

## Second Annual NSF-PIRE-PDC Workshop

Boulder, Colorado July 15-19, 2019

Williams Village Campus, University of Colorado at Boulder

### Full Program

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IMPORTANT WORKSHOP PHONE NUMBERS: TEXT OR CALL			
Williams Village	(303) 735-1445	Zhongkan Ren (Student volunteer)	(541) 602-4599
Sailesh Menon (Primary)	(785) 477-0605	Aly Badran (Student volunteer)	(720) 606-3543
Gurpreet Singh (Secondary)	(720) 891-9385	Raj house	(303) 447-8831

## 1) Transportation options from Denver International Airport to Boulder

**Bus:** The RTD A-line provides a one-way bus service from Denver International Airport (DEN) to Boulder (and Boulder to DEN) for approximately \$10.50. The bus picks up passengers at Denver Airport Station Gate 8 (Board the AB1 towards Downtown Boulder via E-470), and takes approximately 1 hour 40 minutes to reach Boulder. The most convenient stop to disembark is Table Mesa bus stop. We will be available to pick up folks at Table Mesa bus stop (*text or call Sailesh or student volunteer with one hour notice*) to drive you to Williams Village OR you may call Uber from Table Mesa bus stop to Williams Village. Buses depart from Denver Airport Station Gate 8 approximately every 15 minutes. Please use the link below to find the bus schedule-

<https://bit.ly/2XyOamk>

*The super-shuttle service is slow and lousy. Car rental is also more cumbersome than just taking the bus.*

**Car rentals:** Car rental agencies at DEN are located on airport property, and provide courtesy shuttle service to and from Jeppesen Terminal. Pick-up and drop-off points are from Jeppesen Terminal Level 5, Island 4, outside doors 505-513 (east side) and 504-512 (west side).

[https://www.flydenver.com/parking\\_transit/car-rentals](https://www.flydenver.com/parking_transit/car-rentals)

**Taxi:** Taxi services at DEN offer flat rate (\$88.57 to Boulder), and metered rate options. Pick-up and drop-off points are from Jeppesen Terminal, Level 5, Island 1, outside Doors 505, 507 and 511 (Terminal East), and Doors 506, 510 and 512 (Terminal West).

<https://www.flydenver.com/taxi>

**Uber:** Depending on your arrival time, Uber usually charges \$60.00 - \$100.00 for a one way trip from DEN to Boulder. Customers using a ride app service may only be picked up in the designated area of Jeppesen Terminal, Level 5.

[https://www.flydenver.com/parking\\_transit/transit/mobile-app-services](https://www.flydenver.com/parking_transit/transit/mobile-app-services)

The distance from the airport to the local address is approximately 45 miles.

## 2) Local Address

*If you need a parking permit, please contact me immediately as CU Boulder issues digital passes; I will need to send you a link to receive a parking permit.* The local address to be used for rental cars, taxis, Uber and GPS navigation is-

**University of Colorado, Boulder**  
**Williams Village North**  
**3300 Baseline Rd, Boulder, CO 80310**  
**Ph # (303) 735-1445**

**Getting around Boulder** - For public transport, the HOP bus route is a very convenient way to explore Boulder. The bus route covers all the important destinations in Downtown Boulder, with convenient stops on Pearl Street and The Hill. Fares begin at \$3.00, with day passes costing \$6.00. There are plenty of ride share options through Uber and Lyft available as well. Depending on the time of the day, there may be a couple of cars to transport attendees to local areas as well. For more information on the HOP bus route, click on the following link- <https://bouldercolorado.gov/hopbus>

**3) Table 1: Check-in and Check-out time and dates**

<i>Check-in and Check-out location is Darley South Front Desk</i>	
<b>Sunday, 7/14 all day</b>	<b>Check-in for workshop attendees</b>
<b>Tuesday, 7/16 all day</b>	<b>Check-in for Rishi celebration attendees</b>
<b>Saturday, 7/20 11:00 AM</b>	<b>Last day for checkout for all attendees</b>

Although, these are official check-in and check-out times, you may arrive and depart as your schedule dictates. Make sure to check-out when you depart.

**4) Table 2: Breakfast, Lunch and Dinner**

	<b>Sunday July 14</b>	<b>Monday July 15</b>	<b>Tuesday July 16</b>	<b>Wednesday July 17</b>	<b>Thursday July 18</b>	<b>Friday July 19</b>	<b>Saturday July 20</b>
<b>Breakfast 7:00 – 8:15AM</b>	n/a	WVCC Dining	WVCC Dining	WVCC Dining	WVCC Dining	WVCC Dining	WVCC Dining
<b>Lunch 11AM - 1:30PM</b>	n/a	WVCC Dining	WVCC Dining	Sack lunches (sandwich)	WVCC Dining	WVCC Dining	n/a
<b>Dinner 5:00 – 6:30 PM</b>	WVCC Dining	Dinner on your own*	Dinner on your own	Dinner on your own^	Dinner on your own	Dinner at Raj house	n/a

WVCC Dining - Williams Village Community Commons Dining. Dining option at WVCC is included in the package at no extra cost.

\*- Faculty accompanies PIRE students to dinner; **PIRE student** dinners paid for by Singh: Mountain Sun- 1535 Pearl St, Boulder, CO 80302-5408. Ph # (303) 546-0886

^- Singh accompanies PIRE students to dinner; **PIRE student** dinners paid for by Singh: The Taj- 2630 Baseline Rd, Boulder, CO 80305. Ph # (303) 494-5216

**5) NSF-PIRE workshop: July 15-16, 2019**

Scope of the meeting

The workshop will cover all topics related to synthesis, property, testing, and applications of PDCs and related high temperature ceramics including ceramic matrix composites (CMCs). The workshop is a

prominent scientific meeting, focusing on cutting-edge research and technologies involving PDC materials. The primary emphasis will be on PDC-based fibers and ceramic matrix composites (CMCs) for high-temperature applications. Attendees will have an opportunity to gain in-depth information on precursor synthesis; PDC processing including additive manufacturing, polymer-to-ceramic conversion, characterization from preceramic polymers to ceramics, modeling and simulation. Other topics include composite materials recovery or recyclability, PDCs for energy storage, and ultrahigh temperature materials for hypersonics.

**Talk description/format:** Normally, most participants make 30-minute presentations followed by 15-minute discussion. As tradition dictates, most, if not all of the participants talk about their work and interest. Therefore, we would like to have a very productive 15-minute open ended discussion at the end of most presentations.

**MONDAY JULY 15, 2019- SESSION 1- 8:30 – 11:45 AM**

<b>Session 1</b> <b>8:30 – 11:45 a.m</b>	<b>Monday</b> <b>7-15-19</b>	<b>Moderator:</b> <b>Singh</b>
	<b>Speaker</b>	<b>Topic</b>
<b>8:25 – 8:30 a.m.</b>	Gurpreet Singh	Opening remarks
<b>8:30 – 9:15 a.m.</b>	Peter Kroll	Reactive Force Field Simulations of the Pyrolysis of Polysiloxanes
<b>9:15 – 10 a.m.</b>	Zlatomir Apostolov	Pre-ceramic Polymers in Ceramic Composite Constituent Development, Additive Manufacturing, and Process Modeling – Overview of Recent Work at AFRL
<b>10 – 10:30 a.m.</b>		General discussion session-addressing one important issue of the project/Refreshment break
<b>10:30 – 11:15 a.m.</b>	Martin Friess	Mo- and W-Fiber Reinforced SiCN Ceramic Matrix Composites based on PIP Process
<b>11:15 – 11:45 a.m.</b>	Doug Hardy (Invited talk) Starfire Systems	Polymer-Derived Ceramics from Starfire Systems
<b>11:45 a.m. – 1 p.m.</b>		Lunch break

**MONDAY JULY 15, 2019- SESSION 2- 1:00 – 5:15 PM**

<b>Session 2</b> <b>1:00 – 5:15 p.m</b>	<b>Monday</b> <b>7-15-19</b>	<b>Moderator:</b> <b>Kroll and Jain</b>
	<b>Speaker</b>	<b>Topic</b>

<b>1 – 1:45 p.m.</b>	Seetha Raghavan (Invited talk) Univ. of Central Florida	Synchrotron Studies of High Temperature Materials under Operational Conditions
<b>1:45 – 2:30 p.m.</b>	Alexandra Navrotsky	Thermochemistry of Various Materials Containing Carbon and Silicon
<b>2:30 – 3:15 p.m.</b>	Himanshu Jain	Microanalysis of SiC Fibers
<b>3.15 – 3.45 p.m.</b>		General discussion session-addressing one important issue of the project/Refreshment break
<b>3.45 – 4:30 p.m.</b>	Elsa Olivetti	Manufacturing Scalability in Novel Materials Development
<b>4:30 – 5:15 p.m.</b>	Dora Musielak (Invited talk via Skype) Univ. of Texas, Arlington	High Temperature Materials: Enabling Technology for Hypersonic Flight
<b>End of Day 1: Navrotsky, Olivetti, Singh, and Jain accompany PIRE students in attendance to dinner</b>		

**TUESDAY JULY 16, 2019- SESSION 3- 8:30 – 11:45 AM**

<b>Session 3 8:30 – 11:45 a.m</b>	<b>Tuesday 7-16-19</b>	<b>Moderator: Raj</b>
	<b>Speaker</b>	<b>Topic</b>
<b>8:30 – 9:15 a.m.</b>	Masaki Narisawa	Photoluminescence of White Silicon Oxycarbide Synthesized by Hydrogen Decarbonization of Silicone Precursors and Now Remaining Issues
<b>9:15 – 10 a.m.</b>	Brett Compton (Invited talk) Univ. of Tennessee, Knoxville	Direct-write Additive Manufacturing of Polysilazane-derived Ceramic Composites
<b>10 – 10:30 a.m.</b>		General discussion session-addressing one important issue of the project/Refreshment break
<b>10:30 – 11:15 a.m.</b>	Gian Soraru	Polymer-derived Si <sub>3</sub> N <sub>4</sub> Nanofelts with Ultra-low Thermal Conductivity
<b>11:15 – 11:45 a.m.</b>	Rishi Raj	Hafnium oxide/PDC Coatings for Oxidation Protection
<b>11:45 a.m. – 1 p.m.</b>		Lunch break

**TUESDAY JULY 16, 2019- SESSION 4- 1:00 – 6:00 PM**

<b>Session 4</b>	<b>Tuesday</b>	<b>Moderator:</b>
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1:00 – 6:00 p.m.	7-16-19	Soraru and Kroll
	Speaker	Topic
1 – 1:45 p.m.	Chrystelle Salameh	Design of Non-oxide PDCs for Energy Storage Applications
1:45 – 2:30 p.m.	Aitana Tamayo (Invited talk) Ceramics and Glass Institute	Structural and Electrochemical Characteristics of Carbide Derived Carbons
2:30 – 3:15 p.m.	DP Kim (Invited talk) POSTECH, Korea (South) <i>Last minute addition</i>	3D-printed Monolithic Resistant Polymer and SiCN Ceramic Microreactors from a Photocurable Pre-ceramic Resin
3.15 – 3.45 p.m.		General discussion session-addressing one important issue of the project/Refreshment break
3.45 – 4:00 p.m.	Allison Horner (Invited short lecture) Spirit Aerosystems	Spirit AeroSystems and Manufacturing Development of Ox/Ox CMCs
4:00 – 4:15 p.m.	John Holowczak (Invited short lecture) United Technologies Research Center	Safety Considerations for Si based Pre-ceramic Polymer Heat Treating
4.15 – 4:30 p.m.	Kim Nicholson	PIRE External Evaluation Update/ qualtrics survey
4.30 – 6 p.m.		Poster session, Photo shoot, begin interviews

#### 6) Week of July 15-19 at a glance

Date	Time	Activity
7-15-19	8:30 AM – 5:15 PM	NSF PIRE workshop Day 1, Session 1 and 2
	6:00 PM	Navrotsky, Olivetti, Singh, and Jain accompany PIRE students in attendance to dinner. Student dinner covered by Singh
7-16-19	8:30 AM – 4:30 PM	NSF PIRE workshop Day 2, Session 3 and 4
	4:30 PM – 6:00 PM	NSF PIRE Poster Session, Video Interviews, Photo Shoot
	6:00 PM	Singh, Kroll, and Marshall accompany PIRE students in attendance to dinner. Student dinner covered by Singh
7-17-19	7:50 AM – 7:00 PM	Bus tour to Estes and Rocky Mountain National Park (sack lunches available)
	7:00 PM	Singh accompanies PIRE students to Taj for dinner. Student dinner covered by Singh
7-18-19	8:00 AM – 5:00 PM	Free day to explore Boulder on your own

	5:30 PM – 11:00 PM	Blue grass music festival in Lyons, Colorado. Transportation will be provided to Lyons.
7-19-19	8:30 AM – 11:45 AM	Short lectures in honor of Prof. Rishi Raj
	6:30 PM	Dinner at Raj's home

### Student posters

First Name	Last Name	Title
Susana	Aguirre-Medel	Synthesis and Characterization of Silicon Oxycarbide (SiCO) ceramics annealed up to 1500 °C.
Aly	Badran	Deep Learning Image Segmentation on CT Scanned Ceramic Matrix Composites
Shakir	Bin Mujib	Biomass Derived Carbons and PDC Functionalized Carbon Composite for Electrochemical Energy Storage
Karissa	Cordero	Synthesis and characterization of polymeric aerogels.
Spencer	Dansereau	Development of Polymer-Derived Ceramic Matrix Composites with Direct Ink Writing (DIW) and Flash Pyrolysis Infiltration of Polysiloxanes
Sophie	Justus	NSF PIRE Summer Abroad: My Internship Experience at The European Institute of Membranes in Montpellier, France
Jacob	Regler	NSF PIRE Summer Experience at The European Institute of Membranes in Montpellier, France
Zhongkan	Ren	Preparation and Structure of SiOC Fibers Derived from Cyclic Silazane/PAA Hybrid Precursor
Benjamin	Robles	In-situ measurements of stretching and shrinkage during pyrolysis of green PDC fibers under constant load at constant heating rates.
Davi	Soares	Core/shell Nb <sub>2</sub> O <sub>5</sub> Nanoparticles/Carbon on Carbon Nanotubes as Symmetrical Supercapacitor Electrodes.
Federico	Toigo	Additive Manufacture of SiOC Composites and Investigation of Their Electrochemical Behaviour for Energy Storage Application

### 7) Trip to Estes and Rocky Mountain National Park: July 17

We will be organizing a bus tour to Estes and a hike at Rocky Mountain National Park on Wednesday, July 17 from 8:00 AM to 5:00 PM. A bus is scheduled to pick us up at the Williams Village loop at 7:45 AM, and will depart from Williams Village no later than 8:00 AM. All persons interested in the bus tour and hike must be present at the Williams Village loop by 7:40 AM. Please consume a hearty breakfast before the trip as we plan on a fair amount of walking and hiking.

**Journey essentials-** These are pointers posted on the Rocky Mountain Trail Guide

- 1) Waterproof outer layers and extra layers for warmth.
- 2) Wear a hat, sunglasses, and sunscreen.
- 3) Sunlight can damage your eyes and skin, even on cloudy days.

- 4) Pack extra water and snacks.
- 5) Don't drink from streams or lakes without treating the water.
- 6) Carry a map and compass or GPS, and know how to use them.
- 7) Wear sturdy footwear with good ankle support and a treaded sole.
- 8) Don't rely on cell phones, many areas have no service.

**Important tips to consider:**

Never Feed or Approach Wildlife

Pay Attention to Altitude

Watch the Weather: It changes quickly, and almost always rains. Average temperature for the day of our hike is 69<sup>o</sup>/37<sup>o</sup> (high/low)

Bring the Right Gear

Stay Safe and Practice Good Etiquette

For more information, please visit- <https://www.nps.gov/romo/planyourvisit/maps.htm>

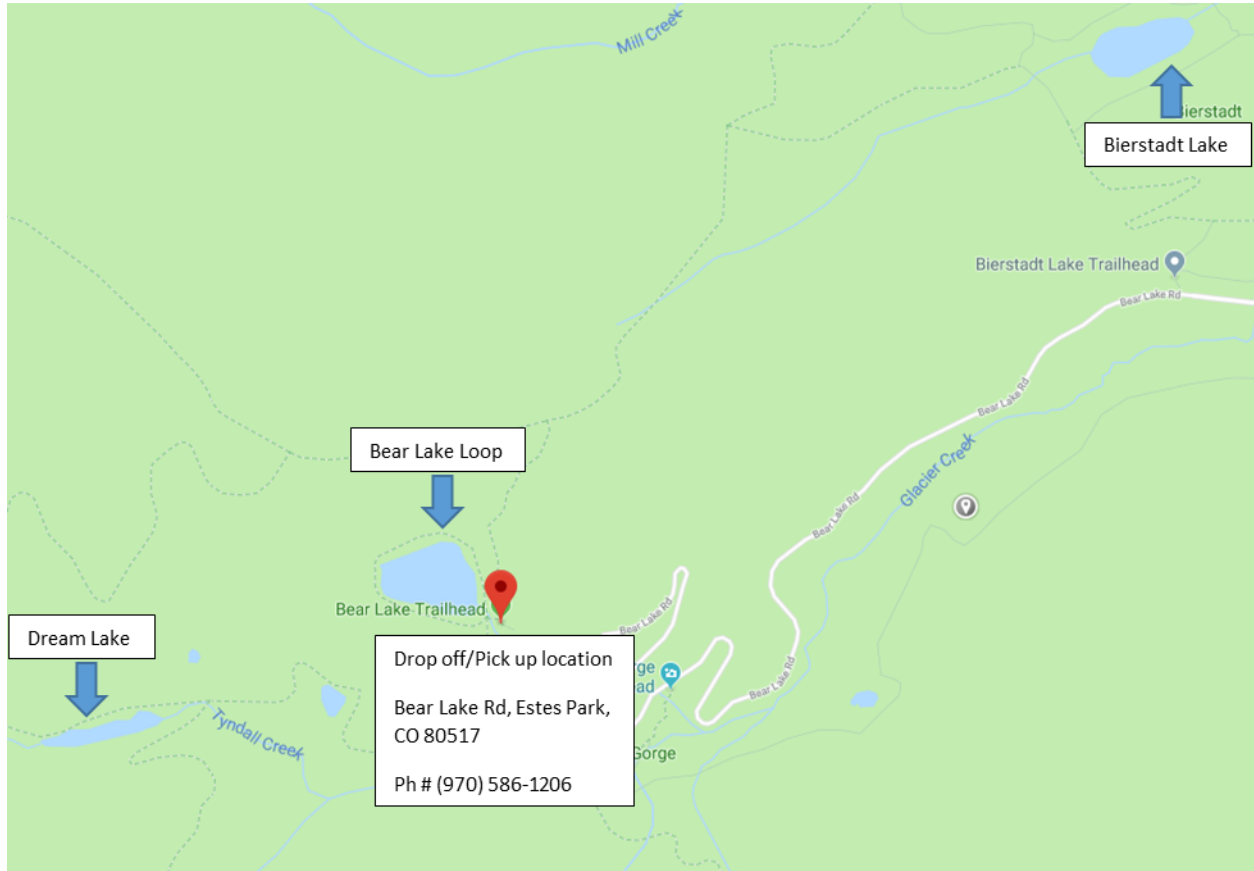
**Rocky Mountain National Park Hike.**

The Journey will take approximately 2 hours to reach Rocky Mountain National Park. As Rocky Mountain Park gets crowded later in the day, our plan is to do our hiking first thing in the morning. We will provide sack lunches and water. If you need something more substantial, we can stop in Estes Park and you may buy food at your own expense. After consulting with current and former students of Rishi, we have decided that we will begin the hike at Bear Lake Head. *If you have altitude sickness, please take necessary precautions, and proceed with caution.* There will be three options for the hikes-

1. [Bear Lake Loop](#). Easy 0.8 miles loop no elevation gain.
2. [Dream Lake](#) (starts from Bear lake trail head). Easy-Moderate 2.2-mile round trip. Elevation gain 450ft
3. [Bierstadt lake](#) (starts from Bear lake trail head). Moderate 4.4-mile round trip. Elevation gain 650ft.

**Important: Always stay with the group, and listen to what the group leader says. Some of you may be physically capable of undergoing a more strenuous challenge; however, as we are traveling as a group, it is important for the safety of everybody that we stay as a cohesive unit.**





We plan on hiking for approximately 4 hours, and returning to the bus, no later than 4 PM. We will then travel to the town of Estes Park and explore the area for an hour. For more information on Estes, please visit-

<https://www.visitestespark.com/>

The bus will then transport us back to Williams Village by approximately 7 PM. Singh will take all students out to dinner at Taj Indian restaurant. Wednesday night dinner will be on your own; feel free to join Singh and the students at Taj.

**8) Free day to explore Boulder on your own, July 18, 2019 8 AM – 5 PM**

There is a vast array of things to do in Boulder, or just take a breather from the hike the day before. Feel free to do as you like. Here are some things that may be of interest-

<https://www.colorado.com/articles/go-local-boulder>

**9) Blue grass music festival in Lyons, Colorado. Transportation will be provided to Lyons**

We will be providing transportation to Lyons, CO. A bus is scheduled to pick us up at the Williams Village loop at 5:20 PM, and will depart from Williams Village no later than 5:30 PM. All persons interested in the Blue grass music festival must be present at the Williams Village loop by 5:15 PM. We will be

attending the Sandstone Summer Concert Series, now in its 21<sup>st</sup> year. For more information, please click on the following link-

<https://www.lyonscolorado.com/events/sandstone-summer-concert-series>

There are many restaurants and food stalls in Lyons during this time of the year. Feel free to enjoy the local food scene. After the concert, we will be going to Pizza Bar 66 for food and drinks; feel free to join us. Dinner will be on your own. We will return to Williams Village by 11:00 PM.

### 10) Options for Thursday

As Thursday, July 18, is a free day, Prof. Raj has invited all attendees to stop by his home, and enjoy wine and beer on the porch! If needed/wanted, food can be ordered from nearby restaurants in a jiffy.

Prof. Raj has mentioned that the following may be of interest to attendees-

- 1) The University library, with its collection of historical books.
- 2) Shakespeare garden on Campus

### 11) Short lectures in honor of Rishi Raj: July 19, 2019 8:30 AM –

The following is the tentative schedule for the morning of July 19. As there may be more lectures added, this session could spill into the early afternoon. The first short lecture will begin at 8:30 AM.

Speaker	Topic
Raj N. Singh (Invited Lecture)	Ceramic Composites for Use at High Temperatures: Historical Perspectives, Current Trends and Future Prospects
Rajendra Bordia	Early (but not so early) Years of Prof. Rishi Raj's lab – Maximizing Entropy
Venkat Gopalan	Remarkable Rishi: Five Life Lessons from Cornell Days
Sandeep Shah	Initial Hiccups and Successes in Polymer Derived Ceramics Processing at Boulder
<b>10 – 10:30 a.m.</b>	<b>Refreshment break</b>
Luke Emmert	Parallels between Laser-Induced Dielectric Breakdown and Fracture Mechanics
Charles Lewinsohn	Opportunities and Challenges facing Application of PDCs in Industrial Ceramic Manufacturing
Ray Baughman	Rishi Raj and other Sources of Energy
David Marshall	

Kurt Maute	
Lisa Thompson	
Suraj Rawal	
John Allegra	
Yigal Blum	
Harold Frost	
Gurpreet Singh	
Rishi Raj lecture	
11:45 AM – 1:00 PM	Lunch at WVCC

**12) Dinner at Raj’s home: July 19 6:30 PM onwards**

Please join us for dinner at Rishi’s place on Friday, July 19 6:30 PM onwards. His address is -

**863 14th St, Boulder, CO 80302**

Rishi’s home is 1.5 miles from Williams Village; for those who do not wish to walk, we will provide transportation. We wish to see all of you there!

**13) End of workshop: July 20, please leave by 11 AM**

Please remember to check-out at the front desk!

#### 14) List of Workshop attendees

First Name	Last Name	Email	Affiliation
Susana	Aguirre-Medel	susana.aguirre-medel@mavs.uta.edu	University of Texas at Arlington
John	Allegra	jallegra@gmail.com	Medical doctor
Diane	Allegra	jallegra@gmail.com	
Zlatomir	Apostolov	zlatomir.apostolov.1@us.af.mil	Air Force Research Lab
Prasad	Apte	jdicarlo@harperintl.com; papte@harperintl.com	Harper International Corporation
Aly	Badran	aly.badran@colorado.edu	University of Colorado Boulder
Ray	Baughman	ray.baughman@utdallas.edu	University of Texas at Dallas
Shakir	Bin Mujib	sbmujib@ksu.edu	Kansas State University
Yigal	Blum	yigalblum@gmail.com	Independent consultant
Rajendra	Bordia	rbordia@clemson.edu	Clemson University
Brett	Compton	bcompto1@utk.edu	University of Tennessee, Knoxville
Karissa	Cordero	karissa.cordero@mavs.uta.edu	University of Texas at Arlington
Spencer	Dansereau	spencer.dansereau@gmail.com	University of Colorado Boulder
Luke	Emmert	lemming@unm.edu	University of New Mexico
Patrick	Flowers	patrick@madeinspace.us	Made In Space
Martin	Friess	martin.friess@dlr.de	DLR- German Aerospace Center
Harold	Frost	harold.j.frost@dartmouth.edu	Dartmouth University
Venkat	Gopalan	vgopalanpsu@gmail.com	Penn State University
Douglas	Hardy	hardyd@starfiresystems.com	Starfire Systems
Janet	Holowczak	jeh430123@sbcglobal.net	
John	Holowczak	holowcje@utrc.utrc.com	United Technologies Research Center
Allison	Horner	allison.l.horner@spiritaero.com	Spirit AeroSystems
Himanshu	Jain	h.jain@lehigh.edu	Lehigh University
Sophie	Justus	sophiej@ksu.edu	Kansas State University
Shinji	Kato	shinji-kato@ma.dic.co.jp	DIC Corporation
Dong-Pyo	Kim	dpkim@postech.ac.kr	Postech
Peter	Kroll	pkroll@uta.edu	UT Arlington
Martina	Kroll	martinakroll@att.net	UT Arlington
Charles	Lewinsohn	clewinsohn@coorstek.com	CoorsTek, Inc.
David	Marshall	david.marshall@colorado.edu	University of Colorado, Boulder
Kurt	Maute	kurt.maute@colorado.edu	University of Colorado, Boulder
Sailesh	Menon	menon@ksu.edu	Kansas State University
Dora	Musielak	dora.musielak@uta.edu	University of Texas at Arlington

Masaki	Narisawa	nar@mtr.osakafu-u.ac.jp	Osaka Prefecture University
Alexandra	Navrotsky	anavrotsky@ucdavis.edu	University of California Davis
Kim	Nicholson	krw36@ksu.edu	OEIE
Elsa	Olivetti	elsao@mit.edu	MIT
Seetha	Raghavan	seetha.raghavan@ucf.edu	University of Central Florida
Rishi	Raj	rishi.raj@colorado.edu	University of Colorado Boulder
Suraj	Rawal	suraj.p.rawal@lmco.com	Lockheed Martin Space
Jacob	Regler	jrr320@lehigh.edu	Lehigh University
Zhongkan	Ren	zhongkan@ksu.edu	Kansas State University
Benjamin	Robles	benjamin.robles@colorado.edu	University of Colorado Boulder
Fausto	Rubio	frubio@icv.csic.es	Institute of Ceramics and Glass (ICV-CSIC)
Chrystelle	Salameh	chrystelle.salameh@enscm.fr	University of Montpellier
Wayde	Schmidt	schmidwr@utrc.utc.com	United Technologies Research Center
Sandeep	Shah	sandeep.r.shah@boeing.com	Boeing
Gurpreet	Singh	gurpreet@ksu.edu	Kansas State University
Raj	Singh	rajns@okstate.edu	Oklahoma State University
Satya	Singh		
Roger	Smith	roger@sierraturbines.com	Sierra Turbines
Davi	Soares	soares@ksu.edu	Kansas State University
Gian Domenico	Soraru	giandomenico.soraru@unitn.it	University of Trento
Aitana	Tamayo	aitanath@icv.csic.es	Ceramics and Glass Institute
Lisa	Thompson	lrt5@cornell.edu	Cornell University
Federico	Toigo	ftoigo@ksu.edu	Kansas State University
Jared	Weaver	weaver@ge.com	GE Research
Darren	Welson	welsond@starfiresystems.com	Starfire Systems
Devinder	Yadav	devinder@iitp.ac.in	Indian Institute of Technology, Patna