

Structural Optimization Application for Aircraft and Spacecraft I

Papers Presented at the AIAA SciTech Forum and Exposition
2024

Orlando, Florida, USA
8 – 12 January 2024

Volume 1 of 2

ISBN: 979-8-3313-0444-7

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

The contents of this work are copyrighted and additional reproduction in whole or in part are expressly prohibited without the prior written permission of the Publisher or copyright holder. The resale of the entire proceeding as received from CURRAN is permitted.

For reprint permission, please contact AIAA's Business Manager, Technical Papers. Contact by phone at 703-264-7500; fax at 703-264-7551 or by mail at 34922 Uwytkug'Xcmg{'Ftkxg.'Uwky'422, Reston, VA 20191, USA.

TABLE OF CONTENTS

VOLUME 1

STRUCTURAL OPTIMIZATION APPLICATION FOR AIRCRAFT AND SPACECRAFT I

Assessment of Truss-Based Modular Structures in the Wingbox Structural Design of Commercial Aircraft	1
<i>Pedro Davim Bastos, Higor Luis Silva</i>	
Moving Morphable Components Based on Strain-Based Beam Formulation for Topology Optimization.....	15
<i>Keisuke Otsuka, Shuonan Dong, Ryo Kuzuno, Hiroyuki Sugiyama, Kanjuro Makihara</i>	
Thermomechanical Performance of Sandwich Structures with Optimized Variable Thickness Lattice Cores.....	38
<i>Andrew J. Gross, Rimah Al-Aridi</i>	
Identifying and Overcoming Gaps Within Generative Design for Aerospace Structures	48
<i>Jason Action, Benjamin Gajus, Katherine Morehead</i>	
Application of Generative Design to Thin-Walled Aerostructure.....	60
<i>Jason Action, Katherine Morehead, Thomas Hiromoto, Benjamin Gajus</i>	

COMPOSITE STRUCTURAL ANALYSIS, DESIGN, TESTING, AND MANUFACTURING I

Stiffness Tailoring for Improved Buckling of Variable Angle Tow Composite Sandwich Plates	77
<i>Mohammed Abir Mahdi, Soumik Dutta, Wei Zhao</i>	
Structural Testing of Sandwich Composite Main Landing Gear Door	97
<i>Mary Dimitroff, Aditya K. Shah, Rani W. Sullivan, Stephen B. Clay</i>	
Demonstration of Predictive Capabilities of a Composite Pi Joint Model	115
<i>James Finlay, Anthony Waas, Jonathan D. Bartley-Cho, Nav Muraliraj</i>	
The Point Force Collocation Method for Generic Cutouts in Composite Structures.....	126
<i>Steven G. Russell</i>	
Verification and Validation of Progressive Damage and Failure Analysis Methods for Intralaminar Failure Modes in Thermoplastic Composites	141
<i>Vivian Johnson, Rebecca Cutting, Alex S. Selvarathinam, Julio Juarez</i>	

HIGH PERFORMANCE MATERIALS FOR EXTREME ENVIRONMENTS

Validation of Porous Microstructure Analysis (PuMA) Against Experimental Thermal Conductivity of Thermal Protection System Materials	160
<i>Samantha Bernstein, Alexandra Litvinov, Colin M. Yee, Steven D. Kim, Wei Li, Richard Liang, Jin Gyu Park, Joseph H. Koo</i>	
Development and Material Characterization of Quartz-Reinforced UHTR/Aerogel Composites: Morphology, Thermal, and Flammability Properties.....	175
<i>Steven D. Kim, Joseph H. Koo</i>	

Exploring Digital Ceramic Designs: A Synergy of Finite Element Modeling and Machine Learning.....	190
<i>Behnam Ashrafi</i>	
High Energy X-Ray Investigation of Ultra-High Temperature Ceramics Under Thermal Cycling.....	199
<i>Zachary Stein, Johnathan Hernandez, Patrick Albert, Peter Kenesei, Jun-Sang Park, Jonathan Almer, Douglas E. Wolfe, Seetha Raghavan</i>	
Development and Fabrication of Thermal Protection Systems for NASA: Enabling the Exploration of Our Solar System	205
<i>Steven Violette</i>	
3D Printable BN/PEEK/PEI Polymer Blend Composites for Thermal Management Applications.....	220
<i>Yunus Emre Bozkurt, Cem Kincal, Ramazan Yüksel, Alptekin Yıldız, Nuri Solak, Hulya Cebeci</i>	

FATIGUE AND FRACTURE

Mechanical Fatigue Characterization of NiTiHf SMAs for a Unified Descriptor to Actuation Fatigue.....	228
<i>Hrishikesh Padalia, Dimitris Lagoudas</i>	
Analyzing the Dynamic Behavior of Metallic Structures Subjected to High-Speed Impacts.....	244
<i>Riza Kaan Gonuleri, Ibrahim Guven</i>	
Experimental Quantification of Fracture and Crack Growth in a Porous Carbon Fiber Material	257
<i>Robert N. Quammen, Paul F. Rottmann</i>	
Water Droplet Impact Damage in Ceramics at Subsonic and Supersonic Velocities.....	271
<i>Ugur Can, Ibrahim Guven</i>	
Non-Local Fatigue Crack Growth Model Using Cohesive Elements and the J-Integral	280
<i>Louis Sponton, Gennadiy Nikishkov, Guillaume Seon, Yuri Nikishkov, Andrew Makeev</i>	

HIGH STRAIN COMPOSITE MATERIALS AND STRUCTURES

Effects of Varying Geometric Design Parameters on the Stability of Deployable Thin-Shell Composite Space Structures	298
<i>Meital O. Carmi, Sage Cooley, Sergio Pellegrino</i>	
Finite Element Model Correlation for Deployable High Strain Fiber Reinforced Composite Boom and Membrane Antenna System	314
<i>Andrew Moran, Vann Stavast, Alexi S. Rakow, Susan Tower, Chris Worsdale</i>	
High-Throughput Viscoelastic Testing for Composite Laminates.....	334
<i>Vivek Khare, Kawai Kwok, Serena Ferraro, Ingie Baho</i>	

STRUCTURAL OPTIMIZATION APPLICATION FOR AIRCRAFT AND SPACECRAFT II

Creasing of Thin, Elastic Plates for Maximizing Fundamental Frequencies.....	348
<i>Avinkrishnan A. Vijayachandran, Othman Oudghiri-Idrissi, Hrishikesh Danawe, Xiaoming Mao, Ellen Arruda, Serife Tol, Anthony Waas</i>	
Analysis, Optimization, and Destructive Testing of Machined Isogrid Cylinders for Small Scale Rocket Airframes.....	357
<i>Hayden Reinhold, Davis Zarfes, Max Eltzroth, Peter McCloud, Andrew Greenberg</i>	

NANOSTRUCTURED MATERIALS I

Aligned Carbon Nanotube Polysiloxane Nanocomposite Laminate for Thermal Protection Systems	379
<i>Palak B. Patel, Steven D. Kim, Jingyao Dai, Jarrod Buffy, Joseph H. Koo, Brian L. Wardle</i>	
Multifunctionality of High Volume Fraction Aligned Carbon-Nanotube/Bismaleimide Nanocomposite Laminates	389
<i>Carina Xiaochen Li, Erick Gonzalez, Aniruddha Ghosh, Yuying Lin, Jingyao Dai, Luiz Acauan, Brian L. Wardle</i>	
Process Development for Carbon/Epoxy Prepreg Laminates with Magnetically Aligned CNT Interlayers	398
<i>Ricardo Braga Nogueira Branco, Jordan A. Sprague, Thomas N. Barkauskas, Namiko Yamamoto, Charles E. Bakis, Jackson A. Schwarz, Dean Nguyen</i>	
2D Materials Guided Interface in Polymer Based Nanocomposites.....	409
<i>Akash Singh, Yumeng Li</i>	
Investigating the Effects of Particle Size Using Photoluminescence Piezospectroscopy	419
<i>Khanh D. Vo, Zachary Stein, Remelisa Esteves, Seetha Raghavan</i>	

MULTISCALE MODELING

A Semiautomated Modular Approach for Multiscale In-Situ Effective Mechanical Property Prediction from Computed Tomography of As-Built Composites.....	427
<i>Reed Kopp, Liam Mackin, Linus Lee, Eric Jayson</i>	
Modeling the Stochastic Response of Fiber Reinforced Composites with Varied Representative Volume Element Sizes	452
<i>Jamal Husseini, Scott E. Stapleton, Eric J. Carey, Hengameh Seyedeh Ghaffari, Farhad Pourkamali-Anaraki, Colin W. Furey, Evan J. Pineda, Brett A. Bednarczyk</i>	
Efficient Nonlinear Multiscale Analysis Using Sparse Sampling-Based Model Order Reduction Method	465
<i>Yujin So, Suhan Kim, Hyunseong Shin, Chun Il Kim, Jaehun Lee</i>	
Multiscale Modeling of Reconstructed Tricalcium Silicate Using NASA Multiscale Analysis Tool	473
<i>Vishnu Saseendran, Namiko Yamamoto, Ibrahim Kaleel, Evan J. Pineda, Brett A. Bednarczyk, Peter Collins, Aleksandra Radlinska</i>	
Quantification of Aleatoric and Epistemic Uncertainty of Microstructures Using Experiments and Markov Random Fields	484
<i>Matthew T. Long, Arulmurugan Senthilnathan, Pinar Acar</i>	
In-Situ Extraction of Modeling Parameters and Mechanics for Parachute Textiles Under Radial Stress with Micro-Tomography and Machine Learning	493
<i>Cutler Phillippe, Marco Mattei, Laura Villafaña Roca, Francesco Panerai</i>	

NANOSTRUCTURED MATERIALS II

Stochastic Model for Electrical Properties of Inkjet Printed Carbon Nanotube Films	503
<i>Samarth Motagi, Sirish Namilae</i>	

Fabrication and Processing of Aligned Boron Nitride and Carbon Nanotubes for Nanocomposite Systems.....	518
<i>Shaan A. Jagani, Jingyao Dai, Luiz Acauan, Brian L. Wardle</i>	
Scaled-Up Continuous Carbon Nanotube Yarn Unidirectional Composite Laminates with Carbon Nanotube Aerogel.....	525
<i>Cecil Evers, Britannia Vondrasek, Claire Jolowsky, Jin Gyu Park, Mike Czabaj, Bailee Ku, Kaylee Thagard, Gregory M. Odegard, Richard Liang</i>	
How Physical-Chemical Changes Control Failure Modes in Nano-Adhesives: An Experimental Approach	534
<i>Elvis C. Monteiro, Juliana P. de Souza, Antonio F. Avila</i>	
Viscoelastic Properties of Carbon Nanotube Reinforced Polyurethane Foams Through Dynamic Mechanical Analysis.....	543
<i>Oytun Ok, Eyuphan Kucukkalfa, Kaan Yildiz, Hulya Cebeci</i>	
Interaction of Heterogenous Particles with Surrounding Matrix Through Atomic Force Microscopy and Finite Element Analysis	551
<i>Tyler Norkus, Brian Raji, Masoud Yekani Fard</i>	

MULTIFUNCTIONAL MATERIALS FOR AEROSPACE

Life Cycle Assessment and Risk Management of Titanium for Aerospace Applications.....	564
<i>Nitya Maruthuvakudi Venkatram, Sara Alsabeeha, Neil R Weston, Zhimin Liu, Dimitri N. Mavris</i>	
Life Cycle Assessment and Risk Evaluation of CFRP in Aerospace.....	584
<i>Nitya Maruthuvakudi Venkatram, Sara Alsabeeha, Neil R Weston, Zhimin Liu, Dimitri N. Mavris</i>	

VOLUME 2

Investigation of Void Removal Behavior During Nanoporous Network Enabled Out of Autoclave Manufacturing of Void-Free Aerospace-Grade Carbon Fiber Reinforced Plastic Composites.....	612
<i>Jingyao Dai, Alisa Webb, Jeonyoon Lee, Kwasi Asamoah-Addo, Justin Griffin, Steven Steiner, Brian L. Wardle</i>	
Energy Absorption Characteristics of Elastomeric Nanoparticle Reinforced Polymeric Foam-Filled Auxetic Structures Under Cyclic Compression.....	620
<i>Eyuphan Kucukkalfa, Oytun Ok, Kaan Yildiz</i>	
Progressive Reinforcing of Re-Entrant Auxetic Structures by Direct Polyurethane Foaming Within Unit Cells.....	629
<i>Nisa Calaner, Erden Burak Kivandik, Eyuphan Kucukkalfa, Kaan Yildiz</i>	

TESTING AND CHARACTERIZATION OF MATERIALS I

Investigation of Stress Concentrations in Parts Manufactured with Fused Deposition Modeling.....	639
<i>Alexis H. Elmer, Alexandre Lasalarie, David Lanning</i>	
A Procedure to Quantify Interlaminar Damage in Refractory Composites by In-Situ Micro-X-Ray Computed Tomography	652
<i>Bryan A. Kubitschek, Bryson Marretta</i>	

Analysis of Interlaminar Damage in Refractory Composites by In-Situ Micro-X-Ray Computed Tomography.....	672
<i>Bryan A. Kubitschek, Bryson Marretta</i>	
Residual Strength Analysis of Carbon Fiber Reinforced Polymer After Impact at Repairable Damage Levels.....	697
<i>Yug V. Desai, Stephen Hilton, Wout De Backer</i>	
Mechanical Properties of 3D-Printed Multi-Material Polymeric Composites.....	707
<i>James Plotzke, Nicholas R. Torgerson, Sajon D. Seaberg, Monique McClain</i>	

TESTING AND CHARACTERIZATION OF MATERIALS II

Performance Evaluation of Compression-Molded Ablative Rocket Engine Materials.....	720
<i>Celimpilo M. Damane, Jean Pitot</i>	
Development and Characterization of an Inductively Coupled Plasma Jet for High-Temperature Testing.....	730
<i>Landon B. Jarrel, Michael T. Brocker, Aimee Williams, John Dec, Krishan K. Ahuja</i>	
In Situ Measurement Method for Degree of Cure of Aerospace Epoxy Adhesives.....	753
<i>Tetsuya Morimoto, Hisaya Katoh, Yuichi Ishida, Eiichi Hara</i>	
Development of a Boron Nitride Precursor Chemical Kinetic Model Using Reaction Mechanism Generator (RMG) Framework.....	759
<i>Andrianna Daniels, Harsha K. Chelliah</i>	
Effects of Manufacturing Defects on Composite Seat Pans at Static and Dynamic Strain Rates.....	768
<i>Akhil Bhasin, Suresh Keshavanarayana, Tanat Maichan, Luis Gomez, Gerardo Olivares</i>	
Cure-Induced Shape Distortion and Process Modeling of Thin-Shell Structures.....	777
<i>Deepak Kumar Patel, Armanj D. Hasanyan</i>	

STRUCTURAL JOINTS AND REPAIRS

Surface Roughness Effects on the Fracture Behavior of Adhesively Bonded Joints.....	785
<i>Manjima Bhattacharya, Stephanie C. TerMaath</i>	
Experimental Investigation of Strength and Time to Failure of Adhesively Bonded Double Lap Shear Joints.....	796
<i>Marcias Martinez, Mst. Jannatul Ferdousi, Craig G. Merrett, Priscilla Fonseca</i>	
Analytical Solution for Tensile Loading of Linear Elastic Single Lap Shear Joint Subject to Clamped-Roller Boundary Conditions.....	808
<i>Craig G. Merrett, Marcias Martinez</i>	
Stress Relaxation of Adhesively Bonded Single Lap Shear Joints.....	822
<i>Trevor Irwin, Marcias Martinez, Craig G. Merrett</i>	
High Fidelity Digital Twin Machining Tool for Quality Informed Composite Drilling.....	836
<i>Jim Lua, Jian Xiao, Xiaodong Cui, Caleb Saathoff</i>	

MATERIALS FOR ADDITIVE MANUFACTURING

Additive Manufacturing and Working Fluid Characterization of Ceramic Heat Pipes.....	851
<i>Giancarlo D'Orazio, William R. Sixel, Sadaf Sobhani</i>	
Process Modeling of the Fused Filament Fabrication of Semi-Crystalline Thermoplastics.....	861
<i>Manish Nagaraj, Marianna Maiaru</i>	
Effects of Hygrothermal Aging on Microstructure and Tensile Strength in 3D Printed Carbon Composites.....	868
<i>Jonathan Glinz, Markus Wolfahrt, Antonios Stamopoulos, Michael Eckl, Manuel Frank, Johann Kastner, Sascha Senck</i>	
Effects of High Temperature on Torsional Fatigue Performance of Additively Manufactured Inconel 718 of Vertical Build Orientation	875
<i>Sydney T. Wickett, Sanna F. Siddiqui</i>	
Additive Manufacturing of Highly Filled Fiber Reinforced Ceramic Matrix Composites.....	884
<i>Joshua Anderson, Monique McClain</i>	
Torsional Response of 3D Printed Onyx and Onyx-Carbon Fiber Reinforced Composites.....	891
<i>Dustin Fandetti, Sanna F. Siddiqui, Ali P. Gordon</i>	

SPECIAL SESSION: INTERNATIONAL COLLABORATIONS ADVANCING MATERIALS AND COMBUSTION

Determining Mechanical Properties of Thermally Sprayed Coatings Through Synchrotron X-Ray Diffraction Measurements.....	901
<i>Perla Latorre-Suarez, Janine Wischek, Marion Bartsch, Jun-Sang Park, Peter Kenesei, Jonathan Almer, Seetha Raghavan</i>	
In-Situ Synchrotron X-Ray Diffraction Volcanic Ash Infiltration Studies on High Temperature Ceramic Coatings.....	908
<i>Zachary Stein, Peter Kenesei, Jun-Sang Park, Jonathan Almer, Uwe Schulz, Ravisankar Naraparaju, Seetha Raghavan</i>	
In-Situ Characterization of Stress Corrosion Crack Initiation Via X-Ray Synchrotron Tomography.....	914
<i>Remelisa Esteves, Quentin Fouliard, Ranajay Ghosh, Pavel Shevchenko, Seetha Raghavan</i>	
Residual Strain Analysis of Additively Manufactured Structural Materials.....	922
<i>Jose Mayi-Rivas, Quentin Fouliard, Seetha Raghavan</i>	

SURVIVABILITY AND AEROSPACE MATERIALS

Mission Resilience Impacts of Space-Based Opportunistic Sensors in Distributed Space Situational Awareness Architectures.....	928
<i>Christopher D. Tommila, Michael P. Jones, Olivier de Weck</i>	
Thermoplastic Matrix Effects on the Ballistic Limit of Glass Composite Panels	941
<i>Sean Bedwell, John H. Hansen</i>	
Effect of Fiber Weave and Matrix Type Within Composite Materials on Secondary Ballistic Projectile Impact.....	957
<i>Ryan M. Dinndorf, John H. Hansen</i>	

Vulnerability of Aerostructures to Drone Impact – Collision with Rotorcraft Engine Cowling.....	966
<i>Michael May, Anja Altes, Benjamin Schaufelberger, Pascal Matura</i>	
Laser-Metal Interaction Modeling for Powder Bed Fusion Simulation.....	977
<i>Jie Zhang, Eric P. Fahrenthold</i>	

STRUCTURAL ANALYSIS, DESIGN, TESTING AND MANUFACTURING (JOINT DE/STR)

Design, Optimization and Additive Manufacture of Generalized Helium Outflow Unit for Latex Balloons to Float	984
<i>Jeremy J. Kuznetsov, Akemi Takeuchi, Daniel Grammer, Michael Kalin, Kruti Bhingradiya, Jack Bishop</i>	
Rheological Study of Property Variation of Virgin Polymer with the Introduction of Recycled Content During Polymer Processing a Parametric Analysis.....	1010
<i>M Burhan Bin Shuaib, Jehanzeb Masud, Mehr Nigar, Muhammad Muneeb Safdar</i>	
Analysis Directed Design of a Novel Composite Quasi-Zero Stiffness (QZS) Shock Isolator Based on Onset Theory	1017
<i>Douglas J. Neill, Jonathan H. Gosse, Kuna Kanthasamy, Terry L. Schneider</i>	
Development of a Payload Module for the Phoenix-1C Hybrid Sounding Rocket	1030
<i>Mthobisi Tshomela, Jean Pitot, Glen Snedden</i>	

CLEAN AVIATION SPECIAL SESSION: NEXT GENERATION MULTIFUNCTIONAL FUSELAGE DEMONSTRATOR I

Investigation of Innovative Technologies for Automated Assembly and Joining of a Full-Scale Thermoplastic Composite Fuselage.....	1036
<i>Benjamin Diehl, Simon M. Kothe</i>	
Aircraft Without Rivets – Laser Welding Makes the Impossible Possible	1043
<i>Eric Pohl, Jens Standfuß, Maurice Langer</i>	

CLEAN AVIATION SPECIAL SESSION: NEXT GENERATION MULTIFUNCTIONAL FUSELAGE DEMONSTRATOR II

Assembly of Thermoplastic Fuselage Structures by Induction Welding of Unidirectional Carbon Fiber Composites.....	1050
<i>Joachim C. de Kruijk, Senne Sterk, Albert de Wit, Niels van Hoorn</i>	

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING FOR MATERIALS AND STRUCTURES I

Adaptive Surrogate Models with Unbalanced Data for Material Design	1062
<i>Yulun Wu, Yumeng Li</i>	
Generative Adversarial Networks for the Inverse Design of 2D Spinodoid Metamaterials	1072
<i>Sheng Liu, Pinar Acar</i>	
Multiphysics-Informed Machine Learning for Uncertainty Quantification on Si Anode Based Battery Performance.....	1085
<i>Parth Bansal, Yumeng Li</i>	

Failure Modeling in Notched Twill Textile Composites Using Machine Learning1101
Eugene R. Kheng, Royan Dmello, Anthony Waas

Integrating Experiments, Simulations, and Artificial Intelligence to Accelerate the Discovery of
High-Performance Green Composites.....1112
Christos Athanasiou, Bolei Deng, Ahmed A. Hassen

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING FOR MATERIALS AND STRUCTURES II

Zero-Bias Deep Neural Network for Defect Detection in Composite Additive Manufacturing Using
Multisource In-Situ Data1117
Nicholas Phillips, Deepak Kumar, Yongxin Liu, Sirish Namilae

Revisiting Cylindrical Buckling Under Axial Compression Using Explainable Machine Learning1125
*Muhammad G. Wafi, Pramudita S. Palar, Mohammad D. Robani, Annisa Jusuf, Zuhail Lavi,
Joseph Morlier*

Analysis of Tow-Steered Laminates of Composites Using a Mixed-Fidelity Neural Network Model.....1139
Xin Liu, Bangde Liu, Su Tian, Wenbin Yu

3D WOVEN COMPOSITES FOR MATERIALS AND STRUCTURES

Probabilistic Sensitivity Studies of a Multiscale Process-To-Performance Model for Bonded
Composite Pi-Joints.....1151
*Matthew Kirby, Marcus L. Stanfield, Carl Popelar, David Riha, Kevin H. Hoos, Endel Iarve,
Eric G. Zhou, Alex S. Selvarathinam, David Mollenhauer*

Direct 3D Printing of Strain Sensors onto 3D Woven Orthogonal Composite Structures: Evaluating
Two Distinct Approaches for Sensor Performance.....1173
*Merve Karabal, Melisa Dincer, Dilan Arslan, Ramazan Yüksel, Zeynep Nur Akyazici, Alptekin
Yildiz, Hulya Cebeci*

Establishing Architectural Effects of Variable Binder on 3D Orthogonal Woven Composites: RVE
Model and Experiment Validation.....1186
Zeynep Nur Akyazici, Ibrahim Halil Sahin, Melisa Dincer, Yusuf C. Sudutemiz, Hulya Cebeci

A Quantitative Analysis of Waviness in Complex 3D Textile Using Least Squares Regression with
Sinusoidal Wave Form.....1203
*Eric G. Zhou, Carl Popelar, Vikram Bhamidipati, David S. Riha, Endel Iarve, Kevin H. Hoos,
Hari Adluru, David Mollenhauer, Keith Ballard*

Nonlinear Beam Based Digital Chain Modeling for 3D-Woven Textiles.....1213
Vikram Bhamidipati, John D. Whitcomb, Michael K. Ballard

Author Index