ASME® 2020 SMASIS

The ASME 2020 Conference on Smart Materials, Adaptive Structures and Intelligent Systems

CONFERENCE
Sep 15, 2020

Virtual, Online

Program

https://event.asme.org/SMASIS

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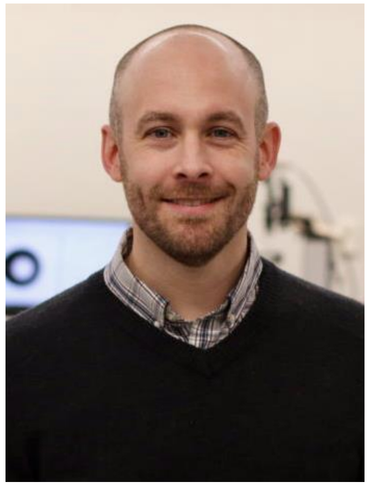
Oliver Myers
General Conference Chair
Clemson University



Stephen (Andy) Sarles
Technical Conference Chair
University of Tennessee, Knoxville

Amin Karami
Technical Program Co-Chair
University of Buffalo

Dear SMASIS Family:

What a year this has been!!!! COVID-19 Quarantines, Financial Challenges and Cultural Unrest have tested us in ways that we have never experienced in our lifetimes, but the great news is that we shall come out of this stronger and better. As our conference name states we are SMART, ADAPTIVE, & INTELLIGENT, just as the systems and research we conduct. We as individuals, immediate families, SMASIS family and this country have overcome a lot and we should continue to be very grateful.

While we are not able to get together for our 13th Annual ASME Smart Materials, Adaptive Structures, and Intelligent Systems (SMASIS) Conference and Family Reunion, we are still dedicated to sharing our best work via a virtual platform.

SMASIS will still present top-quality research, technological designs and development and governmental integrated systems and applications/demonstration through short presentations in:

- Symposium 1: Development & Characterization of Multi-functional Materials
- Symposium 2: Mechanics and Behavior of Active Materials
- Symposium 3: Modeling, Simulation and Control of Adaptive Systems
- Symposium 4: Integrated System Design and Implementation
- Symposium 5: Structural Health Monitoring
- Symposium 6: Bioinspired Smart Materials and Systems
- Symposium 7: Energy Harvesting
- Symposium 8: Emerging Technologies

We will honor our ASME Adaptive Structures Prize Winner who will deliver a keynote presentation. Our virtual platform will include one 15-20 minute invited talk from each symposium, 10 min concurrent talks of the research presentations, student paper and student hardware competitions and we will culminate with our first Virtual Pioneer Awards Banquet where everyone will have the opportunity to share and compete with their favorite backgrounds and hats. Everyone is encouraged to bring your own dinner and favorite beverage!!!

While the COVID quarantine and aftermath has prevented us from physically getting together, the SMASIS Spirit of Improvise, Adapt and Overcome remains strong. This would not have been possible without the support and efforts of ASME, the ASME Aerospace Division Adaptive Structures and Materials Systems Branch; the ASME Aerospace Executive Committee, the ASME SMASIS Symposia Chairs and Co-Chairs, the Technical Committees and organizing committees.

Thank you to each and every one of you for participating and supporting our 2020 ASME SMASIS Virtual Conference and for adapting to this year's protocols. We look forward to laughing at our virtual backgrounds and hats and getting back together at the 2021 ASME SMASIS in Austin, TX. THIS WILL BE OUR FINEST HOUR!!!!

On behalf of the 2020 Conference Committee and ASME, thank you for your participation. Please note that the technical presentations will be available OnDemand via the Pheedloop Platform starting on Tuesday, September 15 for 3 months after the conference and the live presentations will also be available a few days after the conference for 3 months. If you have any questions, please email Mary Jakubowski, the Conference Manager at jakubowskim@asme.org.

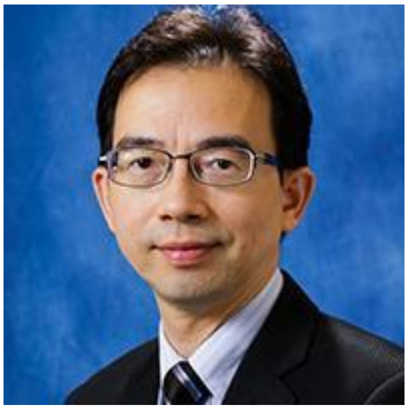
ASME® 2020 SMASIS

SCHEDULE-AT-A-GLANCE

Day 1 - Tuesday, September 15, 2020 - Eastern Daylight Time						
Welcome & Keynote Session						
10:00	10:10	**Welcome - Tom Costabile (ASME), Introduces Oliver Myers (SMASIS General Chair) - Opening Remarks/Moderates Q&A**				
10:10	10:15	**Moderators - Andy Sarles and Amin Karami (SMASIS Technical Chairs) - Speaker Introductions**				
10:15	10:45	Keynote	Wei-Hsin	Liao	2020 ASME Adaptive Structures and Material Systems Award: Vibration, Energy Harvesting, Human Motion	The Chinese University of Hong Kong
10:45	10:55	Q&A				
Session 1: Student Research Highlights and Morphing Aircraft						
10:55	11:00	**Moderators - Giovanni Berselli and Amin Bibo, Chairs of Student Competitions**				
11:00	11:20	Student Highlights			Student Paper & Hardware Competition	
11:20	11:40	Invited Talk 1.1	Antonio	Concilio	Status and perspectives of commercial aircraft morphing	Italian Aerospace Research Center, Italy
11:40	11:50	Q&A				
11:50	12:00	Break				
Session 2: Advances in Shape Memory Alloys						
12:00	12:05	**Moderators - Cornel Ciocanel, Chairs of Symposia 1 and 2**				
12:05	12:25	Invited Talk 2.1	Thomas	Niendorf	Functionally Graded Materials by Additive Manufacturing – From Conventional to Shape Memory Alloys	University of Kassel, Germany
12:25	12:45	Invited Talk 2.2	Gaoyuan	Ouyang	Combinatorial Development of Copper Based SMA	Ames Laboratory of US DOE & Iowa State Univ.
12:45	12:55	Q&A				
12:55	13:05	Break				
Session 3: Flexible Structures - Mechanics, Design, and Intelligence						
13:05	13:10	**Moderators - James Gibert and Andres Arrieta, Chairs of Symposia 3 and 4**				
13:10	13:30	Invited Talk 3.1	Guangbo	Hao	Structure, Stiffness, and Multi-Stability Design in Compliant/Flexible Mechanisms	Univ. College Cork, Ireland
13:30	13:50	Invited Talk 3.2	Ryan	Harne	Smart Mechanical Matter	Penn State University
13:50	14:00	Q&A				
14:00	14:10	Break				
Session 4: Smart Materials and the IoT						
14:10	14:15	**Moderators - Dan Cole and Joe Calogero, Chairs of Symposia 5 and 6**				
14:15	14:35	Invited Talk 4.1	Antonios	Konstsos	An Internet of Things Approach for Dynamic and Data-Driven Remaining Useful Life Predictions	Drexel University
14:35	14:55	Invited Talk 4.2	Dong	Ha	Energy Harvesting for Wireless IoT Devices	Virginia Tech
14:55	15:05	Q&A				
15:05	15:15	Break				
Final Session: Networking and Awards Presentation						
15:15	15:45	Networking Session				
15:45	16:15	**Pioneer Banquet (Awards Ceremony and Closing Remarks) - Oliver Myers, Andy Sarles, and Amin Karami**				

Keynote Speaker

Tuesday, September 15
10:15am-10:45am



Dr. Wei-Hsin Liao
The Chinese University of Hong Kong (Hong Kong, China)

Title: Vibration, Energy Harvesting, Human Motion

Abstract: By utilizing adaptive features, smart materials can be built as actuators and sensors. They were used as intelligent elements for vibration control of structures. Besides passive approach, active, semi-active, and active-passive hybrid vibration control have been extensively studied. For vibration control, applications to hard disk drives using piezoelectric actuators with passive damping, semi-active train suspension systems utilized controllable MR dampers will be shown. On the other hand, energy can be harvested from vibration and human motion. Piezoelectric and electromagnetic power generators were used to transform the mechanical energy from vibration and human motion into electrical energy. An energy flow was proposed with detailed analysis to clarify and illustrate each branch of the energy flow in piezoelectric energy harvesting systems. An equivalent impedance network was proposed and investigated. Since there is a large amount of kinetic energy in the human body during activities, capturing human motion and converting it into electricity is envisaged to render promising prospects for sustainably powering wearables and fulfilling the continuous working requirement of IoT applications. Aimed at scavenging the kinetic energy of the human joints, various energy harvesters have been designed and investigated. Besides, robotic exoskeletons and smart ankle-foot prostheses that can assist people with impaired mobility have been developed. Our related work will be presented.

Biography: Wei-Hsin Liao received his Ph.D. degree in mechanical engineering from The Pennsylvania State University, University Park, PA, USA. Since 1997, Dr. Liao has been with The Chinese University of Hong Kong, where he is currently a Professor and the Chairman of the Department of Mechanical and Automation Engineering. His research has led to publications of over 280 papers in international journals and conference proceedings, 19 granted patents. As the General Chair, he organized the 20th International Conference on Adaptive Structures and Technologies (ICAST 2009). He was the Conference Chair for the Active and Passive Smart Structures and Integrated Systems, SPIE Smart Structures/NDE in 2014 and 2015. He received the T A Stewart-Dyer/F H Trevithick Prize 2005, awarded by the Institution of Mechanical Engineers, the ASME Best Paper Awards in Structures (2008), Mechanics and Material Systems (2017). Dr. Liao is the recipient of the SPIE 2018 SSM Lifetime Achievement Award, and ASME 2020 Adaptive Structures and Material Systems Award. He currently serves as an Associate Editor for the *Journal of Intelligent Material Systems and Structures*, as well as *Smart Materials and Structures*. Dr. Liao is a Fellow of the American Society of Mechanical Engineers, the Institute of Physics, and the Hong Kong Institution of Engineers.

Invited Speakers

Tuesday, September 15
11:20am - 11:40am

Dr. Antonio Concilio, Italian Aerospace Research Center (CIRA), Italy

Title: Status and perspectives of commercial aircraft morphing

Authors: Antonio Concilio (Speaker) and Salvatore Ameduri

Abstract: In a previous paper, the authors dealt with the current showstoppers for morphing systems and a number of reasons that have inhibited their commercial applicability. In this work, the authors would like to express a critical vision of the current status of the proposed architectures and the needs that should be accomplished to make them viable for installation on-board of commercial aircraft. The distinction is essential because military and civil issues and necessities are very different, and both the solutions and difficulties to be overcome are widely diverse. Yet, still remaining in the civil segment, there can be further differences, depending on the size of the aircraft, from large jets, to commuters or general aviation, in turn classifiable in tourism, acrobatic, ultralight and so on, each with their own peculiarities. The paper wants therefore to try to trace a common technology denominator, if possible, and envisage a future perspective of actual applications.

Biography: Antonio Concilio took his degree in Aeronautics Engineering with honour at the University of Napoli "Federico II" (Italia) in 1989; there, he was also awarded his PhD in Aerospace Engineering in 1995.In 2007 he completed the ECATA Master in Aerospace Business Administration, at ISAE-Supaero, Toulouse (France). Since 1989 he works as a Researcher at the Italian Aerospace Research Centre (Italia), where he is currently the Head of the Adaptive Structures Division. Since 2005, he is a lecturer at the PhD School "SCUDO" at the University of Napoli "Federico II" ("Introduction to Smart Structures, Theory and Applications"). He is author of about 200 scientific papers, presented at conferences or published into specialised journals.

12:05pm - 12:25pm

Dr.-Ing. Thomas Niendorf, University of Kassel, Germany

Title: Functionally graded materials by additive manufacturing – From conventional to shape memory alloys

Abstract: Additive manufacturing (AM) allows for realization of components of unprecedented geometrical complexity. Due to the principle of layer-wise manufacturing enabled only by a sliced design file, topologically optimized components can be easily manufactured. Most commonly employed techniques comprise laser- and electron beam powder bed fusion (L-PBF and E-PBF) as well as laser metal deposition (DED). All techniques are characterized by very characteristic features in a very similar way: relatively small melt pools, rapid solidification and intrinsic heat treatment. Thus, all these techniques allow to establish unique microstructures, provided that apt process parameters are employed. As these process parameters in principle can be adjusted on purpose in given volumes, realization of microstructurally and functionally graded components is feasible.

The present paper presents pathways towards tailoring local properties. Focus will be on both conventional and shape memory alloys (SMAs) as well as conditions combining these two different materials within one structure. Results shown will highlight prospects and challenges by detailing microstructure evolution, process induced defect structures, adequate post treatments and eventually mechanical and functional properties.

Biography: Dr.-Ing. Thomas Niendorf is Full Professor at the Institute of Materials Engineering at University of Kassel (Germany) since October 2015. Dr. Niendorf studied Mechanical Engineering at University of Paderborn (Germany). In 2010 he did his doctorate. Dr. Niendorf's research interests are in the interrelationships of process, microstructure, mechanical properties and reliability of metallic materials. Analysis of residual stresses, microstructure evolution and fatigue performance are key aspects of research projects conducted. Materials in focus are steels, aluminum alloys, high-temperature materials, shape memory alloys as well as hybrid materials.

Research activities in the field of additive manufacturing (AM) comprise powder bed techniques (L-PBF and E-PBF) as well as laser metal deposition. Realization of microstructurally graded samples for improved functionality as well as thorough characterization of integrity and reliability of AM components are Dr. Niendorf's actual fields of research in AM. Dr. Niendorf published more than 150 peer-reviewed papers in renowned journals. Furthermore, he holds several patents and has been invited speaker in many conferences. He has been scientific board member and session organizer in several European conferences focusing on AM. For his young career achievements he received several distinguished awards, e.g. the Heinz Maier-Leibnitz-Award by German Research Foundation.

12:25pm - 12:45pm

Dr. Guanyuan Ouyang, Ames Laboratory of US DOE
Iowa State University

Title: Combinatorial Development of Copper Based SMA

Abstract: Copper based SMAs offer higher thermal conductivity and lower cost than the most popular Ni-Ti based SMAs, but suffer from brittleness and low stress to reach super-elastic plateau. Cu-Al-Mn based SMA was reported to exhibit excellent cold workability if its parent A2 phase is disordered, which can be achieved by tuning its composition, such as by limiting its aluminium content to <16 at.%. Unfortunately, such tweaking of compositions also results in shifting of phase transformation temperature outside of the desired working temperature range. A comprehensive compositions optimization effort was carried to identify the fourth and fifth elements allowing the SMA to exhibit reasonable ductility while maintain a good phase transformation characteristic. The effort used combinatorial arc melting technique to rapidly synthesize hundreds of small bulk alloy samples. Bulk sample is preferred over thin film sample despite the fact that the throughput of combinatorial thin film method is much higher. This preference is due to the difficulty in reliably characterizing phase transformation behaviour and crystal structures of thin film. The obtained bulk samples are in the form of a small button weighing about 1-2 gram. These buttons were batch-sealed into quartz ampules and subjected to heat treatment involving solution treatment and quenching. Subsequent characterizations include x-ray for lattice parameters and phase identification, hardness testing, ultrasound elastic module measurement, and thermal imaging screening for phase transformation. The down-selected candidates were further studied using the conventional metallurgical method such as drop casting, DSC, x-ray, and flexural strength measurement using 3-point bending technique. The final composition was also thermal-mechanically treated to refine grain sizes and to encourage the desired texture. In this talk, detailed experimental work will be presented and possible mechanism leading to the disordered A2 phase will be discussed.

Biography: Dr. Ouyang joined Ames Laboratory (a U.S. Department of Energy National Laboratory) as an Assistant Scientist in 2019. Before that, he was a post-doc researcher at Iowa State University (2016-2019). Dr. Ouyang's current research focuses on ferroic materials and high temperature structural materials. His current research projects include combinatorial synthesis and characterization of shape memory alloys and elastocaloric materials, high entropy alloys for high temperature applications, and Fe-Si based soft magnetic materials for motor and power electronics. Dr. Ouyang has extensive experience in shape memory alloys, soft magnetic materials, high temperature alloys and ceramics, and materials processing and characterization. He has 18 papers published on peer review journals and 5 pending patents.

1:10pm-1:30pm

Dr. Guangbo Hao, University of College Cork, Ireland

Title: Structure, Stiffness, and Multi-Stability Design in Compliant/Flexible Mechanisms

Abstract: Compliant mechanisms utilize bending or torsion of flexible beams to transfer motion, force or energy, and have received increasing attentions over the last two decades due to their merits in terms of reduced cost and increased performance. In this talk, we will present some recent work on structure, stiffness, and multi-stability design in compliant/flexible mechanisms. A structure design method is firstly discussed, which is based on the position-space that can be identified by the screw theory. This structure design method can complement other existing design methods such as FACT, and can be used to produce compact configuration, reduced parasitic motions and/or other purposeful reconfigured designs. Then, a stiffness design method is presented, which will be demonstrated by controlling the internal axial load and using tensural-compresual general beams. Finally, a multi-stability design method is reported by designing the elastic potential energy or magnetic potential energy at multiple local minimums, and a self-folding chain for minimum invasive surgery is elaborated.

Biography: Dr. Guangbo Hao is a Senior Lecturer at University College Cork (UCC), and also an academic associate in Tyndall National Institute, Ireland. He is leading the CoMAR research group. His current research interests focus on design of compliant mechanisms and robotics and their applications in precision engineering, energy harvesting and biomedical devices. His research works were indicated by 2 filed patents, 130 peer-reviewed publications and 20 invited talks (3 keynote/plenary), and by successfully securing research grants from EU, Ireland, and China. He is an elected member of the ASME Mechanisms and Robotics Committee. He is serving as an Associate Editor of ASME Journal of Mechanisms and Robotics, the Editor-in-Chief of the IFToMM affiliated journal: Mechanical Sciences (MS), and an overseas editorial board member of Chinese Journal of Mechanical Engineering (CJME). He acted as the Chair of the 2016 and 2018 ASME IDETC/CIE Compliant Mechanism Symposiums, an Associate Editor of 2017-2019 IEEE IROS conferences, and a Program Chair in the 2018 4th IEEE/IFToMM International conference on Reconfigurable Mechanisms and Robots. He received some prizes including the solo winner of 2017 ASME Compliant Mechanisms Award in Application, the joint winner of the 2018 ASME Compliant Mechanisms Award, the winner of the Young Engineers Research Paper Prize 2012 (3rd Prize) presented by IMechE and Engineers Ireland, the Royal Irish Academy Charlemont Award for 2015.

1:30pm – 1:50pm

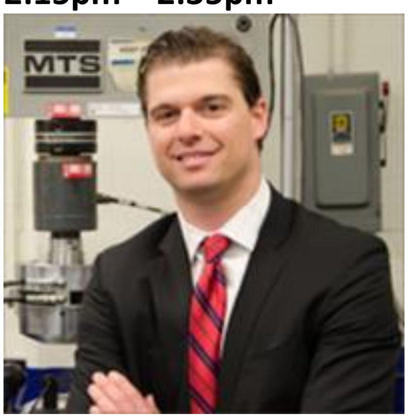
Ryan L. Harne, Penn State University

Title: Smart Mechanical Matter

Abstract: An accelerating attention to flexible electronic materials and devices has opened doors for electronics and machines that seamlessly engage with humans via soft and compliant interfaces, impacting applications of healthcare, medicine, personal electronics, manufacturing, and more. Yet, the attention has largely focused on elementary functional devices such as strain sensors, whereas modern electronics rely on digital logic and determine behavior on the basis of sophisticated intelligence and controllers. This talk will highlight emergent research that creates a bridge between the operation of conventional integrated circuits and advances in soft, conductive materials via a new class of smart mechanical matter. By devising a tangible analogy between Boolean logic and modal behaviors of conductive, mechanical metamaterials, logic gating behavior is cultivated according to mechanical stress application on the metamaterials. This in turn facilitates digital computation and control in response to the stress. The talk summarizes computational and experimental efforts to explore this new opportunity for mechanical metamaterials to directly govern operation of digital controllers. The talk concludes with a detailed vision that synthesizes new and future advances in mechanics, materials, biology, chemistry, and computer science to realize soft, autonomous machines that may independently navigate our world to assist in applications as diverse as ecological reporting, wound healing, assisted living, vehicle safety, and much more.

Biography: Ryan L. Harne is the James F. Will Career Development Associate Professor in the Department of Mechanical Engineering at The Pennsylvania State University where he directs the Laboratory of Sound and Vibration Research. Ryan earned his Ph.D. degree in Mechanical Engineering at Virginia Tech in 2012. From 2012 to 2015, Ryan was a Research Fellow at the University of Michigan. His research expertise spans mechanics, dynamics, vibrations, materials, and manufacturing. He has led research efforts yielding 80 publications, 2 patents, 1 book, 25 student awards, and 1 startup company. Ryan is active in the ASME, ASA, and SPIE in multiple organizational roles. Ryan's contributions to science and engineering have been acknowledged by being recipient of the 2020 ASME CD Mote Jr. Early Career Award, the 2019 ASME Gary Anderson Early Achievement Award, the 2018 National Science Foundation CAREER Award, the 2017 ASME Best Paper Award in Structures and Structural Dynamics, the 2016 ASME Haythornthwaite Young Investigator Award, and the 2011 ASA Royster Award. He currently serves as an Associate Editor for ASME Journal of Vibrations and Acoustics and for the The Journal of the Acoustical Society of America, Proceedings of Meetings on Acoustics.

2:15pm – 2:35pm



Dr. Antonios Kontsos, Drexel University

Title: An Internet of Things Approach for Dynamic and Data-Driven Remaining Useful Life Predictions

Abstract: In prognostic health management multiple gaps have been identified when making estimations or predictions of the current state and the associated remaining useful life (RUL), many of which are associated with the acquisition, handling and use of available sensing information. What is understood currently is that prognostics must account for the stochastic and coupled, also often nonlinear, effects that govern e.g. the progressive failure process structural applications. Practically data acquired during experimental testing and is used to either fit prognostic parameters or perform statistical inference is typically subject to a high amount of variance. Consequently, monitoring of the progressive failure is characterized by high uncertainty making physics-based models either computationally expensive for live prediction or specialized to account for specific damage occurring among This is especially true in the case that the convolution levels make it difficult to discriminate between noise and actual damage. To address signal convolution and increase the capability to identify evolving states of damage, data mining is required to discriminate between signals that allude to noise and signals that are most likely to be attributed to damage. Additionally, when training methodologies that are not physics-based, data management becomes increasingly difficult. To address therefore such data management issues, a data-driven, distributed and dynamically updated methodology of computing could provide significant advantages to diagnostics and prognostics byobjectively dealing with system noise and enhancing prediction capabilities. Such approaches intend to filter, aggregate and consolidate data both for training as well as predictions that also account for the volume, veracity and velocity of incoming data streams related to degradation.

To this aim, a novel Internet of Things (IoT) approach will be presented in this talk. At the core of the approach is the creation of a NoSQL database which is implemented to provide dynamic data transfer from the different components of the approach including the Edge, Fog, and Cloud layers. Specifically, the Edge is responsible for collecting raw data signals and is the closest layer to data collection. Key algorithms to cluster, classify, and filter signals are implemented at the Fog to create an efficient stream of useful data to the Cloud. From there, the processed data is sent to the Cloud for the retraining of algorithms and storage of historical data. These three layers provide the ability to limit human intervention and create a self-correcting knowledge-based system through back propagation.

In the implementation of the approach discussed in this talk, sensing data include inputs from Nondestructive Evaluation (NDE) methods including Acoustic Emission and Digital Image Correlation Data. This information is coupled with mechanical testing data obtained directly by the testing equipment. To demonstrate the capabilities of the approach, results from crack growth monitoring in metallic specimens and components is presented. At first and to validate the approach, compact-tension specimens of aluminum are used in accordance with standardized testing procedures to create a verifiable datasets of crack growth data based on the sensing methods selected in both monotonic and cyclic loading conditions. Such data is used to train a support vector machine alongside a Hidden Markov Chain model that provide

the classification of the data into a number of representative states in accordance with the crack growth process. This classification and mechanical test data is then used as inputs to an adaptive neuro-fuzzy network that produces the RUL predictions. To expand the proposed approach beyond standardized test geometries results and apply it to e.g. structural components subjected to more complex loading conditions, notes are presented to demonstrate the capability to adapt and implement the approach in Structural Health Monitoring Applications.

Keywords: *Prognostic Health Management, Internet of Things, Data Processing, Database Management, Edge Analytics, Remaining Useful Life predictions*

Students contributing to this work: Sarah Malik, Rakeen Rouf and Krzysztof Mazur

Biography: Dr. Antonios Kontsos is an Associate Professor in the Mechanical Engineering & Mechanics Department at Drexel University where he is currently the Director of the Theoretical and Applied Mechanics Group (TAMG). He received his undergraduate 5-year Diploma (2002) in Mechanical Engineering & Aeronautics from University of Patras (Greece), and his M.S (2005) and Ph.D. (2007) degrees in Mechanical Engineering & Materials Science from Rice University (Houston, TX). Before joining Drexel in 2009, Dr. Kontsos held a post-doc position at the Center for Mechanics of Solids, Structures and Materials in the Aerospace Engineering & Engineering Mechanics Department at the University of Texas at Austin (Austin, TX). Dr. Kontsos's primary research interest is in the theoretical, experimental and computational investigation of the mechanical behavior of materials with emphasis on understanding microstructure-properties-behavior evolving relationships.

2:35pm – 2:55pm

Dr. Dong Ha, Virginia Tech

Title: Energy Harvesting for Wireless IoT Devices

Abstract: IoT (Internet of Things) devices will be able to provide innovative services and solutions in the realms of such as smart homes, smart cities, and smart factories. It is envisioned that trillions of IoT devices such as sensors, cameras, and wearables will be connected to the Internet, forming a massive IoT ecosystem. Further, low power wireless technologies such as Bluetooth, Wi-Fi, ZigBee, Cellular, and RFID enable IoT devices to connect with each other over wireless links.

A major design issue for wireless IoT is autonomous power, and energy harvesting is a promising solution. Energy harvested from ambient sources aims to recharge the battery of a wireless IoT device or even remove the battery perpetually. Typical energy harvesting sources include solar, thermal, kinetic, and radio frequency. The operating environment of ambient energy sources changes and the energy level of typical ambient energy sources is low. It poses major design issues for energy harvesting circuits. This talk covers design issues of energy harvesting circuits for various energy sources and major design schemes to address the problems. It also covers recent advances and research issues in energy harvesting circuits built on SoC (System on Chip).

Biography: Dong S. Ha received a B.S. degree in electrical engineering from Seoul National University, Korea, and M.S. and Ph.D. degrees in electrical and computer engineering from the University of Iowa. Since Fall 1986, he has been a faculty member of the Department of Electrical and Computer Engineering, Virginia Tech. He is Founding Director of the Multifunctional Integrated Circuits and Systems (MICS) group with four faculty members and a member of Center for Energy Harvesting Materials and Systems (CEHMS) of Virginia Tech. He specializes in low-power analog RF IC design. His research interests include energy harvesting circuits and systems, high temperature RF ICs, and wireless sensor nodes with machine learning. He is a Fellow of the IEEE.

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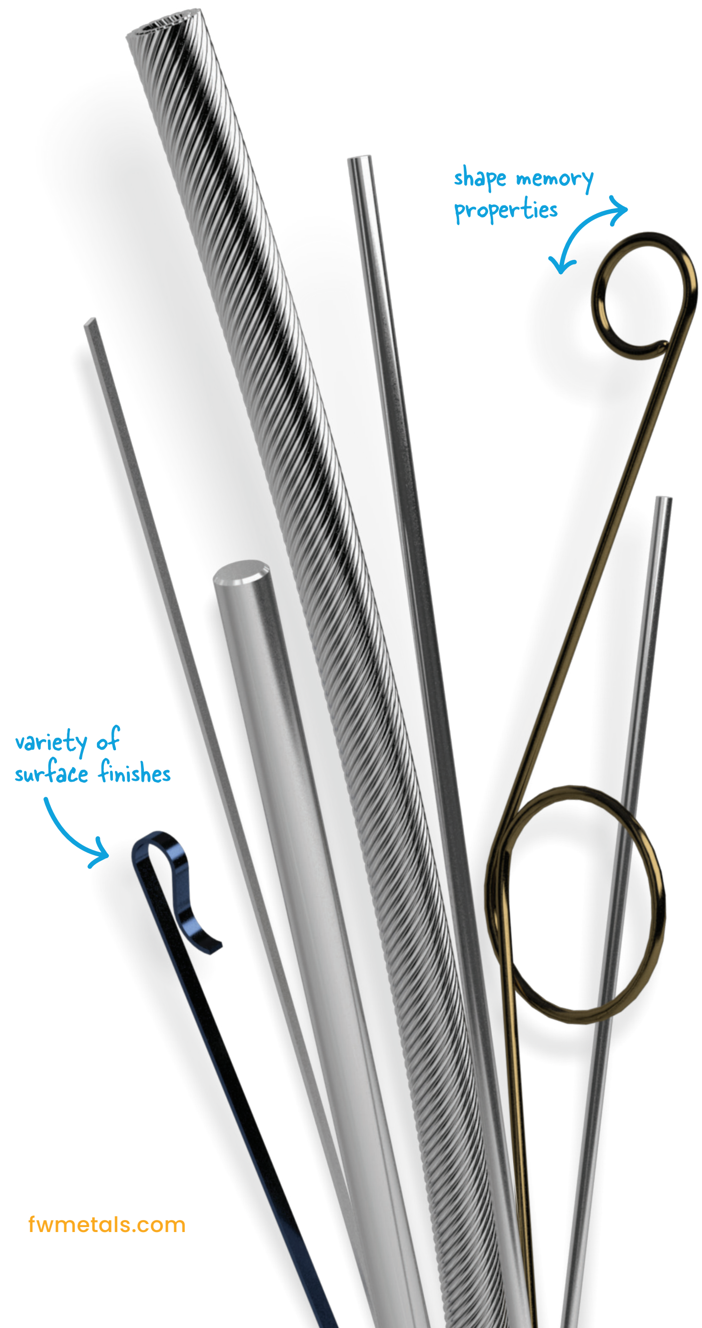
Nitinol

Superelastic and shape memory alloy



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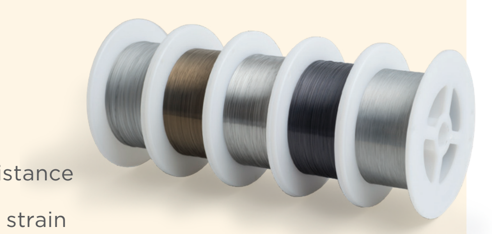
  At > 40% magnification micro scratches are present

Our unique Nitinol solutions



We also offer unique Nitinol products tailored to specific applications, **such as:**

SILK® NITINOL An ultra-smooth oxide-free Nitinol wire

USN® WIRE Engineered for applications that require increased column stiffness and buckling resistance

DPS® NITINOL Designed to achieve high stiffness for applications requiring between 1.5% and 8% strain

ACTUATOR WIRE Nitinol wire that can perform work through phase transformation

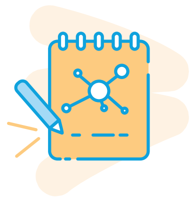
FORT WAYNE METALS

Custom material **solutions.**

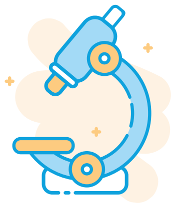
So you can do more.

Precision melting and integrated supply chain

Expert research and development support



Rapid prototyping to full-scale production



Accredited independent material testing services

FORT WAYNE METALS

Solutions for the world's most **demanding** applications

If you're ready to do more, we can help. At Fort Wayne Metals, we're passionate about helping our customers create solutions. We do this by manufacturing precision wire-based products used in the world's most demanding applications. It's about combining our materials expertise and processing capabilities to make products that our customers use to help medical and non-medical devices perform better – ultimately to improve people's lives. That mission has led us to pioneer the development of new alloys and revolutionary materials used in everything from coronary stents and spinal rods to aviation springs and eyeglass frames. We'll continue to push boundaries because we love expanding our knowledge and creating material solutions to help our customers advance the performance of their devices.

Products

An array of solutions – all customizable – from bar and wire to cable constructions and components:

WIRE FORMS round, flat, and uniquely shaped wire

MECHANICAL ASSEMBLIES custom crimps, fittings, and specialized parts

HHS® TUBE improved torqueability and kink resistance, plus an open working channel

SLT® WIRE straightness, grindability, and torque transmission to help streamline production

Materials

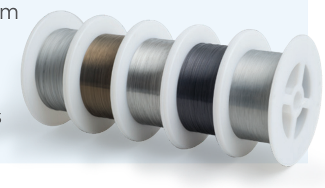
We maximize material mechanical properties to help the performance of your most challenging applications:

HIGH PERFORMANCE ALLOYS 35N LT® alloy, MP35N® alloy, FWM® 1058 alloy, FWM® 1537 alloy, and L605 alloy

STAINLESS STEEL Stainless steel: 302, 304V, 304LV, 316LVM, Custom 455® alloy, and Biodur® 108 alloy

TITANIUM Commercially pure titanium (grades 1-4) and alloyed titanium

NITINOL Grades according to shape memory and superelastic properties



Capabilities

As your needs grow, so does the breadth of our capabilities:

WIREDRAWING Sizes ranging from 0.0127 mm - 13.97 mm [0.0005 in - 0.550 in]

ANNEALING Achieve optimal mechanical properties

STRANDING AND CABLING More wires, more strength

CENTERLESS GRINDING Create tight tolerances

CHEMICAL ETCHING AND MILLING Attain desired surface finish

STRAIGHTENING AND CUTTING Streamline manufacturing processes

CUSTOM SPOOLING Wire packaged to your specs

NITINOL MELTING Ensure quality material from start to finish

Services

Beyond our processing and melting capabilities, we provide the following value-added services:

COATINGS Dielectric and lubricious

LASER ABLATION

CUSTOM ALLOY DEVELOPMENT

VELOCITY℠ PROGRAM Accelerated product delivery

INDEPENDENT MATERIALS TESTING LABORATORY

Certifications

Because we make products used in critical applications, we are certified to industry quality standards:

- AS 9100D
- ISO 9001
- ISO 13485
- FDA registered

Other products include:

STRANDS AND CABLES Complex constructions for advanced applications

CENTERLESS GROUND BAR Polished bar made to tight tolerances

SHAPE SETTING Custom Nitinol wire constructions that can deform and return to a set shape

ACTUATOR WIRE Nitinol wire that can perform work through phase transformation

DFT® COMPOSITE WIRE Two dissimilar materials in a single wire construction

Our custom material solutions can help you do more. Visit **fwmetals.com**

Wired for Innovation.

You may think of Fort Wayne Metals as a wire manufacturer. We think of ourselves as innovators and life savers. We develop new alloys, pioneer revolutionary materials and never stop refining our products to help them perform better in your medical devices.

So when you need a partner to help you push your product to new heights, talk to us. We take pride in manufacturing the world's best wires, cables, composites and assemblies – but we're just as driven by the opportunity to help spark medical innovations that can improve and save lives.

We are all about saving lives.

At Fort Wayne Metals, everything we do is driven by the fact that our materials end up in life-saving medical devices. Which is why quality is valued above everything else. We are constantly researching new materials, developing better products, and we keep looking for better ways to help you go about the business of helping your customers live longer, more fulfilling lives.

We've been focused on saving lives since our beginnings in the early 1970s. And while we have changed in many ways over the years, this focus has remained unaltered.

LOCATIONS AROUND THE WORLD

Global Headquarters
Fort Wayne, Indiana, U.S.A.

European Headquarters
Castlebar, Co. Mayo, Ireland

Advanced Materials Development
Columbia City, Indiana, U.S.A.

International Sales Support
Miami, Florida, U.S.A.
Tamil Nadu, India
Tokyo, Japan
Savyon, Israel
Seoul, Korea
Shanghai, China

U.S.A. Sales Support
Chanhassen, Minnesota
Ridgefield, Connecticut
Ruston, Louisiana
San Mateo, California

Find your sales representative at
fwmetals.com/find-your-rep

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Turning knowledge into solutions.®

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10/2017 2000

Nitinol Shape Setting

Precision Shape Memory Parts

TURNING KNOWLEDGE INTO SOLUTIONS.®

fwmetals.com

Take advantage of shape memory

In order to take full advantage of Nitinol's shape memory properties, some customers require the wire to be in a certain shape in order to perform in their application. At Fort Wayne Metals, we can "set" a wire shape that specifically conforms to your device design requirements.

Shape setting is the process of wrapping Nitinol wire around a mandrel or fixture and heat treating at a closely controlled time and temperature to achieve a desired shape in the material. After the material is quenched and removed from the mandrel, the wire will "remember" its shape after deformation or a change in temperature.

Fort Wayne Metals has multiple precision fluidized beds as well as other proprietary shape setting methods to meet the needs of any complex design requirements. We also have rapid prototyping capabilities, which allow us to design and fabricate our own tooling in-house, resulting in greatly improved lead times. Our engineering team has many years of experience in building components to our customers' specifications.

If your application requires shape set parts, contact Fort Wayne Metals. We're one of the world's leaders in working with Nitinol, and are ready to put our expertise to work for you.

Nitinol Wire Applications

Our Nitinol wire is used for many different medical and industrial applications. The table below gives you an overview of typical engineering applications for each of our standard Nitinol grades:

NITINOL #1 Guidewires, stents, stylets, forming mandrels, stone retrieval baskets, orthodontic files, etc.

NITINOL #2* Often used in applications that require a high loading and unloading plateau stress at room temperature. Chromium doped for decreased transformation temperature and increased tensile strength.

NITINOL #3** Applications requiring increased stiffness. Cobalt doped for decreased transformation temperature and increased tensile strength.

NITINOL #4 Provides the best cycling performances at body temperature (37°C).

NITINOL #5 AND NITINOL #6 These alloys are commonly used in high temperature actuators.

NITINOL #8 Typically used in applications that require a phase transformation at body temperature (37°C).

NITINOL #9 For use in very cold temperature environment applications.

* Typical chemical composition: ASTM F2063 Exc. Cr 0.2% to 0.3%

** Typical chemical composition: ASTM F2063 Exc. Co 1% to 2%

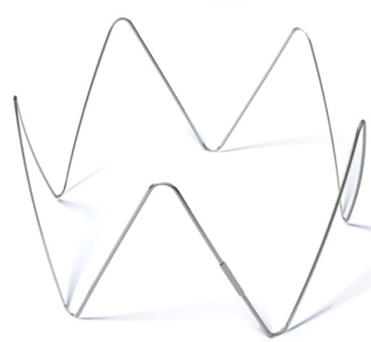
Examples of Shape Sets


Double Diamond - Strand


Folded Ends - Flat Wire


U-Shaped with Beaded Ends


Loop - Twisted with Hypotube


Crown with Crimp

Specifications

PRODUCT FORMS AVAILABLE FOR SHAPE SETTING

- Round wire
- Shaped wire
- Flat wire
- Strands & Cables
- DFT® wire
- HHS® tube

WIRE DIAMETER

0.001 in. - 0.0787 in. (0.0254 mm - 2.000 mm)

SURFACE FINISHES

- Oxide
- Etched
- Electropolished
- Surface Conditioned

END TREATMENTS

- Coining/Flattening
- EDM
- Shear
- Square
- Beaded
- Weld bead
- Beaded & Swaged

INSPECTION METHODS

- Finish A_f testing (DSC, Bend and Free Recovery (BFR), ASTM F2082)
- Mechanical testing of shaped parts
- Dimensional analysis
- Surface roughness testing
- Corrosion testing

Thank you for joining us. Hope you will join us again in 2021!