2022 ISNM SYMPOSIUM ON

NON-CONVENTIONAL MANUFACTURING:

MICRO, NANO, ATOMIC AND CLOSE-TO-ATOMIC SCALE

PROGRAMME & ABSTRACTS

17 December 2022 | Changchun, China

Online

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Tsinghua University, China

Nanomanufacturing and Metrology, Springer Nature

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PREFACE

Aiming to promote academic exchange for people who work in the field of manufacturing. The International Society of Nanomanufacturing (ISNM) has organized a series of symposia, namely ISNM Symposium on Nanomanufacturing (ISN) since 2022, in addition to the well-established biennial conference, i.e., International Conference of Nanomanufacturing (nanoMan). ISN is a platform for international youth scientists, technical specialists, and entrepreneurs to jointly discuss the development trends and exchange the up-to-date research progresses in the manufacturing area. ISN is organized annually including different sessions for specific fields. Each session can be organized either simultaneously or independently within a year.

"Non-conventional manufacturing: micro, nano, atomic, and close-to-atomic scale" is one of the sessions of ISN in 2022, also jointly organized by Jilin University, and Tsinghua University, in Changchun, China. 5 keynote speeches and 5 invited presentations about non-conventional micro/nano manufacturing, atomic and atomic-to-close scale manufacturing (ACSM) technologies will be presented in this ISN session. With the restriction of COVID-19, this ISN session is organized online so that more attendants can be involved.

I wish the symposium a great success!

Prof. Wei Gao

on behalf of

International Society for Nanomanufacturing

17 December 2022

2022 ISNM SYMPOSIUM ON *NON-CONVENTIONAL NANOMANUFACTURING:*

micro, nano, atomic, and close-to-atomic scale

SCHEDULE IN SUMMARY

Saturday, 17 December 2022				
08:40-16:50 Registration	08:40-09:00	Opening Ceremony		Online: Tencent Meeting ID: 294-989-058 Password: 121234
	09:00-09:35	Keynote Speech	1	
	09:35-10:10	Keynote Speech	2	
	10:10-10:20	Coffee Break		
	10:20-10:45	Invited Speech	3	
	10:45-11:10	Invited Speech	4	
	11:10-11:35	Invited Speech	5	
	12:00-13:30	Lunch		
	13:30-15:05	Keynote Speech	6	Online: Tencent Meeting ID: 294-989-058 Password: 121234
	14:05-14:40	Keynote Speech	7	
	14:40-14:50	Coffee Break		
	14:50-15:25	Keynote Speech	8	
	15:25-15:50	Invited Speech	9	
	15:50-16:15	Invited Speech	10	
	16:15-16:25	Closing Ceremony		
ISNM young scientists committee	16:30-18:30	Round-Table Meeting		Online

PROGRAMME

Online: Tencent Meeting ID: 294-989-058; Password: 121234

Opening Ceremony		
Chair: Prof. Qi-Dai Chen, Jilin University, China		
08:40-09:00	Opening Ceremony	Prof. Shuming Yang (Xi'an Jiaotong University, China)
Chair: Prof. Xinghui Li, Tsinghua University, China		
09:00-09:35	Keynote Speech	Title: Advanced plasma processing technology and its applications across TRLs Prof. Nan Yu, the University of Edinburgh, UK
09:35-10:10	Keynote Speech	Title: Development and Application of Large Area Nanometer Precision Diffraction Grating Prof. Wenhao Li, Changchun Institute of Optics,Fine Mechanicsand Physics, China
Chair: Prof. Wenhao Li, Changchun Institute of Optics,Fine Mechanicsand Physics, China		
10:20-10:45	Invited Speech	Title: Ultrafast laser micromachining with precisely controlled profiles Prof. Shaolin Xu, Southern University of Science and Technology, China
10:45-11:10	Invited Speech	Title: Ultrasonic micro/nano manufacturing of bioinspired functional surfaces Prof. Jianjian Wang, Tsinghua University, China
11:10-11:35	Invited Speech	Title: GaN: Beyond Its Ultralow Wear Nature Prof. Guosong Zeng, Southern University of Science and Technology, China
Chair: Prof. Linhan Lin, Tsinghua University, China		
13:30-14:05	Keynote Speech	Title: Fundamental and Application Research of Micro Electrochemical Machining Prof. Wei Han, Fudan University, China
14:05-14:40	Keynote Speech	Title: Two-axis Lloyd's mirror for interference lithography of planar gratings Prof. Xinghui Li, Tsinghua University, China
Chair: Prof. Wei Han, Fudan University, China		
14:50-15:25	Keynote Speech	Title: Laser additive manufacturing of functional nanomaterials Prof. Linhan Lin, Tsinghua University, China
15:25-15:50	Invited Speech	Title: Femtosecond laser advanced manufacturing technologies and applications Prof. Yanlei Hu, University of Science and Technology of China, China
15:50-16:15	Invited Speech	Title: Femtosecond laser-induced nanogratings for eternal data storage Prof. Lei Wang, Jilin University, China
Closing Ceremony		
16:15-16:25	Prof. Xiaokang Liu (Chongqing University of Technology, China)	
16:30-18:30	ISNM young scientists committee	

Keynote

Advanced plasma processing technology and its applications across TRLs

Dr. Nan Yu

The University of Edinburgh, UK

Abstract

Atmospheric plasma technology - discharging plasma in the air - has been under development for several decades and has many benefits over vacuum technologies: in surface engineering applications, there is no limit on component size and processing can be undertaken much faster as there is no requirement for a vacuum chamber. Atmospheric plasma generation has many other applications beyond surface engineering, which includes increasing the range planes can fly on a certain amount of fuel, increasing the energy efficiency of solar energy plants, creating functional nanomaterials, chemical analysis for forensics, advanced engine combustion, and decontamination of microorganisms: fungi, bacteria and viruses.

This talk introduces advanced plasma processing technologies, and a wide range of applications across Technology Readiness Levels (TRLs), from plasma figuring of ultraprecision optics, material surface treatment, to a potential approach for Atomic and Close-to-atomic Scale Manufacturing in the era of Manufacturing III.

Keywords: Plasma processing, surface modification, nanomanufacturing, ACSM

Biography

Dr Nan Yu is an Assistant Professor and Deputy Director of MSc Digital Design and Manufacture at the University of Edinburgh. His research focuses on precision manufacturing and advanced plasma technologies, with 25 journal and 20 conference papers, 4 conference awards, 10 invited talks. He has secured totally over £ 500 K as

PI from Horizon-MSCA, Royal Society, IRC, etc. He was Marie Curie International Fellow (2018-2020) and Irish Research Council Fellow (2020-2021).

He sits in the International Scientific Committee of EUSPEN and organizing committees of the 8th nanoMan (Dublin 2022) and the 15th LAMDAMAP (Edinburgh 2023). Dr Yu is CIRP Research Affiliate (2021-2024) and Co-Chair of the EPSRC Early Career Forum in Manufacturing Research (2023). He is nominated as a Fellow of Royal Society for Art, Manufacture and Commerce (RSA) in 2022.

Keynote

Laser additive manufacturing of functional nanomaterials

Prof. Linhan Lin

Tsinghua University, China

Abstract

Nanomaterials synthesized through wet chemistry own excellent crystallinity, surface quality, tailorable size and shape, and excellent optical or optoelectronic properties. However, the manufacturing of such nanomaterials into various two-dimensional and there-dimensional micropatterns for diverse device applications remains challenging so far. Harnessing the light-matter interaction at nanoscale, we develop a couple of optical tools to assemble these nanomaterials into arbitrary nano- or micro-structures. Specifically, we explored the opto-thermo-mechanic coupling which provides various light-controlled external force for precise nanoparticle manipulation and interparticle bonding. The precise organization of nanoparticles of intriguing optical properties into designer metamolecules enables new functionalities beyond single particles. More recently, we proposed the photo-excitation-induced chemical bonding strategy and achieved high-resolution 3D printing of nanoparticles such as semiconductor quantum dots and metallic nanoparticles.

Keywords: additive manufacturing; laser printing; nanomaterials; optical assembly

Biography

Professor Linhan Lin is an associate professor in the Department of Precision Instruments at Tsinghua University. He received both his B.S. (2008) and Ph.D. (2013) degrees in Materials Science and Engineering from Tsinghua University. He worked at the University of Michigan–Dearborn and UT-Austin as a postdoc between 2014 and 2019, and joined Tsinghua University as an associate professor. He is interested in interdisciplinary research to innovate optical nanotechnologies in advanced manufacturing and quantum photonic devices. He is a senior member of Optica and COS.

Keynote

Fundamental and Application Research of Micro Electrochemical Machining

Young Researcher: Wei Han

Fudan University, China

Abstract

Electrochemical machining (ECM) is a machining method that removes materials by the anodic dissolution process of electrochemical reaction. It has the advantages of good surface quality, independent of material hardness, no heat-affected layer, and no tool wear. With the application of ultra-short pulse current, micro-ECM has developed rapidly in the past few decades. The anodic dissolution region can be limited in the micro-scale region by utilizing the electric double layer formed on the electrode surfaces, enabling significant advantages in the field of micron-scale processing. The report introduces the fundamental and application research of ultra-short pulse current ECM which focusing on the machining challenges of easily passivated and difficult-to-machine metals. The report includes bipolar ultra-short pulse current ECM, conformal ultra-smooth electropolishing, and atomic and close-to-atomic scale (ACSM) ECM.

Keywords: Atomic and close-to-atomic scale manufacturing; Electrochemical machining; Ultra-short pulse current;

Biography

Dr Wei Han received his BS degree in Materials Forming and Control Engineering from Jilin University, Changchun, China, in 2010, MS degree in Mechanical Engineering from Xiamen University, Xiamen, China, in 2013, and Ph. D. degree in Precision Engineering from The University of Tokyo, Tokyo, Japan, in 2016. During 2016-2021, he worked as a researcher, post-doctoral research fellow, Marie Skłodowska-Curie research fellow, assistant professor at The University of Tokyo and

University College Dublin, and joined Fudan University in 2021 as a young researcher. He has published 16 papers in SCI journals including Int J Mach Tools Manuf, CIRP Ann, J Mater Process Technol, J Manuf Process, and Precis Eng. He was awarded the National Natural Science Fund for Excellent Young Scientists Fund Program (Overseas) and Shanghai Leading Talent (Overseas) - Youth Project.

Keynote

Development and Application of Large Area Nanometer Precision Diffraction Grating

Prof. Wenhao Li

National engineering research center for diffraction gratings manufacturing and application of China,

Changchun Institute of Optics, Fine Mechanics and Physics,

Chinese Academy of Sciences, China

Abstract

Large area high-precision diffraction grating is widely used in spectral analysis, laser, displacement measurement, optical communication and other fields. It is an indispensable core component of inertial confinement nuclear fusion device, large astronomical observation equipment, synchrotron radiation light source and other important national scientific projects. The modulation of light field by micro-scale groove precision and distribution determines the diffraction efficiency and wave front of grating macroscopic characteristics. Based on the development trend of large-area high-precision gratings, the report analyzes the effect of grating diffraction efficiency and wave front on groove parameters, and introduces the key technologies that the team has conquered in the production of meter-scale nano-precision gratings. The echelle grating with the largest area 400mm×500mm in the world and the 650mm×1700mm domestic largest monomer non-jointing holographic grating have been developed. The gratings developed by the team have been applied in the national strategic high-tech fields such as large optical system and high-end lithography machine industry, which provides the core device support for China's high-tech strategic deployment.

Keywords: meter-scale holographic grating, diffraction efficiency, diffraction wavefront, nano-precision fabrication.

Biography

Professor Wenhao Li received his PhD degree in Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences. His areas of research include design and manufacture of nanometer precision grating, high energy laser diffraction components, high precision displacement measurement technology.

Keynote Talk

Two-axis Lloyd's mirror for interference lithography of planar gratings

Associate Professor: Xinghui Li

Tsinghua University, China

Abstract

Interference lithography (IL) has advantages on arrayed microstructures fabrication with high throughput, period tunability, and cost-effectiveness over other state-of-the-art fabrication technologies, such as electron beam lithography (EBL), focused ion beam (FIB), photolithography and nanoimprinting. Recently, in IL, two-axis Lloyd's mirror able to fabricate sub-micron planar grating patterns over a large area with a high uniformity by using only one exposure without any mask need, has been studied. Details and key techniques of the two-axis Lloyd's mirror is introduced and demonstration is presented in this talk.

Keywords: Micro-nano fabrication, Interference lithography, Grating, Lloyd's mirror

Biography

Associate Professor Xinghui Li obtained his BS degree in Mechanical Engineering from Wuhan University, Wuhan, China in 2008, MS degree in Mechatronic Engineering from Xi'an Jiaotong University, Xi'an, China in 2011, and Ph.D. degree in Nanomechanics from Tohoku University, Sendai, Japan in 2014. He is currently an associate professor of Tsinghua University, China. His current research interests include precision optical fabrication and measurement, intelligent instruments, computer vision and machine vision. During the last several years, he has published more than 100 papers/proceedings, including 45 SCI-indexed regular articles, filed/granted more than 30 patents, and presided over 16 projects, including National Natural Science Foundation of China (1 general and 1 youth), National Science

Foundation of Guangdong Province (1 key and 1 general), China Postdoctoral Science Foundation Funded Projects (1 special and 1 general), and so forth.

Invited

Ultrafast laser micromachining with precisely controlled profiles

Prof. Shaolin Xu

Southern University of Science and Technology, China

Abstract

Precision machining of microstructures on hard-to-machine materials is primarily important for high added-value manufacturing. The emerging third-generation semiconductors as excellent materials for the further development of optical-electric industry are typical hard-to-machine materials, whose precision machining methods are still barren. Laser beam machining has been proven effective for processing those materials, yet precisely controlling cross-sections of laser-ablated microgrooves is still challenging due to the shielding effects of ablation debris and the limitation on achievable laser spot shapes. Here, an ultrafast laser precision machining technology based on laser-induced micro-jet assisted ablation (LIMJAA) is proposed, which can realize the microstructure machining from several microns to tens of microns on the surface of various typical hard-to-machine materials. A new geometrical model to accurately predict the femtosecond laser ablation process in thin liquid is established, considering the influence of laser polarization and secondary reflection during ablation. Based on the LIMJAA and beam shaping method, diversified microgrooves with controllable width and depth can be freely designed and manufactured, including symmetrical V/W/T-shape microgrooves, asymmetrical V-shape microgrooves, and multilevel microgrooves. The development of this technology provides a new general solution for the precision machining of hard-to-machine materials on the micron scale.

Keywords: Ultrafast laser micromachining

Biography

Dr. Xu is an associate professor at Department of Mechanical and Energy Engineering of Southern University of Science and Technology (Sustech), and a senior member of Chinese Mechanical Engineering Society (CMES). Dr. Xu got his PhD degree at Tohoku University in Japan under the supervision of Prof. Kuriyagawa Tsunemoto in 2015. After graduation, he continued to work as a JSPS research fellow and an assistant professor in the Nano-Precision Mechanical Fabrication Lab. of Tohoku University successively. He had successfully obtained JSPS (Japan Society for the Promotion of Science) Grants-in-Aid for Scientific Research (KAKENHI) twice in the area of ultraprecision mechanical micro-/nanofabrication technologies in Japan. In early 2017, Dr. Xu returned to China and joined in Department of Mechanical and Energy Engineering of Sustech. From then on, Dr. Xu began to establish an ultrafast laser micro-/nanofabrication Lab, focusing on developing new ultrafast laser micro-/nanofabrication technologies, the principles of interactions between ultrafast laser and materials, and the applications of laser-structured surfaces. Until now, Dr. Xu has published more than 20 peer-reviewed journal papers in such as Nature Communications, Laser & Photonics Reviews, Nano Letters, Advanced Optical Materials, International Journal of Machine Tools and Manufacture，International Journal of Extreme Manufacturing，International Journal of Mechanical Sciences.

Invited

Ultrasonic micro/nano manufacturing of bioinspired functional surfaces

Prof. Jianjian Wang

Tsinghua University, China

Abstract

High-end equipment in key national engineering fields, such as aerospace, medical equipment, and new energy, have increasingly higher requirements for the surface performance and functionality of the parts. Conventional surface treatment methods such as rolling and shot peening are unable to meet the application requirements of higher-performance equipment. In nature, various animals and plants use surface microstructures to improve their ability to adapt to the external environment. The bionic surface microstructure opens up a new technological approach for the performance and function control of engineering surfaces. Efficient and controllable equipment is an important guarantee for large-scale industrial applications of surface microstructures. At present, the fabrication of surface microstructures is still dominated by traditional non-mechanical methods. However, these methods generally have inherent problems such as low processing efficiency, harsh process conditions, unfriendly environment, multi-step processing, and complex procedures, which limit the further large-scale industrial applications of microstructures. On the other hand, machining methods represented by metal cutting have unique advantages of high efficiency and low cost in large-scale manufacturing methods. In response to the urgent need for high-efficiency and low-cost manufacturing technology for large-scale industrial applications of bionic surface microstructures, the new technology of surface microstructure processing based on ultrasonic cutting has been developing rapidly, and its excellent geometric shape control ability shows broad application prospects. It has achieved high-efficiency and flexible processing of a variety of difficult-to-process material microstructures and

difficult-to-process multi-scale complex structures and has obtained practical applications in cutting-edge fields such as bionic manufacturing of structural color.

Keywords: Ultrasonic micro/nano manufacturing, Structural color

Biography

Dr. Jianjian Wang received his bachelor's degree in Mechanical Engineering from Shandong University, Jinan, China, in 2011, and PhD degree in Mechanical Engineering from Tsinghua University, Beijing, China, in 2017. From August 2017 to January 2021, he did postdoctoral research at the Chinese University of Hong Kong, Northwestern University, and Karlsruhe Institute of Technology respectively. He was a Humboldt Research Fellow in Germany. From February 2021, he has joined Tsinghua University as an assistant professor. He has been granted by the Science Fund Program for Distinguished Young Scholars. His research interests mainly center on next-generation manufacturing processes and equipment, now mainly focus on the fundamental understandings of process mechanics and principles of vibration machining; to achieve technological advances in vibration tool design and control; and to explore novel applications in vibration enhanced manufacturing. At present, He has published more than 40 SCI/EI journal papers as the first or corresponding author in prestigious journals in the field of advanced manufacturing. These papers have gotten more than 1000 citations in the google database with an H factor of 19

Keynote/invited

Title

GaN: Beyond Its Ultralow Wear Nature

Prof. Guosong Zeng

Southern University of Science and Technology, China

Abstract

Gallium nitride (GaN) semiconductor has been extensively applied in light emitting diodes (LEDs), solar cells, power electronics, etc., as GaN and its ternary alloys span the major solar spectrum. The optoelectronics properties of GaN have been studied for decades for achieving advanced, reliable, high performance and multifunctional GaN-based devices. In stark contrast to the investigations of optoelectronics properties of GaN, there is still lack of the investigation of its tribological properties. There are challenges in implementing GaN-based devices in harsh working environments (e.g., space, desert) without better understanding the wear performance. Our research first reveal that GaN has remarkable wear performance with the wear rate approaching to that of diamond. Furthermore, with presence of water molecules, not only the wear rate of GaN increases over two orders of magnitude, but also the surface states of GaN has been markedly altered, resulted in further upward band bending. This finding links the mechanical shear to surface chemistry and modification of electronic properties of GaN. The ability to introduce band bending on the surface of GaN with spatial control is promising for applications in photovoltaics, photocatalysis and gas sensing.

Keywords: GaN, tribology, surface states, band bending, XPS

Biography

Professor Guosong Zeng received received Ph.D degree in Mechanical Engineering from Lehigh University in January 2018. His PhD research included investigation of mechanical properties of wide bandgap semiconductor materials, mechanochemistry mechanism of semiconductor thin films, as well as mechanochemical tunning of the band structure at the semiconductor surface. Then he joined Lawrence Berkeley National Laboratory as a postdoc. His postdoc work centered on synthesis and characterization of photoelectrodes for solar water splitting and CO2 reduction. His work has been published on several high impact journals, including Nature Materials, Nature Energy, Angew, Advanced Energy Materials, PNAS, ACS Energy Letters, etc. His current research area focuses on semiconductor tribochemistry and its application in the ultraprecision fabrication of semiconductor wafers; development of in-situ/online testing & analysis combined suite; artificial photosynthesis for hydrogen production and CO2 reduction.

Invited

Femtosecond laser advanced manufacturing technologies and applications

Prof. Yanlei Hu

University of Science and Technology of China, China

Abstract

Femtosecond laser micro/nanofabrication has been intensively studied for decades in the fields of micromechanics, micro/nanophotonics, microfluidics and biomedical engineering. However, severe drawbacks have counteracted its application which are the low efficiency caused by the time-consuming point-by-point scanning method and the inflexible direct processing strategy. In this talk, I give a brief review on our recent progress on high efficiency femtosecond laser processing technique and the laser-based hybrid fabrication strategy to broaden its applicability. Parallel laser processing method is developed by adopting digital computer holography to generate hundreds of foci for laser fabrication. A phase only spatial light modulator is utilized with computer generated holograms displayed. High-quality micro-optics and microfluidic structures are readily produced using the parallel method. To overcome the limitation of femtosecond laser direct fabrication, capillary force induced self-assembly is employed to construct active and tunable complex hierarchical structures, which is used in micro-grippers, SERS detection, and chiral optics. Moreover, soft lithography and wet-etching technologies are integrated with femtosecond laser processing to fabricate magnetically responsive high-aspect-ratio microstructures and brittle all-glass optofluidic microchips. Some application demonstrations on bio-inspired structured surfaces, microfluidic functional devices and micro-robots are presented to show the potential of highly efficient femtosecond laser fabrication and the derivative hybrid fabrication methods.

Keywords: Micro/nano-manufacturing, laser direct writing, functional nanostructures

Biography

Professor Yanlei Hu received his bachelor's and doctoral degrees from University of Science and Technology of China in 2007 and 2012, respectively. He has been engaged in scientific research at University of Science and Technology of China, Fraunhofer Institute of Laser Technology in Germany, Swinburne University of Technology in Australia, and Massachusetts Institute of Technology (MIT) in the United States. At present, he is mainly focused on the research of femtosecond laser micro-nano manufacturing and surface processing technology, aiming to use ultrafast laser to achieve micro-optical, micro-mechanical and other functional devices, as well as the efficient preparation of diversified functional surfaces. In recent years, he has presided over more than 10 projects including the National Natural Science Foundation of China, and published more than 100 papers in prestigious journals such as Nature Photonics, PNAS, Nature Communications, Advanced Materials, etc., with a total of more than 4,000 citations. The research results have been selected for more than 30 times such as journal covers, ESI high-citations, editor's picks and journal highlights. He is the youth editorial board member of the International Journal of Extreme Manufacturing and Nanomanufacturing and Metrology. He won the first prize of Natural Science Award in Anhui Province in 2020, the Top 10 Progresses of Chinese Optics in 2018, the Gold Medal of International Invention in Geneva in 2018, and the outstanding member of the Youth Promotion Association of the Chinese Academy of Sciences in 2021.

Invited

Femtosecond laser-induced nanogratings

for eternal data storage

Dr. Lei Wang

Jilin University, China

Abstract

The demand for data storage has extremely increased in the data era. High capacity medium is the top requirement to meet in which multi-dimension storage attracts great attention by increasing 1 bit per dot (state 0 or 1) to 8 bits per dot (any state of 0~255). In this means, artificial electromagnetic media with designable and discrete optical properties are introduced, for example, a dot with birefringent information providing two-dimension optical parameters and theoretically > 8 bits/dot at least. Herein, we will introduce polarized femtosecond laser-induced deep-subwavelength nanostructures which can generate birefringence in three-dimension space. A new type of structure was found, named Type X, having ultralow loss to realize phase (<1%) and high efficiency (>90%). 5 bits per dot and potentially 8 bits per dot were realized for five-dimension data storage. In addition, sub-diffraction was researched and less than 20-nm resolution was realized aiming for hundreds of TB per disc. In the future, we expect more dimensions will be utilized for PB (10^3 TB) or EB (10^6 TB) disc by introducing various metamaterials.

Keywords: Manufacturing; optical data storage; laser direct writing

Biography

Dr. Lei Wang is from College of Electronics Science and Engineering, Jilin University, Changchun, China. His research activities are focused on laser fabrications for data storage and laser-matter interactions.