

## **ADAPT Monthly Members Meeting 09 May 2018**

### **Attendees:**

#### Member companies

Benjamin Collins, ADA Technologies  
Jacob Nuechterlein, Elementum 3D  
Adam Polizzi, Elementum 3D  
Craig Brice, Lockheed Martin  
Thierry Carriere, ADA Technologies  
Doug Nicholson, Boeing  
Chris Borg, Citrine Informatics  
Ed Garboczi, NIST  
Jeff Engel, Reaction Systems  
Ray Bagley, Spatial Corp.

#### Mines

Aaron Stebner  
Ethan Rogers  
Nicholas Low  
Nick Engel  
Connor McLean  
Abbey Zorn  
Isaac Torres  
Bailey Burroughs  
Andy Cornelius  
Sen Liu  
Liu Jian Lu  
Nathan Johnson  
Caleb Schelle  
John Strang  
Behnam Amin-Ahmadi  
Tom Gallmeyer  
Amy Brice

### **Welcome/Introductions**

#### **Announcements**

1. Welcome to Doug Nicholson from Boeing – newest ADAPT member
2. Owen Hildreth, Mohsen Asle Zaeem coming to Mines as new faculty
3. ADAPT and Citrine were awarded an STTR proposal with the Navy: “An Integrated Materials Informatics/Sequential Learning Framework to Predict the Effects of Defects in Metals Additive Manufacturing”

4. NextGen Undergraduate Research Fellowship – Mines is one of five universities hosting summer undergraduate research fellows in machine learning for materials; grant from Schmidt Foundation through Citrine; 3-year program; Mines hosting 8 students this summer
5. DAM Workshop (Design for Additive Manufacturing) – 4 spots open; there is a grant to cover participant fees; classroom setup: each person has own CAD station; one printer for every two students; intensive weeklong workshop; lunch provided each day

### **Technical Program**

Student design presentations: building platforms for the new Advanced Manufacturing Teaching Lab – significant investment by university in conjunction with new Advanced Manufacturing Interdisciplinary degree program.

#### 1. Open-Ended 3D Printer Design (Bailey Burroughs, Andy Cornelius, Connor McLean, Isaac Torres, Abbey Zorn)

- Build a printer to promote learning in AM
- Direct Ink Writing
  - material extrusion process
  - wide range of applications and materials / printing of microstructures
- Printer specifications: PI motion/positioning and Nordson EFD dispensing
- Additional educational benefits: machine vision (camera on gantry system), thermal imaging, lighting
- Planned completion: December 2018

#### 2. Metal Powder Bed Fusion 3D Printer (Nicholas Low, Nick Engel, Ethan Rogers)

- Intro to powder bed fusion (PBF)
- Motivations: build an open-platform printer; facilitate student experimentation; allow investigation of how parameter changes influence behavior of melt pool
- Schematics of laser setup and material delivery system
- Challenges and Risks (print environment requirements, safety considerations, software development, etc.)
- Educational Value to ADAPT and the AM degree program, and to students in ME, CS, Physics and EE

#### 3. Active Learning: A Machine Learning Algorithm for Improved Test Selection (Lyu Jian Lu, PhD student)

- Passive learning relies on an expert to choose which samples to label
- Active learning helps choose which samples should be tested
- Example of active learning applied to an ADAPT dataset
- Goal: representatively sample the features that make the data unique
- Experimental results: better results with fewer tests

Break

#### 4. 3D Printing Shape Memory Alloys (Aaron Stebner)

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- Intro to shape memory alloys (SMAs)
  - SMAs work via phase transformation
- Why use NiTiHf for 3D printing
  - Ni<sub>4</sub>Ti<sub>3</sub> precipitation exploited for 2 purposes: transformation temperature control and strength
  - In binary NiTi, dislocation structure is also needed for strong superelastic responses
  - Cold-working 3D printed parts is undesirable
  - Solution: H-phase precipitation in NiTiHf alloys: provides both strength and transformation tuning abilities
- Other advantages of NiTiHf:
  - NiTiHf advantageous for tribology (dent-proof, low residual stress-bearing elements)
  - Motivation for NiTiHf vs. NiTi: solve quench cracking; better contact fatigue performance
  - NiTiHf for actuation; ex: Spanwise Adaptive Wing (SAW) demonstration
  - NiTiHf for superelastic medical applications
- Our efforts in NiTiHf AM
  - 28 alloys developed with NASA Glenn
  - Example parts printed from Ni + Ti powders

#### 5. Laser Spatial Frequency Modulation for Imaging Microscopy for 3D Printed Metal Parts (Caleb Schelle, John Strang)

- Goal: convert an experimentally proven technology to a tangible part; calibrate and test system; quantify results
- Current technology Keyence microscope (can scan small parts, high resolution, slow scan speeds)
- More advanced: SPIFI (spatial frequency modulation for imaging) – larger working distance, larger field of view
- Examples of 3D-printed tensile bar images
- Example of imaging translucent objects with SPIFI vs. traditional microscope
- Pictures of the custom staging system the team built

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#### Next Meeting

Wednesday, June 13, 2018, 1:30–3:30

Starzer Welcome Center (Mines campus): 1812 Illinois St., Golden CO 80401

Agenda: Graduate Student Research Updates