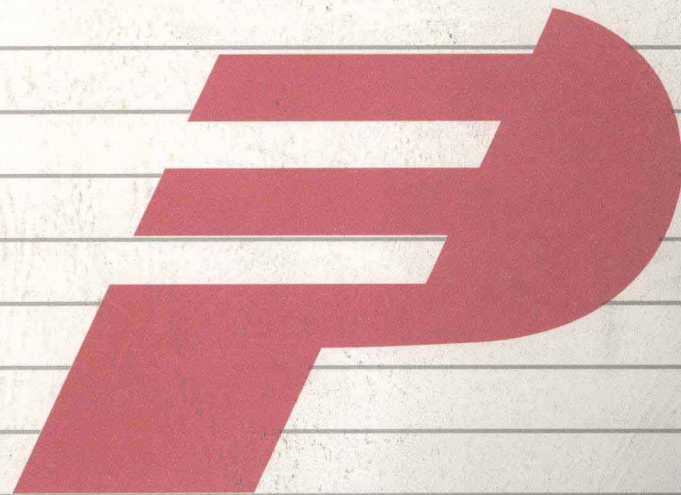


Proceedings

ASPE 2003 Annual Meeting

October 26-31, 2003



Proceedings of:

The Eighteenth Annual Meeting

The American Society for Precision Engineering

October 26-31, 2003

DoubleTree Jantzen Beach Hotel

Portland, Oregon

The American Society for Precision Engineering (ASPE) is a multidisciplinary professional and technical society concerned with research and development, design, manufacture and measurement of high accuracy components and systems. ASPE activities encompass relevant aspects of mechanical, electronic, optical and production engineering, physics, chemistry, and computer and materials science. Membership is open to anyone interested in any aspect of precision engineering.

Founded in 1986, ASPE provides a new focus for a diverse but important community. Other professional organizations have covered aspects of precision engineering, always as a sideline to their principal goals. ASPE is based on the core of generic concepts necessary to achieve precision in any application; independent of discipline, ASPE intends to be the focus for precision technology — and to represent all facets from research to application.

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Preface

This book comprises the proceedings of the 2003 Annual Meeting. The contributions reflect the authors' opinions and are published as presented to ASPE, without change. Their inclusion in this publication does not necessarily constitute endorsement by the ASPE, or its editorial staff.

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2003

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Raleigh, NC 27603

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Welcome Note

Welcome to Portland for the Eighteenth Annual Meeting of The American Society for Precision Engineering, co-sponsored by JSPE. The growth and success of the Society reflects the increasing importance of precision engineering in a wide variety of fields of endeavor, from manufacturing to microelectronics to basic science. The Society serves as a focus for precision engineers across all of these fields. The Annual Meeting has evolved into a premier international forum for the exchange of ideas and presentation of research results relating to precision engineering, metrology, controls, and system integration. Precision engineers and scientists from private industry, government laboratories, and universities meet to learn about the latest developments and to exchange ideas about the future directions of these technologies.

This year's meeting continues the tradition of offering two full days of tutorials—including 12 new tutorials—presented by some of the foremost precision engineers and scientists in the world. The technical sessions and poster presentations offer the latest research results in the areas of ultraprecision machining, metrology, controls, precision grinding, micro-positioning, material processing, design, precision transducers, surface profilometry, machine tool metrology, and error compensation. The commercial exhibit will provide attendees with the opportunity to view and discuss the latest precision engineering equipment, products, and services that are commercially available. The open forum will give attendees the opportunity to express their opinions and pose questions for discussion by the group, enhancing the exchange of information.

The conference organizing committee is proud to present the program for the Eighteenth Annual Meeting of the ASPE. We welcome your participation and your feedback on how to make next year's meeting even better.

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Program

2003 ASPE Annual Meeting

<i>Time</i>	<i>Sun., Oct. 26</i>	<i>Mon., Oct. 27</i>	<i>Tues., Oct. 28</i>	<i>Wed., Oct. 29</i>	<i>Thurs., Oct. 30</i>	<i>Fri., Oct. 31</i>
8:00	Registration	Registration	Registration			
9:00	Tutorials	Tutorials	Technical Session I	Technical Session III	Technical Session VI	Technical Tours
10:00			Break	Break	Break	
11:00			Technical Session II	Technical Session IV	Technical Session VII	
12:00						
1:00			Lunch and Committee Meetings	Awards Lunch and Business Meeting	Lunch and Roundtable Discussions	
2:00	Tutorials	Tutorials	Commercial Session	Poster Session	Technical Session VIII	
3:00			Break	Break		
4:00			Poster Session	Technical Session V		
5:00			Hospitality Hour	Hospitality Hour		
6:00				Open Forum		
7:00		Keynote Address				
8:00		Welcome Reception	Off-site Dinner Banquet			
9:00						

Business Forum

Monday, October 27, 8:00 a.m. - 4:00 p.m.

*Session Co-Chairs: William J. Bryan, 3M Company and
Andrew J. Devitt, New Way Machine Components*

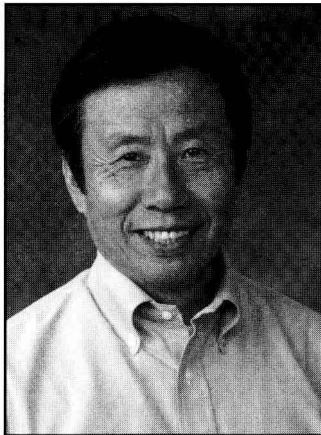
The ASPE Business Forum is open to all attendees of the annual meeting and will be of particular benefit to those with interests in business or the management of technology. The program will combine business and technology issues pertinent to leaders in the precision engineering community. It will be held this year on Monday October 27, 2003, just prior to the start of the formal ASPE meeting and overlapping one day with the Tutorial Program. The program will consist of morning and afternoon talks, a lunch break, and ample time to network with speakers and other attendees. The forum should conclude by mid-afternoon. Sustaining Corporate Sponsors of the ASPE are welcome to send one attendee to the Business Forum free of charge. Additional participants from the same Sustaining Corporate Sponsor, Corporate Sponsors, or from other organizations will be charged a fee of \$250.

Keynote Address

Milton Chang

Monday, October 27, 6:30 p.m.

Session Chair: Michele H. Miller, Michigan Technological University



"Confessions of a Technical Entrepreneur"

Dr. Milton Chang will share his insights on entrepreneurship which he learned the hard way over thirty years. Starting off as a research engineer and having been on both sides of the fence as an entrepreneur and as an investor, he will present a balanced view on how to go about learning, preparing, starting, and managing a business as well as working effectively with venture capital investors. He is a strong believer that entrepreneurship can be a satisfying and productive career for engineers, and will look back and reflect on his experience as a student, an engineer, a businessman, an angel investor, and a venture capitalist.

Milton Chang is Managing Director of Incubic (www.incubic.com), a venture fund in Silicon Valley "to help entrepreneurs build great companies." He earned a BS with Highest Honors from the University of Illinois, and MS and Ph.D. degrees from the California Institute of Technology, all in Electrical Engineering. Milton worked briefly as a research engineer before joining a startup company to begin his entrepreneurial career. He was president/CEO of Newport Corporation and New Focus, and has incubated more than a dozen companies with nearly a perfect record. He is currently on the boards of Arcturus Engineering, Lightwave Electronics, OEpic, OpVista, Rockwell Scientific, and YesVideo. He is active in the technical community and has received a number of prestigious awards. He was recently President of the IEEE Laser Electro-Optical Society, and writes monthly business columns for Laser Focus World and Photonics Spectra.

2003 Annual Meeting

Contents

<i>Preface</i>	<i>ii</i>
<i>Welcome Note</i>	<i>iii</i>
<i>Organizing Committee — 2003 Scholarship Recipient</i>	<i>iv</i>
<i>Sponsor Members</i>	<i>vi-vii</i>
<i>Cooperating Sponsors—Technical Exhibitors</i>	<i>viii</i>
<i>Program</i>	<i>ix</i>
<i>Keynote Address</i>	<i>x</i>
<i>Commercial Session/Open Forum</i>	<i>1</i>
<i>Technical Paper Index</i>	<i>2-10</i>
<i>Technical Papers</i>	<i>13-594</i>
<i>Authors Index</i>	<i>595-598</i>

Commercial Session

Tuesday, October 28, 1:30 - 3:00 p.m.

Session Chairman: Alex Sohn, North Carolina State University

The Commercial Session will take place early in the week on Tuesday afternoon. This is a special session where company representatives are invited to make brief presentations (five minutes) on new products associated with precision engineering. This provides participants with the opportunity to receive timely information on new technologies that have been commercialized into products and services, as well as information on advances that can be expected in the near future.

Open Forum

Wednesday, October 29, 5:30 - 6:30 p.m.

Session Chairman: Eric R. Marsh (The Pennsylvania State University)

The Open Forum was created to encourage dissemination of new and significant results, as well as observations on precision engineering subjects and other topics of interest to the Society. So bring your overheads, problems, and experiences to this enlightening hour of impromptu discussions! Signup sheets will be available at the conference registration table.

Technical and Poster Sessions Index

The technical program for the 2003 ASPE Annual Meeting contains over 150 papers on precision engineering advances. Papers that lent themselves to significant verbal interaction, concise but important discoveries, or strongly visual or tactile subjects have been selected for the poster session. Authors will be present to discuss their work on Tuesday, October 28, from 3:30 to 5:00 p.m., and again on Wednesday, October 29, from 1:30 to 3:00 p.m.

Session I

Micro Manufacturing

Tuesday, October 28, 2003, 8:15 AM - 10:00 AM

Session Chair: E. Clayton Teague (National Science and Technology Council/NIST)

1. **Achieving Precision Through System Engineering (Invited Paper)**
van Eijk, J. (Delft University of Technology/Philips CFT); Soemers, H. M. J. R. (Twente University of Technology/Philips CFT); and Franse, J. (Philips CFT) page 13
2. **Dimensional Challenges in Printhead Micromachining and Inkjet Writing Systems (Invited Paper)***
Saul, K. (Hewlett Packard Corporation)
3. **Microtechnology-based Energy and Chemical Systems and Multi-scale Fabrication (Invited Paper)**
Paul, B. K.; Drost, K. M. (Oregon State University) page 19

Session II

Optical Systems and Metrology

Tuesday, October 28, 2003, 10:30 AM - 12:00 PM

Session Chair: Vivek G. Badami (Corning Tropel Corporation)

1. **High-NA Interference Microscopy of Complex Surface Structures (Invited Paper)**
de Groot, P. J.; Colonna de Lega, X.; Grigg, D. A. (Zygo Corporation) page 23
2. **Interferometric Thickness Measurement of Free Form Silicon Wafers**
Jansen, M.; Haitjema, H.; Schellekens, P. H. J. (Eindhoven University of Technology) page 27
3. **Roundness, Angle, Straightness and Waviness Measurements on Recessed Cones Using Scanning White-light Interferometry**
Colonna de Lega, X.; de Groot, P. J. (Zygo Corporation) page 31
4. **Stabilization for Atomic Tracking Control of the Scanning Tunneling Microscope Tip by Referring Regular Crystalline Surface**
Aketagawa, M.; Rerkkumsup, P.; Takada, K.; Togawa, Y.; Thinh, N. T.; Kozuma, Y. (Nagaoka University of Technology) page 35

* Abstract unavailable at press time

Session III

Equipment Design

Wednesday, October 29, 2003, 8:30 AM - 10:00 AM

Session Chair: Anthony E. Gee (University College, London)

1. **Lens Mounting Technology for Precision Lithography Optics (Invited Paper)***
Watson, D. (Nikon Research Corporation of America)
2. **Thin Glass Optic and Silicon Wafer Deformation and Kinematic Constraint**
Forest, C. R.; Akilian, M.; Vincent, G.; Lamure, A.; Schattenburg, M. L. (Massachusetts Institute of Technology) page 39
3. **Dynamic Friction Coefficient Measurements: Device and Uncertainty Analysis**
Schmitz, T. L.; Action, J.; Ziegert, J.C.; Sawyer, W. G. (University of Florida) page 43
4. **Design of Detachable Precision Fixtures which Utilize Hard and Lubricant Coatings to Mitigate Wear and Reduce Friction Hysteresis**
Culpepper, M. L.; Slocum, A. H.; Dibiaso, C. M. (Massachusetts Institute of Technology) page 47

Session IV

Interferometry

Wednesday, October 29, 2003, 10:30 AM - 12:00 PM

Session Chair: David D. Gill (Sandia National Laboratories)

1. **Fabry-Perot Displacement Metrology with a Femtosecond Laser (Invited Paper)***
Lawall, J. R. (National Institute of Standards and Technology)
2. **A Laser Speckle Sensor for Compound Rotary-linear Motion Metrology**
Shilpiekandula, V.; Trumper, D. L. (Massachusetts Institute of Technology) page 51
3. **Developing Atomic-resolution Measurements Using a Tunable Diode Laser-based Interferometer**
Zhou, H.; Damazo, B. N.; Silver, R. M. (National Institute of Standards and Technology); and
Gonda, S. (National Institute of Advanced Industrial Science and Technology). page 55
4. **New Heterodyne Interferometric Method of Displacement Measure and Control with a Sub-nanometric Precision Over a Range of Several Millimeters**
Haddad, D.; Topçu, S.; Chassagne, L.; Alayli, Y. (Universite de Versailles); and Juncar, P. (BNM-INM/CNAM) page 59

Session V

Precision Machining

Wednesday, October 29, 2003, 3:30 PM - 5:00 PM

Session Chair: Thomas A. Dow (North Carolina State University), and Hashimoto Hiroshi (Kanagawa Institute of Technology)

1. **Dynamic Material Properties for Machining Simulation Using the NIST Pulse-heated Kolsky Bar**
Rhorer, R. L. (National Institute of Standards and Technology) page 63
2. **Direct Single Point Diamond Cutting of Stavax Assisted with Ultrasonic Vibration to Produce Optical Quality Surface Finish**
Liu, X. D.; Ding, X.; Lee, L. C.; Fang, F. Z.; Lim, G. C. (Singapore Institute of Manufacturing Technology). page 67
3. **Characterizing Residual Stress in Scribes on Silicon Using Deflection Measurements**
Randall, T.; Scattergood, R. O. (North Carolina State University). page 71
4. **Effect of Machining Parameters on Machining Performance of Micro EDM and Surface Integrity**
Yu, Z.; Rajurkar, K. P.; Narasimhan, J. (University of Nebraska-Lincoln) page 75

* Abstract unavailable at press time

Session VI

Advanced Machines

Thursday, October 30, 2003, 8:30 AM - 10:00 AM

Session Chair: Allen Y. Yi (Ohio State University), and Werner R. Preuss (Bremen University)

1. **Ultra-precision Surface Machining by Ion Beams and Plasma Jets (Invited Paper)***
Schindler, A. (Leibniz-Institut für Oberflächennmodifizierung e.V. - IOM)
2. **An Ultra-high Speed Spindle for Micro-milling**
Ziegert, J. C.; Pathak, J. P. (University of Florida); and Jokiel Jr., B. (Sandia National Laboratories) page 79
3. **Fundamental Analysis on the Novel 3-D Probing Technique for Microparts Using the Optical Fiber Trapping**
Hashimoto, T.; Takaya, Y.; Miyoshi, T.; Nakajima, R. (Osaka University) page 83
4. **Rotary Type Micro-Engineered Tool**
Akimoto, K.; Hashimoto, H. (Kanagawa Institute of Technology) page 87

Session VII

Novel Applications

Thursday, October 30, 2003, 10:30 AM - 12:00 PM

Session Chair: Andrew J. Hazelton (Nikon Research Corporation of America), and Aoyama Hiusayuki (University of Electro-Communications)

1. **LIGA Fabrication Technology for Micro Systems (Invited Paper)***
Henderson, C. C. (Sandia National Laboratories/Livermore)
2. **Fabrication of a Precision Mandrel for Replicating Wölter x-ray Optics**
Nederbragt, W. W. (Lawrence Livermore National Labs) page 91
3. **Pinpoint Chemical Vapor Deposition of Carbon Nanowire for Nanometer-scale Electronic Devices**
Ooi, T.; Kasuya, K.; Tsuchiya, K.; Hamaguchi, T.; Nakao, M. (The University of Tokyo) page 95
4. **Manufacturing and Quality Control of the NIST Reference Material 8240 Standard Bullet**
Whitenton, E. P.; Johnson, C. E.; Kelly, D. R.; Clary, R.; Dutterer, B. S.; Ma, L.; Song, J.-F.;
Vorburger, T. V. (National Institute of Standards and Technology) page 99

Session VIII

Equipment and Controls

Thursday, October 30, 2003, 1:30 PM - 3:00 PM

Session Chair: Stephen J. Ludwick (Aerotech, Inc.)

1. **Electromagnetically Driven Fast Tool Servo**
Lu, X.; Trumper, D. L. (Massachusetts Institute of Technology) page 103
2. **Error Compensation Using Inverse Actuator Dynamics**
Panusittikorn, W.; Garrard, K. P.; Dow, T. A. (North Carolina State University) page 107
3. **Machining of Freeform Optical Surfaces by Slow Slide Servo Method**
Tohme, Y. F.; Lowe, J. A. (Moore Nanotechnology Systems, LLC) page 111
4. **High Bandwidth Short Stroke Rotary Fast Tool Servo**
Montesanti, R. C. (Lawrence Livermore National Labs); and Trumper, D. L. (Massachusetts Institute of Technology) page 115

* Abstract unavailable at press time

Poster Session

Tuesday, October 28, 2003, 3:30 PM - 5:00 PM

Wednesday, October 29, 2003, 1:30 PM - 3:00 PM

Session Chair: Bradley H. Jared (3M Precision Optics)

BIOMEDICAL

Biomedical

1. **Fabrication of a Microrobot Movable in Flexible Pipes Like the Large Intestine**
Ono, M.; Sasazaki, T.; Kato, N.; Kato, S. (Nippon Institute of Technology) page 119

EQUIPMENT, MACHINES & INSTRUMENTS

Analysis & Modeling

1. **Design and Analysis of Nano-positioning Stage Driven by Piezoelectric Elements**
Choi, K.-B.; Ryu, S.-H.; Han, C.-S. (Korea Institute of Machinery & Materials) page 123
2. **Theoretical and Experimental Study on Surface Finish for Multi-axis CNC Milling**
Sahasrabudhe, A.; Liu, X.; Zhang, X.; Yamazaki, K. (University of California-Davis) page 127
3. **Development of an Internet-based Platform for High-speed Milling Process Parameter Selection**
Schmitz, T. L.; Tummond, M.; Duncan, G. S.; Zahner, C. (University of Florida); and Snyder, J. P. (TechSolve, Inc.) page 131
4. **Modeling and Investigation on a Jet Pipe Electrohydraulic Flow Control Servovalve**
Somasekhar, S. H.; Singaperumal, M.; Krishna Kumar, R. (Indian Institute of Technology Madras) page 135
5. **Computational Accuracy Analysis of a Coordinate Measuring Machine Under Static Load**
Sousa, A. R.; Bento, D. A. (Federal Center for Technological Education - Santa Catarina) page 139

Controls

1. **Adaptive Feedforward Cancellation Viewed from an Oscillator Amplitude Control Perspective**
Cattell, J. H.; Byl, M. F.; Trumper, D. L. (Massachusetts Institute of Technology) page 143
2. **Development of an Electro-dynamic Planar Motor**
Compter, J. C. (Philips CFT); Peijnenburg, A. T. (Philips CFT NA) page 147
3. **Model-based Control Input Compensation for Parallel Kinematic Machine Tools**
Hadorn, M. C. (Institute of Machine Tools and Mfg. [IWF-ETH]) page 151
4. **Force Feedback Control of Tool Deflection in Miniature Ball End Milling**
Hood, D. W.; Buckner, G. D.; Dow, T. A. (North Carolina State University) page 155
5. **Numerical Control with Surface Driven Interpolation**
Kato, K. (Tokyo University of Science); and Takahashi, N.; Iriguchi, K. (Mitsubishi Electric Corporation) page 159
6. **Compensatory Control of Thermal Errors for High-speed Machine Tools**
Kim, K.-D.; Chung, S.-C. (Hanyang University) page 163
7. **Identification of Nonlinear Characteristics for Precision Servomechanisms**
Kim, M.-S.; Chung, S.-C. (Hanyang University) page 167
8. **A Fuzzy Logic Based Adaptive Feedforward PI Controller for Nanometer Positioning**
Lu, X.; Tran, H. D. (University of New Mexico) page 171
9. **Waveform Determination and Positioning Control of the NanoSlider with Inertial Sliding and Stick-positioning**
Shim, J. Y.; Gweon, D.-G. (Korea Advanced Institute of Science & Technology - KAIST) page 175
10. **Development of Controlled Surface Acoustic Wave Planar Actuators**
Vermeulen, M. M. P. A.; Peeters, F. G. P.; (Philips CFT); and Peijnenburg, A. T. (Philips CFT NA) page 178

Design & Testing

1. **Differentiating Guidance from Support Functions in Ultra Precision Mechanism Design****
Gee, A. E. (University College, London) page 182
2. **Ultraprecision XY Stage with Millimetre Travel Range Using Leaf-spring Mechanism and Voice-coil Motor**
Kang, D.-W.; Kim, D.-M.; Kim, K.-H.; Shim, J.-Y.; Gweon, D.-G. (Korea Advanced Institute of Science and Technology - KAIST) page 183

**Extended abstract unavailable at press time

3. Control and Design of a Dual Servo with Fine 6-axis Stage Kim, K.-H.; Lee, M.-G.; Kim, D.-M.; Gweon, D.-G. (Korea Advanced Institute of Science and Technology)	page 187
4. Integrated Design Methodology for High-Precision/Speed Servomechanisms Kim, M.-S.; Chung, S.-C. (Hanyang University)	page 191
5. Conceptual Design Support and Prototyping of a Miniature Machine Tool Mishima, N. (National Institute of Advanced Industrial Science and Technology)	page 195
6. Water Energy Drive Spindle Supported by Water Hydrostatic Bearing for Ultra-precision Machine Tool Nakao, Y.; Mimura, M.; Kobayashi, F. (Kanagawa University)	page 199
7. Design and Characterization of an Aerostatic Spherical Bearing Robertson, A. P.; Slocum, A. H. (Massachusetts Institute of Technology)	page 203
8. Theoretical and Experimental Determination of the Stiffness Properties of a Capstan Drive Werkmeister, J. B.; Slocum, A. H. (Massachusetts Institute of Technology)	page 207
9. Experimental Determination of Kinematic Coupling Repeatability in Industrial and Laboratory Conditions Willoughby, P. J.; Hart, A. J.; Slocum, A. H. (Massachusetts Institute of Technology)	page 211

Mechatronics

1. Design and Development of a High Precision Lens Focussing Mechanism Using Flexure Bearings Gaunekar, A. S.; Widdowson, G. P.; Srikanth, N.; Guangneng, W. (ASM Technology Singapore Pte. Ltd.)	page 215
2. Synthesis of the 3D Linux-based CNC System for Precision Machines Kang, B.-K.; Kim, M.-S.; Chung, S.-C. (Hanyang University)	page 219
3. Fabrication of an Inch-worm Type Mobile Microrobot Movable in Different Diameter and Long Pipes Kato, S.; Ono, M.; Aizawa, Y.; Nakamura, H. (Nippon Institute of Technology)	page 223
4. Fine Motion Performance of L-shaped Seal Mechanism with 3 Degrees of Freedom Kawagoe, K.; Furutani, K. (Toyota Technological Institute)	page 227
5. Design and Development of Micro Hopping Robots for Rescue Operation Misumi, R.; Kurata, S.; Aoyama, H. (University of Electro-Communications)	page 231
6. A Simple Hybrid Positioning Stage With <1nm Resolution Okazaki, Y. (National Institute of Advanced Industrial Science and Technology); Ichikawa, S. (Sigma Tech Co. Ltd.); and Otsuka, J. (Shizuoka Institute of Science and Technology)	page 235
7. Fabrication of an Artificial Earthworm Type Mobile Inspection Robot Movable in 100 m Long Pipes Ono, M.; Kato, M.; Naito, T.; Sasazaki, T.; Kato, S. (Nippon Institute of Technology)	page 239
8. Nonlinear Friction Behavior of Discontinuity at Stroke End in a Ball Guide Way Tsuruta, K.; Futami, S. (Yaskawa Electric Corporation); and Murakami, T. (Kyushu University)	page 243
9. Global Tele-operation for Micro-assembly Tasks Zaeh, M. F.; Ehrenstrasser, M.; Schilp, J. (Technische Universität München)	page 247

MEMS & Nanotechnology

1. Multi-axis Nano Positioning Flexure Stage Using Magnetically Preloaded PZT Actuator Han, C.-S.; Baek, S. (Korea Institute of Machinery and Materials); Kang, J. O.; Hong, S. W. (Kumoh National Institute of Technology); and Noh, M. D. (Chungnam National University)	page 251
2. Development of a Micro Screw Thread and a Micro Gear Utilized Extra Fine Wires Honda, S. (Tokyo Metropolitan Institute of Technology)	page 255
3. A Dual Stage Compliant Positioning System with Integrated Planar Optical Grating for Position Feedback Mueller, U. (Optomech)	page 259
4. The Application of Surface Mount Technology to Multi-scale Process Intensification Sharma, N.; Paul, B. K. (Oregon State University)	page 263
5. A Comparison of the Mass Transfer Performance of Conventional and Micromanufactured Porous Membranes Tseng, C. H.; Paul, B. K. (Oregon State University)	page 267

Novel Systems

1. Novel Ultraprecise Tool Alignment Setup for Contour Boring and Ball-end Milling Brinksmeier, E.; Gläbe, R.; Autschbach, L. (Bremen University)	page 271
2. Large Displacement Flexure Based Nano-precision Motion Stage for Vacuum Environments Choi, Y.-J.; Sreenivasan, S. V. (The University of Texas-Austin)	page 275