

A Joint Meeting of:

***The 2020 Annual Grantees'/Contractors' Meeting for
AFOSR Program on “Mechanics of Multifunctional
Materials & Microsystems”***

***The 4th Annual Review of CoE'16
“Self-Healing, Regeneration & Structural Remodeling”***

***The 4th Annual Review of BRI'16
“Muscular-Skeletal System Inspired
Morphing Air Vehicles Using Active Materials”***

***The 1st Annual Review of DESI'19
“Super-maneuverable Autonomous Pursuit”***

***The 1st Annual Review of MURI'19
“Neuromorphic Networks for Multifunctional
Intelligent Systems”***

***21-25 September 2020
“Virtual” (Contact AFOSR ITA / BRICC)***

SPONSORED BY:



Program Officer:

B.-L. ("Les") Lee (Air Force Office of Scientific Research)

Meeting Hosts & Co-Hosts (**session chair; **rapporteur*):

9/21/'20 -

***Host:** Somnath Ghosh (Johns Hopkins Univ.)

***Co-Host:** James Thomas (Naval Research Lab)

***Co-Host:** Ray Baughman (Univ. of Texas at Dallas)

****Co-Host:** Chandra Prakash (Johns Hopkins Univ.)

9/22/'20 -

***Host:** Nancy Sottos (Univ. of Illinois)

***Co-Host:** Philippe Geubelle (Univ. of Illinois)

***Co-Host:** Ioannis Chasiotis (Univ. of Illinois)

****Co-Host:** Ashely Trimmell (Univ. of Illinois)

9/23/'20 -

***Host:** Martin Dunn (Univ. of Colorado, Denver)

***Co-Host:** Kurt Maute (Univ. of Colorado, Boulder)

***Co-Host:** Jerry Qi (Georgia Inst. of Technology)

****Co-Host:** Tammy Hassan (Univ. of Colorado, Denver)

****Co-Host:** Erica Lefave (Univ. of Colorado, Denver)

9/24/'20 -

***Host:** Fu-Kuo Chang (Stanford Univ.)

***Co-Host:** Daniel Inman (Univ. of Michigan)

***Co-Host:** David Lentink (Stanford Univ.)

****Co-Host:** Faisal Haider (Stanford Univ.)

9/25/'20 -

***Host:** Yong Chen (Univ. of California, Los Angeles)

***Co-Host:** Stanley Williams (Texas A&M Univ.)

***Co-Host:** Qing Wu (Air Force Research Lab)

****Co-Host:** Jungmin Lee (Univ. of California, Los Angeles)

****Co-Host:** Dhruva Nathan (Univ. of California, Los Angeles)

Overall Registration Information:

<https://community.apan.org/wg/afosr/w/researchareas/27727/2020-annual-grantees-contractors-meeting-for-afosr-m-4-program/>

ZoomGov Access Information:

Zoom Link, Meeting ID and Password will be emailed to each registrant on 18 Sept 2020;

Background information - <https://youtu.be/YA6SGQIVmcA>; <https://youtu.be/-s76QHshQnY>

PoC: Kathy Ragsdale (Air Force Office of Scientific Research/ITA)

PoC: Keonna Sims (Air Force Office of Scientific Research/BRICC)

Keynote Speaker (21 September 2020):

William Carter (*Program Manager*, Defense Advanced Research Projects Agency)

Welcome Remark (25 September 2020):

Col Michelle Ewy (*Deputy Director/Commander*, Air Force Office of Scientific Research)

Speakers, PI's & Co-PI's (Non-Gov't):

Douglas Altshuler (Univ. of British Columbia, **Canada**)

Leif Asp (Chalmers Univ. of Technology, **Sweden**)

Ray Baughman (Univ. of Texas at Dallas)

J. William Boley (Boston University)

Richard Bomphrey (Royal Veterinary College, **UK**)

Fu-Kuo Chang (Stanford Univ.)

Ioannis Chasiotis (Univ. of Illinois)

Yong Chen (Univ. of California, Los Angeles)

Nikolaus Correll (Univ. of Colorado)

Mark Cutkosky (Stanford Univ.)

Martin Dunn (Univ. of Colorado, Denver)

Aaron Esser-Kahn (Univ. of Chicago)

Philippe Geubelle (Univ. of Illinois)

Somnath Ghosh (Johns Hopkins Univ.)

Emile Greenhalgh (Imperial College London, **UK**)

Darren Hartl (Texas A&M Univ.)

Lei He (Univ. of California, Los Angeles)

Ximin He (Univ. of California, Los Angeles)

Noel Holbrook (Harvard Univ.)

Jonathan Hopkins (Univ. of California, Los Angeles)

Yuhang Hu (Georgia Inst. of Technology)

Guoliang Huang (Univ. of Missouri)

Doug Hunsaker (Utah State Univ.)

Peter Ifju (Univ. of Florida)

Daniel Inman (Univ. of Michigan)

Sung Kang (Johns Hopkins Univ.)

Deok-Soo Kim (Hanyang Univ., **S. Korea**)

David Kisailus (Univ. of California, Irvine)

Roy Kornbluh (SRI International)

Nicholas Kotov (Univ. of Michigan)

Jay Kudva (NextGen Aeronautics, Inc.)

Amrita Kumar (Acellent Technologies)

Walter Lacarbonara (Univ. of Rome, **Italy**)

Giulia Lanzara (Univ. of Rome, **Italy**)

David Lentink (Stanford Univ.)

Hayk Martirosyan (Skydio, Inc.)

Kurt Maute (Univ. of Colorado, Boulder)

Majid Minary-Jolandan (Univ. of Texas at Dallas)

Jeffrey Moore (Univ. of Illinois)

Boris Murmann (Stanford Univ.)

Dave Myszka (Univ. of Dayton)

Jason Patrick (North Carolina State Univ.)

Harry Perkinson (TRI Austin, Inc.)

Jerry Qi (Georgia Inst. of Technology)

Jordan Raney (Univ. of Pennsylvania)

S. Andrew Sarles (Univ. of Tennessee, Knoxville)

Robert Shepherd (Cornell Univ.)

Henry Sodano (Univ. of Michigan)

Nancy Sottos (Univ. of Illinois)

Geoffrey Spedding (Univ. of Southern California)

Abraham Stroock (Cornell Univ.)

Sameh Tawfick (Univ. of Illinois)

Salvatore Torquato (Princeton U)

Jim Usherwood (Royal Veterinary College, **UK**)

Stanley Williams (Texas A&M Univ., formerly Hewlett-Packard Labs)

Joshua Yang (Univ. of Southern California)

Suin Yi (Texas A&M Univ.)
Pablo Zavattieri (Purdue Univ.)
Dan Zenkert (KTH Royal Institute of Technology, **Sweden**)
Jun Zhang (Univ. of Michigan)

Speakers, PI's & Co-PI's (Gov't):

Philip Beran (Air Force Research Lab - AFRL/RQVC)
Philip Buskohl (Air Force Research Lab - AFRL/RXAS)
Larry Drummy (Air Force Research Lab - AFRL/RXAS)
Michael Durstock (Air Force Research Lab – AFRL/RXA)
John Ferguson (Air Force Research Lab - AFRL/RXAN)
James Joo (Air Force Research Lab - AFRL/RQVS)
Abigail Juhl (Air Force Research Lab - AFRL/RXAS)
Alex Pankonien (Air Force Research Lab - AFRL/RQVC)
Ajit Roy (Air Force Research Lab - AFRL/RXAN)
Gregory Reich (Air Force Research Lab - AFRL/RQVC)
Christopher Tabor (Air Force Research Lab - AFRL/RXAS)
James Thomas (Naval Research Lab)
Carl Thrasher (Air Force Research Lab - AFRL/RXAS)
Richard Vaia (Air Force Research Lab - AFRL/RX)

Invitees:

William Carter (Defense Advanced Research Projects Agency), **Keynote Speaker**
Col Michelle Ewy (Air Force Office of Scientific Research), **Welcome Remark**
Dan Hammerstrom (Portland State Univ.)
Alamgir Karim (Univ. of Houston)
William Oates (Florida State Univ.)
Kai Yu (Univ. of Colorado, Denver)
Ray Kamin (Collins Aerospace)
Eric Ruggiero (GE Aviation)
Robert Smith (Boeing)
Siddiq Qidwai (National Science Foundation)
Daniel Cole (Army Research Office)
Todd Henry (Army Research Lab)
Daniel O'Brien (Army Research Lab)
Sina Najmaei (Army Research Lab)
Ignacio Perez de Leon (Office of Naval Research)
Hans Cho (Naval Research Lab)
Peter Finkel (Naval Research Lab)
Keith Perkins (Naval Research Lab)
William Baron (Air Force Research Lab - AFRL/RQV)
Jeffery Baur (Air Force Research Lab - AFRL/RXCC)
Benjamin Dickinson (Air Force Research Lab - AFRL/RWWN)
Sabyasachi Ganguli (Air Force Research Lab - AFRL/RXAN)
Joseph Vannostrand (Air Force Research Lab - AFRL/RITB)
Qing Wu (Air Force Research Lab - AFRL/RI)
Members of AFRL/ARL/NRL Applied Research for Advancement of S&T Priorities (ARAP)
Members of Multifunctional Materials for Defense Workshop

Erik Blasch (Air Force Office of Scientific Research)
Patrick Bradshaw (Air Force Office of Scientific Research)
Jean-Luc Cambier (formerly Air Force Office of Scientific Research)
Fariba Fahroo (Air Force Office of Scientific Research)
Kenneth Goretti (Air Force Office of Scientific Research)
Hal Greenwald (Air Force Office of Scientific Research)
Frederick Leve (Air Force Office of Scientific Research)
Ming-Jen Pan (Air Force Office of Scientific Research)
Sheena Winder (Asian Office of Aerospace R&D)
David Garner (European Office of Aerospace R&D)
Shad Reed (European Office of Aerospace R&D)
Douglas Smith (European Office of Aerospace R&D)

AGENDA (Time: EDT)

Monday, September 21

The 2020 Annual Grantees'/Contractors' Meeting for AFOSR Program on "Mechanics of Multifunctional Materials & Microsystems" – Day 1

Meeting Host: Somnath Ghosh (Johns Hopkins U);
Meeting Co-Hosts: Jim Thomas (NRL); Ray Baughman (U Texas Dallas);
Chandra Prakash (Johns Hopkins U)

Join Zoom Meeting
Details to be emailed to each registrant

Time	Speaker	Title of Presentation
09:00		Registration
Session Chair: Somnath Ghosh (Johns Hopkins U)		
10:30	Les Lee AFOSR	Opening
10:35	Bill Carter DARPA	Keynote Presentation – Multifunctional Materials for Harsh Environments: Enabling the "High Ground"
11:00	Salvatore Torquato Princeton U	Extraordinary Multifunctional Disordered Composites
11:25	Jordan Raney U Pennsylvania	Bifurcation Based Actuation for Autonomous Smart Structures
11:50	Ioannis Chasiotis U Illinois	Local Multiphysics Studies in Nanostructured Materials
12:15	Rich Vaia Larry Drummy AFRL/RX	Extreme Mechanical Energy Absorption: Plasticity of Polymer-Nanoparticle Solids
12:40	Break	Break

Session Chair: Jim Thomas (NRL)		
13:30	Nicholas Kotov U Michigan	Graph Theory of Nanoscale Framework Materials
13:55	Ray Baughman U Texas Dallas	Knowledge-Driven Design and Optimization of New Types of Yarn and Fiber Artificial Muscles
14:20	Ajit Roy John Ferguson Steven Fairchild AFRL/RX	High Temperature Electronics Module Failure Physics and Design
14:45	Somnath Ghosh Johns Hopkins U	Integrated Multi-Physics, Multi-scale Computational Modeling Framework for Multifunctional Applications
15:10	Break	Break

Session Chair: Ray Baughman (U Texas Dallas)		
16:00	Somnath Ghosh Johns Hopkins U Jim Thomas NRL	Validation of Multiscale Modeling and Design Platform for Protective Hybrid Composite Systems for Aerospace Structures
16:40	Jerry Qi GA Tech Martin Dunn Kurt Maute U Colorado	(i) Hybrid 3D Printing: Pick-and-Place Robotics for Additive Fabrication of 4D Composites; (ii) Integrated Multiscale Design and Additive Manufacture of Multifunctional Composites
17:20	Will Boley Boston U	(YIP) 4D Printing Materials with Programmed Responsiveness and Stiffness for Multifunctional Adaptive Architectures
17:45		Open Discussion
18:00	Adjournment	Adjournment

Tuesday, September 22		
<p>The 2020 Annual Grantees'/Contractors' Meeting for AFOSR Program on "Mechanics of Multifunctional Materials & Microsystems" – Day 2</p> <p>Meeting Host: Nancy Sottos (U Illinois); Meeting Co-Hosts: Philippe Geubelle (U Illinois); Ioannis Chasiotis (U Illinois); Ashely Trimmell (U Illinois)</p> <p>Join Zoom Meeting Details to be emailed to each registrant</p>		
Time	Speaker	Title of Presentation
09:00		Registration
<p>The 4th Annual Review of Center of Excellence in "Self-Healing, Regeneration & Structural Remodeling"</p> <p>Session Chair: Nancy Sottos (U Illinois)</p>		
10:30		Housekeeping
10:35	Nancy Sottos U Illinois	CoE'16 in "Self-Healing, Regeneration & Structural Remodeling" – (i) Overview
11:00	Nancy Sottos U Illinois	(ii) Rapid Manufacturing of Multifunctional Composites
11:20	Ioannis Chasiotis U Illinois	(iii) Durability and Damage Resistance of pDCPD Composites in Space Environment
11:40	Philippe Geubelle U Illinois	(iv) Modeling of Frontal Polymerization and Instabilities
12:00	Aaron Esser-Kahn U Chicago	(v) Frontal Polymerization and Phase Change Materials for Patterning
12:20	Jeffrey Moore U Illinois	(vi) Toward Morphogenic Manufacturing

12:40	Break	Break
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Session Chair: Philippe Geubelle (U Illinois)		
13:30	Jason Patrick North Carolina State U	(YIP) Integrated Self-healing and Self-sensing using Optical Waveguides in Microvascular Fiber-Composites
13:55	Ximin He UCLA	(YIP) Bio-inspired Artificial Homeostatic Multifunctional Material Microsystems (AHM3)
14:20	Yuhang Hu GA Tech	(YIP) Tough Gel: A Perfect Platform for Designing Chemo-Mechano-Chemically Responsive Multi-Functional Materials
14:45	Sung Kang Johns Hopkins U	(YIP) Bioinspired Synthesis of Multifunctional Materials with Self-Adaptable Mechanical Properties and Self-Regeneration
15:10	Break	Break

Session Chair: Ioannis Chasiotis (U Illinois)		
16:00	Abraham Stroock Cornell U Noel Holbrook Harvard U	Plant-Mimetic Functional Materials for Thermal Management and Suppression of Freezing
16:25	Sameh Tawfick U Illinois	(YIP) Additive Manufacturing of Polymorphic Hair Material Systems for Multifunctional Reconfiguration and Damage Restoration
16:50	Majid Minary-Jolandan U Texas Dallas	Self-Sensing and Self-Healing Metal Matrix Composites
17:15	David Kisailus UC Irvine Pablo Zavattieri Purdue U	Investigation of Force Transduction and Actuation in Integrated Multifunctional Biological Structures
17:40		<i>Open Discussion</i>
18:00	Adjournment	Adjournment

Wednesday, September 23		
<p><i>The 2020 Annual Grantees'/Contractors' Meeting for AFOSR Program on "Mechanics of Multifunctional Materials & Microsystems" – Day 3</i></p> <p><i>Meeting Host:</i> Martin Dunn (U Colorado Denver);</p> <p><i>Meeting Co-Hosts:</i> Kurt Maute (U Colorado Boulder); Jerry Qi (Georgia Tech); Tammy Hassan (U Colorado Denver); Erica Lefave (U Colorado Denver)</p> <p><i>Join Zoom Meeting</i></p> <p><i>Details to be emailed to each registrant</i></p>		
<p><i>Dedicated to Memory of Prof. Minoru Taya at Univ. of Washington, A Pioneer of Multifunctional Materials</i></p>		
<i>Time</i>	<i>Speaker</i>	<i>Title of Presentation</i>
09:00		<i>Registration</i>

Session Chair: Martin Dunn (U Colorado Denver)

10:30		Housekeeping
10:35	Martin Dunn U Colorado Dan Inman U Michigan	<i>Celebration of Life for Prof. Minoru Taya</i>
11:20	Leif Asp Chalmers Univ. of Technology Dan Zenkert KTH Royal Institute of Technology Emile Greenhalgh Imperial College London	(i) Damage Tolerance and Durability of Structural Power Composites; (ii) Mechanical and Impact Properties of Structural Power Devices
12:00	Mike Durstock Phil Buskohl Abby Juhl AFRL/RX	Architecting the Future of Energy Storage – From 2D to 3D
12:40	Break	Break

Session Chair: Kurt Maute (U Colorado Boulder)

13:30	Guoliang Huang U Missouri C. T. Sun Purdue U	Programmable Elastic Metamaterials for Unprecedented Wave and Dynamic Control
13:55	Chris Tabor Carl Thrasher AFRL/RX	Responsive Electronics Using Liquid Metal Colloids
14:20	Amrita Kumar Acellent Technologies Boris Murmann Fu-Kuo Chang Stanford U	(STTR Phase II) Flexible Sensor Network and Its Embedded Integrated Circuits for Structural Health Monitoring
14:45	Jonathan Hopkins UCLA	Mechanical Neural-network Architecture Materials that Learn
15:10	Break	Break

Session Chair: Jerry Qi (Georgia Tech)

16:00	Greg Reich Philip Beran Alex Pankonien AFRL/RQ	Bio-inspired Reconfigurable System Design via Topology Optimization
16:25	Rob Shepherd Cornell U Nikolaus Correll U Colorado	Localized and Rapid Variable Compliance Via Phase Changing Matter and Distributed Computation
16:50	Harry Perkinson TRI Austin Peter Ifju U Florida	(STTR Phase II) Biomimetic Design of Morphing Micro Air Vehicles
17:15	Jay Kudva Concepts to Systems	(STTR Phase II) Biomimetic Design of Morphing Micro Air Vehicles

	Geoffrey Spedding U Southern Calif Roy Kornbluh SRI International	
17:40	James Joo AFRL/RQ Doug Hunsaker Utah State U Dave Myszka U Dayton	Bio-inspired Flight Using a Rotating Empennage
18:05		<i>Open Discussion</i>
18:20	Adjournment	Adjournment

Thursday, September 24

The 2020 Annual Grantees'/Contractors' Meeting for AFOSR Program on "Mechanics of Multifunctional Materials & Microsystems" – Day 4

Meeting Host: Fu-Kuo Chang (Stanford U);
Meeting Co-Hosts: Dan Inman (U Michigan); David Lentink (Stanford U);
Faisal Haider (Stanford U)

[Join Zoom Meeting](#)
Details to be emailed to each registrant

Time	Speaker	Title of Project
09:00		<i>Registration</i>
<i>The 4th Annual Review of AFOSR Basic Research Initiative '16: "Muscular-Skeletal System Inspired Morphing Air Vehicles Using Active Materials"</i>		
Session Chair: Dan Inman (U Michigan)		
10:35	Dan Inman U Michigan	<i>AFOSR BRI'16 on "Avian-Inspired Multifunctional Morphing Vehicles" – Program Overview</i>
11:05	Giulia Lanzara Walter Lacarbonara U Rome	Highly Reconfigurable, Multistable Composites with Tunable Morphing Capability
11:30	Richard Bomphrey Jim Usherwood Royal Veterinary College	Laboratory-Based Approaches for Bird Wing Morphing Experiments
11:55	David Lentink Stanford U	Inspiration from Biological Avian Morphing: Aerodynamic Performance
12:20	Doug Altshuler U British Columbia	Inspiration from Biological Avian Morphing: Aerodynamic Performance
12:45	Break	Break

Session Chair: David Lentink (Stanford U)		
13:30	Dan Inman U Michigan	Avian Inspired Morphing Surfaces
13:55	Darren Hartl Texas A&M	Emulation of Avian Muscular Work Loops with Multi-Physical Actuators
14:20	Fu-Kuo Chang Stanford U	Bio-inspired Distributed Sensing
14:45	Henry Sodano U Michigan	3D Printed Actuators and Sensors
15:10	Dan Inman U Michigan	<i>Conclusions</i>
15:15	Break	Break

Session Chair: Fu-Kuo Chang (Stanford U)		
<i>The 1st Annual Review of Defense Enterprise Science Initiative '19: "Super-maneuverable Autonomous Pursuit"</i>		
16:00	David Lentink Mark Cutkosky Stanford U Hayk Martirosyan Skydio Inc.	<i>DoD DESI '19 Grant on "Super-maneuverable Autonomous Pursuit: Peregrine Falcon vs Pigeon Inspired UAVs"</i>
<i>Guest Presentation for AFRL/ONRG Co-sponsored Grant on "Swarm of Multiple Drones"</i>		
17:30	Deok-Soo Kim Hanyang U	<i>AFRL/ONRG Co-sponsored Grant on "Collision Avoidance Among the Swarm of Multiple Drones: Voronoi Diagram Based Analysis"</i>
18:00	Adjournment	Adjournment

Friday, September 25		
<i>The 1st Annual Review of MURI'19: "Neuromorphic Networks for Multifunctional Intelligent Systems"</i>		
Meeting Host: Yong Chen (UCLA); Meeting Co-Hosts: Stanley Williams (Texas A&M U); Qing Wu (Air Force Research Lab); Jungmin Lee (UCLA); Dhruva Nathan (UCLA)		
Join Zoom Meeting <i>Details to be emailed to each registrant</i>		
Time	Speaker	Title of Presentation
09:00		<i>Registration</i>
Session Chair: Stanley Williams (Texas A&M U)		
10:30	Col Michelle Ewy Deputy Director/ Commander	<i>Welcome Remark</i>

	AFOSR	
.10:40	Yong Chen UCLA	Introducing MURI Team Members and Participants (UCLA / U Tenn / U So Calif / Texas A&M / Stanford U / U Michigan) (PI: Yong Chen; Co-PIs: Andy Sarles, Joshua Yang, Stanley Williams, Lei He, Fu-Kuo Chang, Dan Inman, Jun Zhang) (PM: Les Lee; Co-PM's: Pat Bradshaw, Ken Goretta, Jean-Luc Cambier)
10:45	Yong Chen UCLA	MURI'19 on "Brain-Inspired Networks for Multifunctional Intelligent Systems in Aerial Vehicles" – Program Overview
Thrust A: Devices to emulate synapses and neurons Thrust B: Circuits to emulate neural networks		
.11:30	Yong Chen UCLA	Synaptic Resistor Networks for Multifunctional Intelligent Systems
12:05	Break	Break

Session Chair: Yong Chen (UCLA)		
12:35	Andy Sarles U Tenn Knoxville	Biomolecular Synapses that Mimic the Composition, Structure, and Transport Properties of Biological Synapses
13:10	Joshua Yang U Southern Calif	Memristive Devices for Brain-Inspired Computing
13:45	Lei He UCLA	Design and Simulation of Synstor Circuits for Intelligent Systems
14:20	Break	Break
Thrust C: Multifunctional intelligent systems in aerial vehicles		
14:50	Fu-Kuo Chang Stanford U	Intelligent Multifunctional Composite Materials with Sensory Neuron Networks, Neuromorphic Chips and Batteries
15:25	Dan Inman U Michigan	Towards Self-Piloted UAV (SPUAV) Through Real-Time Learning on Brain-Inspired Circuits
16:00	Break	Break

Session Chair: Qing Wu (Air Force Research Lab)		
Thrust D: Theories about the brain, circuits, and intelligent systems		
16:15	Stanley Williams Suin Yi Texas A&M U	Quantitative Modeling and Nonlinear Analysis of Neuromorphic Elements and Circuits
16:50	Jun Zhang U Michigan	Unifying Information with Physics for Intelligent Networks/Systems: The Information Geometric Approach
17:25	Yong Chen UCLA	Open Discussion & Wrap-up
17:40	Break	Break
Close Door Session for Government Reviewers AFRL Meet-me line to be reserved (audio; invitee only)		
18:30	Qing Wu Air force Research Lab	Summary of Government Reviewers' Feedbacks

18:45	Yong Chen UCLA	<i>Closing Remark</i>
18:50	Adjournment	Adjournment