

Table of Contents

| | <u>Page</u> |
|--|-------------|
| <i>Preface</i> ----- | vii |
| <i>Organizing/Advisory Committee</i> ----- | ix |
| Education | |
| Using Literature Reviews as a Learning Tool for Solid Freeform Fabrication | |
| <i>Brent Stucker</i> , Utah State University ----- | 1 |
| Product Focused Freeform Fabrication Education | |
| <i>Frank Liou, Ming Leu</i> , Missouri University of Science & Technology----- | 10 |
| Integrating Rapid Prototyping into Product and Process Development | |
| <i>Bahram Asiabanpour</i> , Texas State University – San Marcos ----- | 21 |
| Materials | |
| Tunable Digital Material Properties of 3D Voxel Printers | |
| <i>Jonathan Hiller, Hod Lipson</i> , Cornell University----- | 33 |
| Effects of Degree of Particle Melt and Crystallinity in SLS Nylon-12 Parts | |
| <i>C.E. Majewski^a, H. Zarringhalam^b, N. Hopkinson^a</i> , ^a Loughborough University, ^b University of Birmingham Campus----- | 45 |
| Flame Retardant Intumescent Polyamide 11 Nanocomposites – Further Study | |
| <i>S.C. Lao^a, J.H. Koo^a, T.J. Moon^a, W. Yong^a, C. Lam^a, J. Zhou^a, B. Hadisujoto^a, G. Wissler^b, L. Pilato^b, Z. P. Luo^c</i> , ^a The University of Texas at Austin, ^b KAI, LLC, ^c Texas A&M University----- | 55 |
| Polyamide 11-Carbon Nanotubes Nanocomposites: Preliminary Investigation | |
| <i>S.C. Lao^a, J.H. Koo^a, W. Yong^a, C. Lam^a, J. Zhou^a, T. Moon^a, P.M. Piccione^b, G. Wissler^c, L. Pilato^c, Z.P. Luo^d</i> , ^a The University of Texas at Austin, ^b Arkema, ^c KAI, LLC, ^d Texas A&M University ----- | 67 |
| Investigating Dielectric Properties of Sintered Polymers for Rapid Manufacturing | |
| <i>Matthew J. Thompson, David C. Whalley, Neil Hopkinson</i> , Loughborough University ----- | 79 |
| Tailoring the Mechanical Properties of Selective Laser Sintered Parts | |
| <i>C.E. Majewski, D. Toon, H. Zarringhalam, N. Hopkinson, M.P. Caine</i> , Loughborough University ----- | 94 |

| | |
|--|-----|
| Solid Freeform Fabrication of Stainless Steel Using Fab@Home <i>Maxim Lobovsky^a, Alexander Lobovsky^b, Mohammad Behi^b, Hod Lipson^a,</i> ^a Cornell University, ^b United Materials Technologies, LLC ----- | 104 |
| Microstructural Characterization of Diode Laser Deposited Ti-6Al-4V <i>Tian Fu, Zhiqiang Fan, Syamala R. Pulugurtha, Todd E. Sparks,</i> <i>Jianzhong Ruan, Frank Liou, Joseph W. Newkirk, Missouri University of</i> <i>Science & Technology-----</i> | 110 |
| Processing and Microstructure of WC-CO Cermets by Laser Engineering Net Shaping <i>Y. Xiong^a, J.E. Smugeresky^b, E.J. Lavernia^a, J.M. Schoenung^a,</i> ^a Univerisity of California – Davis, ^b Sandia National Laboratories – Livermore, CA ----- | 116 |
| Microstructure and Wear of SLM Materials <i>S. Kumar, Utah State University -----</i> | 128 |
| Wear of SLS Materials under Plastic and Elastic Contact Conditions <i>S. Kumar, Utah State University -----</i> | 143 |
| Selective Laser Melting of Inconel 625 using Pulse Shaping <i>K.A. Mumtaz, N. Hopkinson, Loughborough University -----</i> | 165 |
| Selective Laser Sintering and Post Processing of Fully Ferrous Components <i>Phani Vallabhajosyula, David L. Bourell, The University of Texas at</i> <i>Austin -----</i> | 179 |
| Fabrication of Electrically Conductive, Fluid Impermeable Direct Methanol Fuel Cell (DMFC) Graphite Bipolar Plates by Indirect Selective Laser Sintering (SLS) <i>Kaushik Alayavalli, David L. Bourell, The University of Texas at Austin -----</i> | 186 |
| Freeform Fabrication of Zirconium Diboride Parts using Selective Laser Sintering <i>Ming C. Leu, Erik B. Adamek, Tieshu Huang, Greg E. Hilmas, Fatih</i> <i>Dogan, Missouri University of Science & Technology -----</i> | 194 |
| The Characteristics and Applications of Ceramic Laser Fusion and Ceramic Laser Sintering <i>H.H. Tang, H.C. Yen, M.L. Chiu, J.H. Jou, National Taipei University of</i> <i>Technology-----</i> | 206 |
| <i>Process Development</i> | |
| A Film Fabrication Process on Transparent Substrate using Mask Projection Micro-Stereolithography <i>Amit S. Jariwala, Fei Ding, Xiayun Zhao, David W. Rosen, Georgia</i> <i>Institute of Technology -----</i> | 216 |

| | |
|--|-----|
| Analysis of Droplet Train/Moving Substrate Interactions in Ink-Jetting Processes | |
| <i>S. Fathi, P.M. Dickens, R.J.M. Hague, K. Khodabkhsi, M. Gilbert,</i> Loughborough University ----- | 230 |
| Printing High Viscosity Fluids using Ultrasonic Droplet Generation | |
| <i>David W. Rosen^a, Lauren Margolin^b, Sanjay Vohra^a,</i> ^a Georgia Institute of Technology, ^b Lutron Electronics, Inc. ----- | 239 |
| A New Layer Casting System for Ceramic Laser Rapid Prototyping Apparatus | |
| <i>H.C. Yen, M.L. Chiu, P.H. Huang,</i> National Taipei University of Technology ----- | 254 |
| Impact Absorbent Rapid Manufactured Structures (IARMS) | |
| <i>J.P.J. Brennan-Craddock, G.A. Bingham, R.J.M. Hague, R.D. Wildman,</i> Loughborough University ----- | 266 |
| Processing Parameters for Selective Laser Melting (SLM) of Gold | |
| <i>M. Khan, P.M. Dickens,</i> Loughborough University ----- | 278 |
| Direct-to-Part Machining Waste Recycling using Laser Metal Deposition | |
| <i>Todd Sparks, Frank Liou,</i> Missouri University of Science & Technology ----- | 290 |
| Laser Micro Sintering – A Quality Leap through Improvement of Powder Packing | |
| <i>A. Streek, P. Regenfuss, R. Ebert, H. Exner,</i> Fachbereich MPI----- | 297 |
| Rotational 3D Printing of Sensor Devices using Reactive Ink Chemistries | |
| <i>C. Hauser^a, D.M. Lewis^b, K.F. Morris^b, P.J. Broadbent^b, X. Zhao^b, A.T. Clare^a,</i> <i>M. Dunschen^c,</i> ^a University of Liverpool, ^b University of Leeds, ^c FreeSteel ----- | 309 |
| Experimental Investigation of Laser Surface Remelting for the Improvement of Selective Laser Melting Process | |
| <i>Jean-Pierre Kruth, Jan Deckers, Evren Yasa,</i> Catholic University of Leuven ----- | 321 |
| Direct 3D Layer Metal Deposition | |
| <i>Jianzhong Ruan, Lie Tang, Todd E. Sparks, Robert G. Landers, Frank Liou,</i> Missouri University of Science & Technology ----- | 333 |
| Machine Path Generation using Direct Slicing from Design-by-Feature Solid Model for Rapid Prototyping | |
| <i>Mohammad T. Hayasi^a, Bahram Asiabanpour^b,</i> ^a Universiti Putra Malaysia, ^b Texas State University – San Marcos ----- | 342 |
| Effect of Path Strategies on Metallic Parts Manufactured by Additive Process | |
| <i>J. Kerninon^a, P. Mogno^a, J.Y. Hascoet^a, C. Legonidec^b,</i> ^a Institut de Recherche en Communications et Cybernétique de Nantes (IRCCYN), ^b Ecole Centrale de Nantes ----- | 352 |

Three-Dimensional Off-Axis Component Placement and Routing for Electronics Integration using Solid Freeform Fabrication
Erick DeNava, Misael Navarrete, Amit Lopes, Mohammed Alawneh, Marlene Contreras, Dan Muse, Silvia Castillo, Eric MacDonald, Ryan Wicker, The University of Texas at El Paso ----- 362

An Experimental Determination of Optimum Foil Joint Conditions for Structural Parts Fabricated by Ultrasonic Consolidation
J.O. Obielodan, G.D. Janaki Ram, B.E. Stucker, Utah State University ----- 370

Modeling

A Novel Method for Part Decomposition Based on Undercut Edges for Efficient Hybrid Rapid Prototyping
Abhishek Goel, Anupam Surana, Asimava Roy Choudhury, Indian Institute of Technology----- 388

Material Spreading and Compaction in Powder-Based Solid Freeform Fabrication Methods: Mathematical Modeling
Yaser Shanjani, Ehsan Toyserkani, University of Waterloo----- 399

Modeling and Experimental Results of Concentration with Support Material in Rapid Freeze Prototyping
Frances D. Bryant, Ming C. Leu, Missouri University of Science & Technology----- 411

Efficient Concurrent Toolpath Planning for Multi-Material Layered Manufacturing
S.H. Choi, W.K. Zhu, The University of Hong Kong ----- 429

Freeform Fabrication Assists Forensic Scientists in the Identification of Unknown Victims
Bahram Asiabanpour, Jerry Melbye, Vicky Melbye, Evan Jensen, Joshua Shaw, Texas State University – San Marcos----- 441

Templates for Consumer Use in Designing Customised Products
Y. Ariadi, A.E.W. Rennie, Lancaster University ----- 450

A Comparison of Synthesis Methods for Cellular Structures with Application to Additive Manufacturing
Jane Chu, Sarah Engelbrecht, Greg Graf, David W. Rosen, Georgia Institute of Technology ----- 459

Layer-to-Layer Height Control for Laser Metal Deposition Processes
Lie Tang, Jianzhong Ruan, Todd E. Sparks, Robert G. Landers, Frank Liou, Missouri University of Science & Technology----- 473

Study on the Influence of Rapid Prototyping Parameters on Product Quality in 3D Printing
G. Arumaikkannu, N. Anil Kumar, R. Saravanan, Anna University----- 495

| | |
|--|-----|
| Development of an Additive Laser Manufacturing (ALM) Selection Tool for Direct Manufacture of Products <i>P.C. Smith, A.E.W. Rennie, Lancaster University</i> | 507 |
| Manufacturing Complexity Evaluation for Additive and Subtractive Processes: Application to Hybrid Modular Tooling <i>O. Kerbrat, P. Mognol, J.-Y. Hascoet, Institut de Recherche en Communications et Cybernétique de Nantes (IRCCyN)</i> | 519 |
| Using Customer Interaction with Functional Prototypes to Support Innovative Product Development <i>R.I. Campbell^a, D.J. de Beer^b,^aLoughborough University, ^bCentral University of Technology</i> | 531 |
| <i>Applications</i> | |
| Wear Behavior of SLS WC-Co Composites <i>S. Kumar^a, J.-P. Kruth^b, L. Froyen^b, ^aUtah State University, ^bKatholieke Universiteit Leuven</i> | 543 |
| New Rapid Casting Techniques for Competitive Motor Sports <i>Franco Cevolini^a, Stewart Davis^b, Sergio Rinland^c, ^aCRP Technology, ^bCRP USA, ^cEpsilon Euskadi</i> | 558 |
| Utilizing the Design Freedoms of Rapid Manufacturing to Optimize Structural and Acoustical Interactions of “Brass” Musical Instruments <i>D.J. Brackett, I.A. Ashcroft, R.J. Hague, Loughborough University</i> | 570 |
| The Application of Rapid Manufacturing Technologies in the Spare Parts Industry <i>S. Hasan, A.E.W. Rennie, Lancaster University</i> | 584 |
| Object Augmentation for the Visually Impaired using RP <i>Marilyn Chung^a, Evan Malone^a, Michael T. Tolley^a, Andrew J. Chepaitis^b, Hod Lipson^a, ^aCornell University, ^bELIA Life Technology, Inc.</i> | 591 |
| Developing Printable Content: A Repository for Printable Teaching Methods <i>Mary E. Knapp, Ryan Wolff, Hod Lipson, Cornell University</i> | 603 |
| Solid Freeform Fabrication of Calcium Polyphosphate Dual-Porous Structure Osteochondral Scaffold <i>Yaser Shanjani^a, Ehsan Toyserkani^a, Robert Pilliar^b, ^aUniversity of Waterloo, ^bUniversity of Toronto</i> | 613 |
| Process Resolution of Laser Sintering Process using Plastic Powder Containing Inorganic Filler at a High Rate <i>Toshiki Niino, Shunsuke Oizumi, Kazuki Sato, The University of Tokyo</i> | 621 |

| | |
|--|-----------|
| Fabrication of Embedded Horizontal Micro-Channels using Line-Scan Stereolithography | |
| <i>Jae-Won Choi^a, Rolando Quintana^b, Ryan B. Wicker^a, ^aThe University of Texas at El Paso, ^bThe University of Texas at San Antonio</i> | ----- 632 |
| Fabrication of Complex 3D Micro-Scale Scaffolds and Drug Delivery Devices using Dynamic Mask Projection Microstereolithography | |
| <i>Jae-Won Choi^a, In-Baek Park^b, Ryan Wicker^a, Seok-Hee Lee^b, Ho-Chan Kim^c, ^aThe University of Texas at El Paso, ^bPusan National University, ^cAndong National University</i> | ----- 652 |
| Optimized Polymerization Conditions for Inkjetting of Caprolactam to Produce Polyamide Parts | |
| <i>K. Khodabakhshi, M. Gilbert, P. Dickens, R. Hague, S. Fathi, Loughborough University</i> | ----- 668 |
| Improved Quality of 3D-Printed Tissue Constructs Through Enhanced Mixing of Alginate Hydrogels | |
| <i>Daniel L. Cohen^a, Andrew M. Tsavaris^{ab}, Winifred M. Lo^{ac}, Lawrence J. Bonassar^a, Hod Lipson^a, ^aCornell University, ^bPrinceton University, ^cNorthwestern University</i> | ----- 676 |
| Rapid Manufacturing in Biomedical Materials: Using Subtractive Rapid Prototyping for Bone Replacement | |
| <i>Matthew C. Frank^a, Christopher V. Hunt^a, Donald D. Anderson^b, Todd O. McKinley^b, Thomas D. Brown^b, ^aIowa State University, ^bThe University of Iowa</i> | ----- 686 |
| <i>Author/Attendee List</i> | ----- 697 |