# Chair's update on PCSA activities and welcome to the student *ACerS Bulletin* issue

**By Olivia Brandt, PCSA Chair**


2021–2022 PCSA delegates at the PCSA annual meeting in October 2021.

The challenges that students faced throughout the past few years are immense; yet, hope remained ever-present in the face of these challenges.

The hope of returning to in-person gatherings and meetings. The hope of reconnecting with friends, colleagues, and loved ones separated by travel restrictions and quarantines.

This year's student issue of the *Bulletin* aims to provide perspectives from students on their hopes. As students, we are often told we are the future, and thus we embody society's hopes for the future. Yet as materials scientists and engineers, we carry hopes of our own as well—hopes that our research will be meaningful, hopes for how we can learn from the past, and hopes for the future to come. We have used this hope to overcome obstacles, break down barriers, and better the world in ways both large and small.

For me, as chair of the ACerS President's Council of Student Advisors (PCSA), my hopes lie in leading the next generation of student leaders to reach their fullest potentials. The PCSA currently comprises 44 delegates, representing 29 universities and eight countries.

When the PCSA began its term last October during ACerS Annual Meeting at MS&T21, hopes were high—delegates met face to face at what was for many their first in-person conference in more than a year and half, and for some their first conference ever. With this hope, the PCSA delegates produced a vision for the 2021–2022 term centered on cultivating an internal environment that encourages leadership and creativity, plus strengthening and expanding external partnerships and connections. Our committees are hard at work bringing this vision of the PCSA to life.

- **The Outreach Committee** is working to improve upon previous classroom outreach efforts, which includes wider distribution of both the mini and full-size Materials Science Classroom Kits as well as increasing collaboration with local community organization starting STEM outreach.
- **The External Partnerships Committee** is working toward increasing international connections. The biggest initiative underway is the student mentoring program (https://ceramics.org/mentorship), which has more than 50 mentor–mentee pairs. Additionally, this committee hosted an activity that promotes connection between ACerS and ECerS students at the Winter Workshop, which is held between ICACC and EMA every year.
- **The Communications Committee** is continuing to expand connections through engaging social media content that focuses on interesting aspects of ceramics and glass science, such as the science behind glassware.
- **The Programing Committee** is finding new ways of engaging with students through virtual competitions and virtual career panels at conferences such as EMA and ICACC.
- **The Recruitment Committee** is looking toward the future as they select the next PCSA delegates, who they hope will continue improving diversity and inclusion within the PCSA, which, in turn, helps to diversify ACerS.

There are so many things to be hopeful for—from the hope that a research hypothesis is met; to the hope that knowledge gained in a classroom STEM activity opens the eyes of younger students; to the hope for a safer, more tolerant world. Hope is something that is constant, but it is not something that should be taken for granted. We must never forget to celebrate hope.

*Olivia Brandt is a Ph.D. candidate at Purdue University studying under professors Rodney Trice and Jeffrey Youngblood. As the 2021–2022 chair of the PCSA, Olivia's vision is to effectively collaborate with the PCSA committees to achieve their key, strategic goals for the 2021–2022 term.* ■

# Congressional Visits Day 2022 recap

**By Yolanda Natividad**
**ACerS Liaison to the Material Advantage Student Program**

The Material Advantage Student Program's Virtual Congressional Visits Day (CVD) was held this year from May 17–19, 2022. The CVD is an annual event that gives students an opportunity to visit Washington, D.C. to educate congressional decision makers about the importance of funding for basic science, engineering, and technology. While we again were unable to physically be in D.C. this year, we did put together a virtual CVD program for Material Advantage students.

The CVD experience began with a virtual welcome event on May 17, featuring talks by Sean Gallagher, senior government relations officer at the American Association for the Advancement of Science, and Meg Thompson, cofounder and partner of Federal Science Partners.

After the talks concluded, students were provided with a chance to go into breakout rooms to further organize their teams and to do some role-play in advance of their appointments in the following days.

Students and faculty from the following universities registered for this year's Material Advantage Virtual CVD event:

Colorado School of Mines
Drexel University
Iowa State University
Michigan Technological University
Missouri S&T
The Pennsylvania State University
San Jose State University
The Ohio State University
University of Arizona
University of Maryland, College Park
University of Tennessee, Knoxville
Washington State University

Credit: Christopher Walker, University of Tennessee - Knoxville

Continued thanks to David Bahr, head and professor of materials engineering at Purdue University, and Iver Anderson, senior metallurgist at Ames Laboratory and adjunct professor in the materials science and engineering department at Iowa State University, for conducting the training on how to visit with legislators and for their assistance over the years in helping to coordinate CVD. Bahr and Anderson both serve on the Material Advantage Committee, the advisory committee that provides recommendations and feedback about the program to the four partnering organization's leadership.

We hope to be back in-person in D.C. for the 2023 CVD event. If you are a student and did not get a chance to participate this year, make sure that you plan to register EARLY for the 2023 CVD event. Or if you are a professor/faculty advisor, make sure to plan on gathering a group together from your university.

For future updates, visit the Material Advantage website at www.materialadvantage.org. It is an opportunity that you will not want to miss! ■

MATERIAL™ ADVANTAGE
The Student Program for Materials Science and Engineering
The American Ceramic Society www.ceramics.org | AIST Association for Iron & Steel Technology | ASM International | TMS The Minerals, Metals & Materials Society

# From crisis to hope—pandemic drives increase in mental health awareness and support

By Becky Steadman

Steadman

Among the many hardships we've faced the past two years due to the COVID-19 pandemic, its toll on student mental health is one consequence that has caused concern among parents, educators, and students alike.

As students, we often feel pressured to uphold people's dreams and expectations for the future society. But when the pandemic hit, job offers were withdrawn, graduations were cancelled, and connections were lost—yet the pressure remained.

As a result, many students experienced a decline in mental health. A survey by Student Minds, a U.K.-based student mental health charity, found that between March 2020 to 2021, 74% of students reported COVID-19 had a negative impact on their mental health and wellbeing at university.[1] A survey by *The Washington Post* supported these findings when it found nearly 73% of U.S. students reported moderate or serious psychological distress.[2]

However, as the number of students struggling with mental health increased, support services for students did not keep pace. That same survey by Student Minds found that while 65% of students said they needed additional support, just 19% got the help they needed.[1]

In response, students worked to raise awareness of the burgeoning mental health crisis. For example, Foothills University in California created a Mental Wellness Ambassadors program run by student representatives who aim to reduce social stigma and raise awareness of mental health resources.[3] Students also began to advocate for new policies and mental health programs at their universities. For example, a common request was the implementation of a "no detriment" or "safety net" policy,[4] which would ensure a student's education remained unaffected as they took exams from home in an unfamiliar format, away from in-person professional and personal support systems.

**Resource list—Student mental health organizations**

| Organization | Website | Description |
|---|---|---|
| Student Minds | https://www.studentminds.org.uk | U.K.-based student mental health charity dedicated to raising awareness and providing support for students across the U.K. |
| JED Foundation | https://jedfoundation.org | U.S.-based nonprofit aimed at providing resources to young adults to better understand mental health issues and also crisis hotlines for those in need. |
| Crisis Text Line | https://www.crisistextline.org | Global nonprofit providing free mental health texting service. Available 24/7 throughout the U.S., Canada, U.K., and Ireland. |
| The Trevor project | https://www.thetrevorproject.org | U.S.-based nonprofit that is the world's largest suicide prevention and crisis intervention organization for LGBTQ+ young people. |
| Samaritans | https://www.samaritans.org | U.K.-based crisis line for all ages, focusing on suicide prevention. |
| Switchboard LGBT+ helpline | https://switchboard.lgbt/how-we-can-help | U.K.-based charity supporting those in the LGBTQ+ community struggling with mental health. |
| Active Minds | https://www.activeminds.org | U.S.-based nonprofit dedicated to promoting mental health, especially among young adults, via peer-to-peer dialogue and interaction. |

Universities acted as well, with many investing in online "telehealth" services to expand student access to mental health professionals. For example, the University of West Virginia established a partnership with online and mobile therapy company Talkspace, and Belmont University in Tennessee purchased the telehealth support platform TimelyCare.[5]

National charities such as the JED Foundation and Student Minds also provided aid to universities in the form of crisis hotlines and educational resources for students. You can learn more about these organizations and others in the accompanying resource list above.

As someone who began a Ph.D. program in 2020, I know all too well the despair the pandemic wrought for students. But I also know the hope that is growing among students that universities will begin taking mental health of students more seriously, even after the pandemic. As lockdowns end and life slowly transitions back to in-person gatherings, universities continue to implement plans to support and acknowledge those working on their mental health.

As a society, we should remember the challenges we faced during the pandemic and address them with concern, understanding, and respect. Only by helping our peers can we create a bedrock of knowledge and trust for others to build on.

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## Redefining the looking glass: Reconnecting glass art and science

**By Brittney Hauke**

Hauke

The International Year of Glass (IYoG) could not have come at a better time; for me personally, the last two years have challenged my ability to focus on research. But having an international celebration for the material I love provides a great chance to step back and remind myself why I study glass, reflect on how far we have come, and look forward to the future of this field.

As an artist as well as a scientist, I especially appreciate the emphasis of glass art in the IYoG celebrations. Reintroduction of the arts into STEM fields has gained in popularity as a way to increase student interest in science and engineering and to improve problem solving skills.[1] I say "reintroduction" because for most of history, art and science were studied together: think Leonardo da Vinci and the concept of the "Renaissance man." The supposed dichotomy between glass art and science is a relatively recent perspective.[2]

Art and science are mutually beneficial for several reasons. For one, solving scientific problems often requires creativity, but creativity is a difficult concept to teach and is often not emphasized to STEM students. The introduction of art into STEM classes is a great way to develop this ability.

Similarly, many artists stand to gain from scientists, both in terms of how scientists conduct experiments and the resulting material knowledge. In my own artist endeavors, I found that documenting my experiments in the format of a laboratory notebook helps me clarify my processes and come up with new ideas. In addition, learning about the structure–property relationships of different materials allows artists to arrive at desired artistic results more directly than traditional trial-and-error endeavors.

Art is also a great way to reach new audiences and teach them about science. Glass is a particularly good material for education because in addition to being readily present in our everyday lives, it easily captures out attention; from there it is simple to start teaching about the science and history of glass and what it holds for our future. The Corning Museum of Glass is a great example of using art as a bridge to science outreach.[3] The museum blends the technological and artistic histories of glass into an amazing learning experience, while also spotlighting contemporary artists.

Regarding the combination of glass art and science in the classroom, Márcia Vilarigues of Universidade NOVA de Lisboa recently gave a good overview of this topic in a talk at the IYoG opening ceremony titled "Education in glass art and science—challenges of transdisciplinarity," which you can view online.[4] Some of the challenges she discussed are ones I have experienced personally in the materials science and engineering department at Penn State, where we are working to overhaul our glass blowing studio to make it more portable for outreach events.

Credit: Brittney Hauke

**An example of combining art and science from the author's senior art exhibition at Coe College in Cedar Rapids, Iowa. Vanadium tellurite glass used for research was remelted on the bottom of a glazed ceramic bowl.**

Even though I have experimented with many different mediums as an artist, my relationship with glass art is just beginning. I have a little experience with flameworking and just finished an introductory class on stained glass. This summer, I hope to learn how to blow glass once our studio space reopens. I am excited to work with glass in new ways, and I hope that it gives me more innovative ideas and appreciation for my research.

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## Science fiction sparks 'a new hope'

**By Erin Valenzuela**

Valenzuela

While curiosity is a trait we all share, the strength of our wonder tends to fade the older we grow. Yet if we can hold on to that childhood excitement, it can help us advance research into realms previously unexplored. In my opinion, science fiction is an excellent way to spark that inspiration in adults.

Science fiction films account for many key moments in my childhood, with some films deemed a rite of passage by certain family members. As a child, I would sit, think, imagine, and question what and how the social themes within sci-fi might trickle through and grow during my lifetime. Now, as a full-time researcher, I see a real and direct influence by sci-fi science on today's cutting-edge technological accomplishments.

While some of these advancements were pursued for pleasure—do people really need personal jetpacks?—others such as "waldo" remote manipulator arms[1] and language translators[2] were developed out of necessity or a hope for a more collaborative and sustainable future.

Sometimes these sci-fi-inspired discoveries reach beyond their original purpose to benefit other fields. As a personal example, I have always been interested in the space exploration industry, in part due to my love of Star Wars. Yet after working the past three years on aerospace ceramics for supersonic speeds—like those surely used on the T-65B X-wing starfighter—I started to develop a research identity that stretches across and beyond aerospace. What started out as a supersonic aerospace ceramic could also be developed into a ceramic for wind turbine blades,[3] materials for the developing nuclear energy field,[4] and much more.

Science fiction is not only inspiring real-world science—scientific knowledge is shaping new science fiction as well. One of my favorite examples comes from the filming of Christopher Nolan's "Interstellar." Nolan met with astrophysicist Kip Thorne to ensure the story would align with current knowledge on black holes. As they worked with others to develop a black hole simulation to feature onscreen, they ended up making a scientific breakthrough in the understanding and modeling of black holes![5] What originally started as a hope for accuracy in scientific portrayal led to actual scientific discoveries—demonstrating how science and science fiction can mutually benefit each other.

I am the first to say that not all people appreciate science fiction—on some days, even I find it difficult to enjoy the Culture series, which are some of my favorite books. It takes curiosity and patience to pull yourself away from the day to day and immerse yourself into a universe so far from our own. However, I was heavily reminded about the excitement of science while recently watching Villeneuve's "Dune" remake. While completely—and literally—out of this world, adventures such as this one are a key reminder for why we do what we do as researchers and as scientists.

When researching a small section of science, it is often easy to forget the bigger picture. Next time you feel overwhelmed, grant yourself a couple of hours to watch or read some science fiction. It can give you the hope that you are working for something much bigger than the furnace breaking or your particles falling out of suspension. Even though some sci-fi is simply fiction, a lot of it is closer to reality than we realize.

Credit: Erin Valenzuela

**Me as a baby, probably imagining that the balloon is a rocket. Carrying our childhood wonder into adulthood can greatly benefit our approach to research.**

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# Toward where no earthling has gone before

By Elia Zancan

Zancan

"Space: the final frontier!" I've never been a Star Trek fan, but I admit those words struck me when I first heard them. While final frontiers do exist within the confines of our atmosphere—more than 80% of the ocean remains unexplored, after all—the thought of exploring among the stars is a tantalizing prospect.

Of course, active exploration of the cosmos currently remains out of reach. But we are slowly increasing our capacity to peek into deep space, with the newly launched James Webb Space Telescope being a star among stars. But these advances are, for the most part, unmanned explorations. Sixty-six years passed between the Wright brothers' first flight and the moon landing, and almost the same time has now passed without any significant steps toward manned space flight, an indication of how great is the technological leap required for space exploration.

Leaving aside—at least for now—the science fiction required for long-distance space travel, one of the most critical improvements we can implement regards the propulsion system. Considering how insignificant our lifespan is related to the incredibly vast ranges of space, faster ships are needed to shorten travel time. To go faster, though, ships require more powerful engines operating at much higher temperatures.

Here is where my research on ultra-high-temperature ceramics (UHTCs) plays a role. These materials can withstand incredibly demanding thermal and/or mechanical stresses with the help of fibrous reinforcement. Still, their remarkable properties make manufacturing them difficult, especially if more complex shapes are desired. For this reason, I am developing a new production route for UHTCs that overcomes some of the challenges experienced with traditional manufacturing techniques, such as extremely long processing times or very high temperatures.


**European Space Agency astronaut Luca Parmitano carries the new thermal pump system that was installed on the Alpha Magnetic Spectrometer during the third spacewalk to upgrade the machine. One day, an unknown planet will be in the background of these pictures.**

The latter is a crucial point, as it requires adequate materials for the construction of furnaces and other processing equipment capable of resisting high temperatures, plus a considerable energy consumption to run them. As both fixed and operating costs scale superlinearly with component size and progressive harshening of operating conditions, working on alternative manufacturing routes is a must to enable a larger scale deployment of this class of materials.

Of course, we do not have to reach far into the galaxy for a reason to fund UHTC research—commercial aircraft will also benefit from easier access to these materials. The implementation of thermal protection systems, similar to those employed by atmospheric reentry vehicles, will enable hypersonic flight, which will dramatically reduce the duration of intercontinental flights.[1] Traveling from Europe to either the west coast of the Americas or to East Asia will take just a couple of hours rather than a whole day—the dream of every passenger seated next to a whiny baby!

Although the aerospace industry has used UHTCs for some time, much research is still required to cut production costs and to improve their performance. As such, I do not expect my research to produce an immediate breakthrough. But even if it is just a bolt in the framework on a future build, I will deem myself happy. And what is humanity without dreams and hope, after all?

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# Vitrification of nuclear waste offers hope for a cleaner future

**By John Bussey**

Bussey

In my home state of Washington, the disposition of legacy nuclear waste is a complex pursuit that has evolved since the Hanford site in eastern Washington was converted from a production mission to an environmental cleanup mission in 1989 (Figure 1).

About 56 million gallons of radioactive tank waste are currently stored at Hanford, generated between 1944 and 1989 from five different chemical processes performed on 96,000 tonnes of irradiated nuclear fuel.[1] Some of these tanks are confirmed to be leaking while others are suspected, leading (unsurprisingly) to societal and environmental concerns; releases from these tanks pose a potential health risk to people and organisms that rely on the Columbia River.

The planned approach for safe disposal of the nuclear waste is vitrification, that is, turning the waste into glass.[2] After nuclear waste is vitrified, it will go into long-term storage for thousands of years, either on-site in controlled shallow burial (for low radioactivity waste) or in a yet-to-be-commissioned deep geological repository (for high radioactivity waste).

Nuclear sites throughout the world use vitrification, but each collection of nuclear waste has its own "fingerprint," requiring a unique solution. The waste at the Hanford site is particularly tricky. It includes some of the first nuclear waste ever generated, before standard extraction methods were established. As such, scientists have identified more than 70% of elements (up to curium) on the periodic table in this waste. These many components cause diverse potential technical issues during immobilization, requiring extensive risk reduction research.[1]

Research devoted to solving the technical challenges associated with vitrification has taken place for many years, including at my institution, Washington State University. This devotion has led to large strides in a wide range of basic and applied glass science topics, including composition, characterization, durability, solubility/retention, corrosion, glass-ceramics, and refractory materials used in glass melting furnaces.

All this research—and ongoing work probing outstanding scientific issues to provide further risk reduction—is being used to develop the Hanford Waste Treatment and Immobilization Plant (WTP). The WTP will be the most complex vitrification effort to date, helping to remediate one of the largest environmental clean-up sites of all time.[1] According to Bechtel National, Inc., the Department of Energy contractor obligated to start up the vitrification plant, this facility is currently in the commissioning phase. This phase is the last one before full scale plant operations begin (tank waste vitrification is planned to start at the end of 2023).[3]




**Figure 1. 1943 construction of nuclear waste tanks at the Hanford site. These tanks were designed with a 20-year lifetime, although some waste (including the waste stored in the above tanks) was later relocated to tanks with a 50-year lifetime.[1]**

I am hopeful and excited to see all the vitrification research being used to develop real-world solutions for nuclear waste storage. As ceramists and glass scientists, we often work on wide-ranging projects that take a long time to come to fruition. This project is a great example of how many years of research, from a broad and diverse community, can eventually be applied. In this case, decades of ceramics and glass research will help to protect human health and the environment for years to come.

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## With a touch of magic: Lessons learned from alchemists and historic ceramics

**By Celia S. Chari**

**Chari**

In April 2020, amid the start of the COVID-19 pandemic, I spent my time reading through the literature and researching production methods of 18th century overglaze enamels from the Meissen porcelain manufactory, which was located near Dresden in present-day Germany.

Founded by Augustus II the Strong, Elector of Saxony, the Meissen manufactory housed renowned alchemists like Johann Friedrich Böttger and Ehrenfried Walther von Tschirnhaus, who helped develop the first European hard paste porcelain. Prior to their breakthrough, porcelain was procured solely from the Far East, primarily China, where its production secret was closely guarded for centuries, including the high firing temperature requirements from specialized kilns. However, through clever control of materials chemistry and a high inclusion of lime, these alchemists produced the desired vitreous consistency of porcelain at a much lower temperature than required in the original formula.

Reading through the recipes and stories of Meissen, I could not help but become captivated and inspired by the resiliency of these ceramists; despite their high-pressure work environments, they still flourished in their production of "white gold" and other admired ceramic objects.

As the months passed by, my research slowly transitioned back to the laboratory, where the pressure to make up for lost time was very real (though admittedly it originated mostly from my own ambitions). With limited access to instruments and facilities, my research pace was infuriating at times. But I remained hopeful as I kept reading about the intricate discoveries from alchemists at Meissen, born under self-pressure and immense creativity.

I was particularly mesmerized by the complex nanotechnology that appeared to be featured in their purple overglaze enamels, predominantly two called *Böttger luster* and *Purple of Cassius*.[1] How did alchemists from 1710–1735 know to work with gold nanoparticles to produce purple glazes? How did they synthesize nanoparticles with their limited technology and understanding of materials science? Were they truly magical beings, or just obsessive experimentalists? Based on the numerous technological advancements that have taken place since the 18th century, it is unlikely the original alchemists from Meissen had any understanding of the fundamental chemistry and physics dominating the optical properties of their glazes. Yet they successfully carried out experiments and produced artworks through repeated trial and error, imagination, and an abundance of pressure from the impatient Augustus II the Strong, who was funding their research. So, I eventually concluded: if they could develop an impressive palette of enamels and porcelains under their work conditions, I could carry out my doctorate during the pandemic.

Hope and resilience. Despite their unfortunate circumstances and timing, alchemists from Meissen made an impact in the history of the world, fabricating lustrous glazes that are still talked about today. Studying their historic purple glazes, I felt like I was tackling a mystery that had puzzled conservators and scientists for centuries—what makes *Böttger luster* purple and iridescent? I felt incredibly lucky that I could work on this project using modern microscopy and materials characterization tools, more technologically advanced than ever before.


**Example of a tureen created at the Meissen porcelain manufactory (c. 1730–1735).[2] You can see the *Purple of Cassius* overglaze in the people's clothing, while *Böttger luster* is the purple-brown glaze found in the frame-like cartouche around the different images.**

Yet as I get further into my research, it is sobering to realize that some research questions cannot be answered even with our advanced techniques. That does not mean, however, they cannot be answered in the future when the right analytical equipment and literature is available to aid in investigation. I am filled with hope thinking about the continuity of research from that perspective, and it inspires me to think about how far mankind's knowledge will grow with the right facilities and continued curiosity for discovering why materials behave the way they do.

As modern-day ceramists, please remember the spirit of our alchemist past when studying the advanced materials of the future. With patience, resilience, and hope, what seems magical today will likely be explainable in the future.

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## Hope in collaborations: A driving force for research

**By Kartik Nemani and Brian C. Wyatt**

Nemani

Wyatt

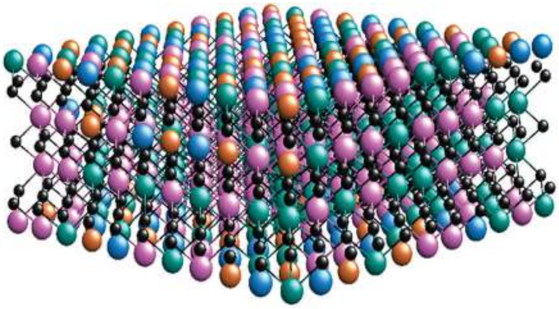
Throughout history, civilizations have gone through periods of highs and lows. Yet even in the hardest times, hope has driven people to come together to beat the odds and emerge triumphant, sometimes with breakthroughs and many times with reinforced will and courage.

The COVID-19 pandemic is again reinforcing the importance of collaborations, something we have personally experienced as Ph.D. students who started a semester before the pandemic hit.

Our research is on the synthesis and high-temperature stability of MXenes, which are a family of 2D transition metal carbides, nitrides, and carbonitrides. First discovered by two groups of Drexel University researchers in 2011, MXenes are quickly finding application in a wide variety of fields, from environmental remediation to electronics to ultrahigh-temperature ceramics.

Though MXenes are a relatively new research field, they have attracted much attention from the 2D materials community, and studies on these materials are being published at a high rate, even during the pandemic. As new Ph.D. students trying to keep up with this ever-growing body of research, the inability to meet with professors and other students in person left feelings of disorientation and worry that we would not grasp the topic well enough to contribute something new.

However, in 2021, our perseverance through these challenging times started bearing fruit when collaborative efforts between us and three other teams, across two continents, led to the discovery of high-entropy MXenes[1] as well as advancements in understanding MXene high-temperature behavior.[2]





**Left, schematic representation of high-entropy MXenes $TiVNbMoC_3$ or $TiVCrMoC_3$ discovered by our group in 2021. Right, MXenes being brought to ultrahigh temperatures (> 2,000°C) in a graphite die placed in a spark-plasma sintering equipment.**

The vital experiments were conducted at our Indianapolis lab, with the data generated being channeled to a supercomputer at Argonne National Laboratory. Simultaneously, we shipped a batch of our samples to collaborators at Argonne for atomic scale imaging, while our collaborators in Norway verified results and measured other vital parameters through simulations.

Consistent communication helped us develop strong synergy with our collaborators, and this teamwork was the source of much needed hope during tough times, both inside and outside the lab. When we both fell ill and needed to take a break from experiments, our collaborators supported and motivated us to continue our work once we returned. While discovering high-entropy MXenes was exciting scientifically, being able to share the discovery with our collaborators, now friends, helped lessen worries about our individual capabilities and appreciate what we can accomplish when working together.

As Ph.D. students who have conducted well over 70% of our doctoral studies during a life-changing pandemic, we have come to realize that passion in research does not necessarily come from chasing inspirational breakthroughs, published manuscripts, or raucous applause. It comes from the opportunity to express ourselves through something that brings joy and hope to our lives while strengthening relationships with others in the field.

As the Rig Veda, a book of hymns from 10000 BCE, states: "May noble thoughts come to us, may there be advancement in all aspects." (1.89.1) Perhaps hope, in its true essence, is finding our humanity in the pursuit of a solution while steering through the ocean of challenges.

### References

[1]Nemani et al., "High-entropy 2D carbide MXenes: $TiVNbMoC_3$ and $TiVCrMoC_3$," *ACS Nano* **15**(8), 2021:12815–12825.

[2]Wyatt et al., "High-temperature stability and phase transformations of titanium carbide ($Ti_3C_2T_x$) MXene," *J. Phys. Condens. Matter* **33**, 2021:224002.

*Kartik Nemani and Brian C. Wyatt are Ph.D. candidates in the Layered Materials and Structures Lab at Indiana University–Purdue University. Their research focuses on synthesis and high-temperature stability studies of MXenes. When not working, Kartik can be found either painting, hunting for subjects to capture with his camera, or behind a moth-eaten book of ancient Sanskrit. Similarly, when not on campus or behind his computer, Brian can be found enjoying the company of his wife and two dogs, trying new coffee shops in the city, or hiking on a trail across the state of Indiana.*

## The far-reaching impact of the Mini Materials Kit

**By Nathaniel Olson and Nathaniel S. McIlwaine**

Olson

McIlwaine

STEM outreach is more than an activity to inspire and educate the next generation. Outreach also serves as a source of hope for the scientists, engineers, and educators who conduct it—hope that the next generation will continue to advance research and development in support of the planet and its inhabitants.

Recent times have left many of us feeling isolated, with access to in-person education severely limited. Nonetheless, many inventive and passionate individuals overcame these limitations by leveraging new tools and infrastructure for remote education. Here, we highlight outreach efforts by members of ACerS President's Council of Student Advisors, the student-led committee of ACerS, using the Ceramic and Glass Industry Foundation (CGIF) Mini Materials Kits.[1]

CGIF was established by ACerS in 2014 to attract, inspire, and train the next generation of ceramic and glass professionals. CGIF developed the Mini Materials Kit in 2020 as a more accessible follow-up to the larger Materials Science Classroom Kit. The kit is a collection of seven simple experiments accompanied by video demonstrations and written instructions that can be done independently by teachers, parents, and students.

Isabella Costa has led efforts to distribute the kits in Brazil by providing kits she brought back from the U.S. to 7th–9th grade teachers at public schools who do not have laboratory facilities (Figure 1). Speaking to the impact of the kits, Costa relates, "Through the kits I was able to introduce contents that were never discussed in the classroom, such as the periodic table and atomic bonds, in an interactive way. The kids were not only excited about the experiment but were also interested in understanding the science behind it."


**Figure 1. Isabella Costa (center, white shirt) with teacher Eduardo Siríaco Trezza (center, blue shirt) and students from Antônio Ferreira Martins Municipal School after a lesson demonstrating the Mini Materials Kits.**

Like Costa, Matthew Julian became aware of the significant costs of shipping the kits internationally after accepting a Ph.D. position in France. So, he put together a bill of materials using suppliers in Europe and established a partnership with a French company to assemble and distribute the kits to students and teachers in Europe. Julian says, "This [work] is all in hopes of planting the seeds to cultivate the next generation of scientists who will develop the technology of tomorrow."

Shannon Rogers expanded the kit's reach beyond the classroom and into afterschool programs by helping to establish the ACerS Colorado Section's Denver kit distribution program. This program, in collaboration with the Denver Scholarship Foundation's Future Centers,[2] enabled the distribution of 14 kits to underserved high schools in the Denver area. A key motivation behind Rogers' passion for outreach is her own journey in materials science. She relates, "I didn't know what [materials science] was until I was looking at Alfred University for a degree in ceramic art and design, and saw ceramic engineering listed as a major. ... I think [the kits] could really open the minds of young engineers and get them excited about materials."

There are many other past and present PCSA members who helped make these achievements possible, including project leadership from Andy Ericks, Spencer Dahl, Michael Thuis, and Nathan McIlwaine, and hard work from Ruth Adam, Megan Owen, and Anna Schmidt-Verma. This work provides hope that access to STEM education and outreach can be expanded even in the most difficult of times, helping to foster a materials science community that spans the globe.

### References


[1]Mini Materials Kit, https://foundation.ceramics.org/mini-kits

[2]"Find Your Future Center," Denver Scholarship foundation, https://denverscholarship.org/students/future-center



*Nathaniel Olson is a fourth-year Ph.D. candidate and NASA Space Technology Research Fellow in materials science and engineering at the University of Illinois Urbana-Champaign. His work focuses on the development of highly porous ceramic materials (aerogels) for use as insulation in aerospace applications. In addition to his graduate work, Nate is a member of the Illini Motorsports FSAE team and a Pathways Intern at NASA Johnson Space Center.*

*Nathaniel McIlwaine is a second-year Ph.D. candidate and National Defense Science and Engineering Graduate Fellow in materials science and engineering at The Pennsylvania State University. His work focuses on the investigation of spinodal-hardened high-entropy ceramics to achieve ultrahigh hardness. In addition to his graduate work, Nathan is a third-year PCSA delegate and is currently serving as Outreach Committee chair.*