



Multi-Functional Materials Interdisciplinary Research Theme
2018 Year End Report

2018 Multi-

Functional Microbubble Swarms: Theory and Experiment (PIs: Mark Borden, Franck Vernerey, Orit Peleg)

Leveraging Novel Tactile Robotic Materials to Solve Molyneux's Problem (PIs: Bradley Hayes, Christoffer Heckman)

Development of Artificial Muscles for Prosthetic Devices using Hydraulically Amplified Self-healing Electrostatic (HASEL) Actuators

New external collaborations

[Dr. Thomas Cooley](#), Chief Scientist at Air Force Research Laboratory, toured campus on August 6 and met with MFM faculty Sean Humbert, Timothy White, and Sean Shaheen to discuss potential collaborations.

Shaheen visited Army Research Labs and held meetings with Dr. Paul Pellegrino, Branch Chief for Optics & Photonics Integration, and Dr. Christopher Morris, Branch Chief for Micro/Nano Materials. Discussion of collaborative efforts and conference organizing on neuromorphic materials and systems were held, and a follow-up visit is planned.

Nikolaus Correll advised NSF program managers on the creation of a new NSF Designing Materials to Revolutionize and Engineer our Future (DMREF) solicitation, which includes a section on "robotic materials" that was inspired by the [workshop](#) that Correll organized.

Richard Han and Nikolaus Correll have interacted with DARPA and are helping to organize a conference on Autonomous Proprioceptive Actuators for Injury Neutralization (A-PAIN), motivated by their work on Active Bandages for rapid wound healing.

Shaheen has had preliminary discussions with [Dr. Paul Lane](#) at the NSF to advise on the creation of an EFRI program on neuromorphic devices, to be released in 2019 if selected by NSF management.

Shaheen has arranged discussions with [Dr. Shawn Walsh](#) of the Army Research Lab. He has expressed interest in expanding collaborations in the public sector.

Shaheen has arranged meetings with representatives of 3M Corporation to discuss potential collaborations and sponsored research opportunities. In attendance from 3M will be Dr. Daniel Snustad, Global Technical Director of the Corporate Research Materials Laboratory (CRML), Dr. Philip Clark, Technical Director of CRML, and Dr. Mark Strobel, Corporate Scientist in their Corporation Research Process Laboratory.

Technology transfer, IP generation, and start-ups

Patent Application [US20180153631A1](#) on Multifunctional operational component for robotic devices was published by Mark Rentschler.

Patent Application [US9909814B2](#) on Flexible thermal ground plane and method for manufacturing the same was published by Ronggui Yang.

Patent Application [US20180066132A1](#) on Conductive polymeric compositions and applications was published by Shaheen and Robert McLeod.

Patent Application [US20180306218A1](#) on Complex Stress-Engineered Frangible Structures was published by Gregory Whiting and colleagues.

Patent Application [US20180252659A1](#) on Printed Gas Sensors was published by Gregory Whiting and colleagues.

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Faculty in national leadership positions

A workshop on [Robotic Materials](#) was organized by Nikolaus Correll at the Keck Center in Washington D.C. in April 2018. It was hosted by the Computing Community Consortium. Correll wrote a summary of the workshop on [CCC Blog](#).

Nikolau Correll was the General Chair of the [2018 Symposium on Distributed Autonomous Robotic Systems](#), held here on campus.

Nikolaus Correll wrote an article on [Robotics Getting a Grip on General Manipulation for IEEE Spectrum](#).

Robert MacCurdy was named as Associate Editor for the Journal of 3D Printing and Additive Manufacturing.

National press for IRTs

Christopher Bowman's work on Programmable, fully reversible shape-switching material appeared in [Science Daily](#) and [phys.org](#).

Jian Liang Xiao's work on Lightweight, strong, and super thermally insulating nanowood appeared in [phys.org](#).

Christoph Keplinger's work on Hydraulically amplified self-healing electrostatic actuators appears in [Newsweek](#), [National Geographic](#), [Tech Times](#), [Science Daily](#), and elsewhere.

Students working with Nikolaus Correll's company Robotics Materials, Inc. won the President's Award from the Japanese Society of Mechanical Engineers.

Sean Humbert's was interviewed on Colorado Public Radio's program Colorado Matters, for his work the DARPA Subterranean Challenge. The interview can be found [here](#).

Recognition by peer institutions

Major research awards below included collaborations with colleagues at Cornell University, Carnegie Mellon University, and Jet Propulsion Laboratory, among others.

Multi-department proposals/projects (> \$1M)

Christopher Keplinger and colleagues were awarded \$2M from the NSF EFRI program for a project on [An End-To-End Framework For Soft Robot Design And Control Based On High-Performance Electrohydraulic Transducers](#).

Sean Humbert and colleagues were awarded \$4.5M to support its participation in the [Subterranean Challenge](#).

Gregory Whiting and collaborators were awarded a \$1.7M award from DARPA for a project on [Precision Agriculture using Networks of Degradable Analytical Sensors \(PANDAS\)](#).

Gregor Henze and team were awarded a \$2M award from ARPA-E for a project on [Battery-free RFID sensor network for human presence sensing](#). The award was announced by Colorado U.S. Senators Michael Bennet and Cory Gardner ([here](#)) and was publicized by [NREL](#).

Srubar	Wil	CEAE	wil.srubar@colorado.edu
Trivedi	Ashutosh	CS	ashutosh.trivedi@colorado.edu