach to the machine and its components, the new generation machine and tool will be introduced, while creating new business in grinding tools.

- **Coolant flow in grinding**
  Investigation of the impact of coolant flow on workplace and tool from CFD simulations to cylindrical grinding experiments.

- **CO₂ - cooled tool grinding**
  Alternative to conventional flood cooling with oil. Design of suitable nozzles, analysis of cryo jet, including cooling efficiency. Measurement and simulation of heat fluxes into wheel and workplace.

- **Diamond wire sawing**
  Kinematic process analysis and modeling, investigation of material removal of hard and brittle materials such as silicon.

- **Process simulation**
  Geometric-kinematic, particle method and CFD simulation of a wide range of abrasive processes and base materials.

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**Electric Discharge Machining**

- **Micro EDM**
  Research goals are the minimizing of structure size, maximizing the aspect ratio and the guarantee of high quality. High quality stands for no burr formation, low roughness and high form accuracy. Example: Micro-connections.

- **EDM Drilling & Shaping**
  Due to the entry angles and difficult to machine aerospace materials, EDM find opportunity as a potential machining process for cooling holes.

- **EDM Fundamentals**
  Discharge and plasma analysis by optical emission spectroscopy (OES) and high-speed imaging. Plasma parameters estimation and synthetic plasma spectra simulation.

- **Process Simulation**
  Geometric simulation that emulates the stochastic characteristics of the process, considering the geometric attributes of the electrodes and the different energy pulses.
Meshfree Methods in Machining Simulation

Cutting Simulation
Without mesh restrictions, particle methods accurately predict chip formation and other physical parameters.

Tool Development
Graph Processing Unit (GPU) enhanced algorithms largely shorten the computational time, and thus provide with possibility of fast development of cutting tools.

Material Modeling
Through reduced simulation time, inverse parameter identification or constitutive model and friction mode at extreme conditions can be achieved.

Laser Drilling
Based on the successful thermal modeling, optimization of process parameters can be achieved with higher efficiency.

Machine Tool Analysis
Simulation - Optimization - Metrology

MORe Simulation Tool
Mechanical, mechatronic, thermal, and thermo-mechanical simulation of machine tools brought to the point.

Static Optimization
Design and correction methods for high-precision machine tools under gravity loads.

Dynamic Optimization
Optimal control parameterization and structure design for high-dynamics machine tools.

Machine Tool Testing
Measurement of precision and dynamics. Geometric, kinematic and dynamic testing of machine tools.

Face Gear Application
Development of software tools for parameter studies and laser ablation process development.
Laser Ablation using Pulsed Laser Sources

Cutting tools

Grinding tools
Quasi tangential laser profiling and conditioning. Application: Cubic Boron Nitride (CBN) - and Polycrystalline Diamond (PCD) - composite grinding tools.

Surface adjustment

Parameter studies

Software development
Development of software tools for parameter studies and laser ablation process development.

Additive Manufacturing with Deposition Welding

Direct Metal Deposition
Welding of layered geometries with laser and metal powder for build up of coatings, geometries and repairs.

Wire Arc AM
Highly productive process with a electric arc and wire feedstock for build up of simple medium to large-scale metallic structures.

Laser Hardfacing
Hard surfacing with metal matrix composites. Application: Wear protection of tribologically stressed components.

DMD and Milling
Combines the high buildup rate of DMD with the accurate surface finish of milling in an alternating process and with a single clamping setup.

Micro structure simulation
Microstructure simulations in AM help to understand the solidification process and the evolution of crystals more in detail.
Powder Bed Additive Manufacturing of Metals

AM material systems
Alloys and advanced material systems for SLM. Example: SLM-processed metal matrix composites with diamond particles.

Powder qualification
Powder qualification methods and quantitative requirements for SLM.

SLM Process

AM-Machines
Advanced AM machine concepts and machine component optimization.

Intelligent applications
Industrial AM-applications with integrated sensors. Example: High pressure H2 valve with integrated sensors for condition monitoring.

Powder Bed AM of Polymers and Ceramics

Materials research
Development of new Additive Manufacturing (AM) powders (polymers and ceramics) in close collaboration with industry and research.

Powder Qualification
Understanding the process behavior of AM powders by particle/powder properties analyses, impact tools and knowledge.

Process Development
Process development for new polymer powders in a close to industry approach on commercial machine set-ups. Laser sintering of ceramics with post processing steps.

Applications
Acceleration sensor integration in polymer parts during running Selective Laser Sintering (SLS) process.

Qualifications
Innovation Center Virtual Reality

Real Walking in VR
Natural locomotion by real walking allows intuitive exploration of large-scale virtual worlds. The user is tracked and their walking behaviour is mapped to their virtual viewpoint.

Deep Learning for VR
Hand gesture recognition using Deep Learning in computer vision to assist blind and visually impaired people. Other research problems: Body pose estimation, scene graph processing and segmentation.

Training in VR
Virtual training presents many benefits over traditional real training (e.g. safety). But how can a topic be effectively and efficiently taught in VR?

Affective VR
Virtual environments reacting to individual users based on their emotional states, which are identified using eye tracking and other physiological measurements.

Collaboration in VR
Multi-user settings provide novel opportunities for product development, planning and project coordination among stakeholders.

Artificial Intelligence in Manufacturing

Assisted Optimisation
Support operators in finding optimal parameters for complex processes and cost functions efficiently.

Data Driven Modeling
Data driven approaches to fuse noisy sensor information for autonomous learning and prediction.

Enhanced Sensors
Enhanced sensors for data generation and interaction with the machine for control and prediction.

Shopfloor Data Flow
Data acquisition, transmission and structures for digital shadows of parts, processes, tools and assets in a factory.

Connectivity
Machine data acquisition and analysis with standardized interfaces (OPC UA - umati) and legacy machines connectivity retrofit.

For further information visit www.iwf.mavt.ethz.ch
LIST OF ISEM CONFERENCES

1960: ISEM I - Prague Czechoslovakia/Czechia
1966: ISEM II - Brno, Czechoslovakia/Czechia
1970: ISEM III - Vienna, Austria
1974: ISEM IV - Bratislava, Slovakia
1977: ISEM V - Wolfsberg, Switzerland
1980: ISEM VI - Cracow, Poland
1983: ISEM VII - Birmingham, UK
1986: ISEM VIII - Moscow, Russia (USSR)
1989: ISEM IX - Nagoya, Japan
1992: ISEM X - Magdeburg, Germany
1995: ISEM XI - Lausanne, Switzerland
1998: ISEM XII - Aachen, Germany
2001: ISEM XIII - Bilbao, Spain
2004: ISEM XIV - Edinburgh, UK
2007: ISEM XV - Pittsburgh, USA
2010: ISEM XVI - Shanghai, China
2013: ISEM XVII - Leuven, Belgium
2016: ISEM XVIII - Tokyo, Japan
2018: ISEM XIX - Bilbao, Spain
2021: ISEM XX - Zürich, Switzerland (Online conference)
2022: ISEM XXI - Zürich, Switzerland