Celebrating 100 years

AMERICAN CERAMIC SOCIETY

bulletin

emerging ceramics & glass technology

OCTOBER/NOVEMBER 2021

AFRICA–

A wealth of resources and aspirations

Bioinspired GRIN optics | MicroRNA in medicine | Processing in Ceramics wiki

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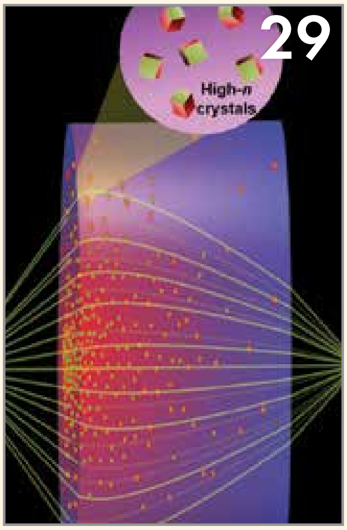
October/November 2021 • Vol. 100 No.8

feature articles

Africa—A wealth of resources and aspirations

Africa sees its future in technological advance—and actively seeks global partners to help achieve its research and economic development potential.

By Alex Talavera and Randy B. Hecht



Bioinspired optics: Chalcogenide glass-ceramic nanocomposites mark a milestone in infrared gradient refractive index materials

A combination of multicomponent chalcogenide nanocomposites and laser/thermal processes enables a transformative opportunity to bring gradient refractive index lenses one step closer to commercialization.

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As seen on *Ceramic Tech Today*...

Credit: CTS Corporation, YouTube

Neural network speeds up identification of piezoelectric properties

Modeling is a good way to evaluate the performance of new piezoelectric materials without conducting costly experiments. Two researchers from University of the Republic in Uruguay explored using a neural network to speed up the modeling process.

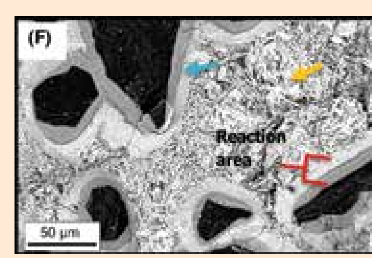
Read more at www.ceramics.org/identify-piezo

Also see our ACerS journals...

Utilization of moderate pressure and elevated temperatures in the optimization of Ti_2AlC-cBN composites using SPS technique
By T. Rampai, I. Sigalas, and D. Whitefield
International Journal of Ceramic Engineering & Science

$(BaTiO_3)_{1-x}$ + $(Co_{0.5}Ni_{0.5}Nb_{0.06}Fe_{1.94}O_4)_x$ nanocomposites: Structure, morphology, magnetic and dielectric properties
By Y. Slimani, S. E. Shirsath, E. Hannachi, et al.
Journal of the American Ceramic Society

Searching for the fundamentals of rehydroxylation dating of archaeological ceramics via NMR and IR microscopy
By M. Avramovska, C. Chmelik, A. Derkowski, et al.
Journal of the American Ceramic Society



Defluoridation of drinking water using a ceramic filter decorated with iron oxide-biochar composites
By C. Mandoreba, W. Gwenzi, and N. Chaukura
International Journal of Applied Ceramic Technology

Journal of the American Ceramic Society | International Journal of Applied Ceramic Technology | International Journal of Applied Glass Science | International Journal of Ceramic Engineering & Science

Read more at www.ceramics.org/journals

American Ceramic Society Bulletin covers news and activities of the Society and its members, includes items of interest to the ceramics community, and provides the most current information concerning all aspects of ceramic technology, including R&D, manufacturing, engineering, and marketing. The American Ceramic Society is not responsible for the accuracy of information in the editorial, articles, and advertising sections of this publication. Readers should independently evaluate the accuracy of any statement in the editorial, articles, and advertising sections of this publication. *American Ceramic Society Bulletin* (ISSN No. 0002-7812). ©2021. Printed in the United States of America. *ACerS Bulletin* is published monthly, except for February, July, and November, as a "dual-media" magazine in print and electronic formats (www.ceramics.org). Editorial and Subscription Offices: 550 Polaris Parkway, Suite 510, Westerville, OH 43082-7045. Subscription included with The American Ceramic Society membership. Nonmember print subscription rates, including online access: United States and Canada, 1 year $135; international, 1 year $150.* Rates include shipping charges. International Remail Service is standard outside of the United States and Canada. *International nonmembers also may elect to receive an electronic-only, email delivery subscription for $100. Single issues, January–October/November: member $6 per issue; nonmember $15 per issue. December issue (*ceramicSOURCE*): member $20, nonmember $40. Postage/handling for single issues: United States and Canada, $3 per item; United States and Canada Expedited (UPS 2nd day air), $8 per item; International Standard, $6 per item.

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ACSBA7, Vol. 100, No. 8, pp 1– 48. All feature articles are covered in Current Contents.

To ACerS members and Bulletin readers,

We are pleased to share that on May 18, 2021, the United Nations General Assembly formally approved a resolution declaring the year 2022 as "The International Year of Glass."

This seminal and celebratory moment for the global glass community is noteworthy because it is the first time that the United Nations accorded such a recognition to a specific material. It represents an acknowledgment of the vital role glass has played and will continue to play in the advancement of human society.

The IYOG initiative was led by the International Commission on Glass, headed by its president, Alicia Durán. The proposal went to the U.N. General Assembly with about 1,700 letters of support from companies, universities, professional societies, trade associations, museums, individuals, and other organizations from 81 countries. This strong global support was crucial for the approval of the resolution.

The North American Steering Committee for IYOG was established to coordinate activities in the U.S. and Canada with members from all the key constituencies associated with glass, such as academia, industry, artists, R&D institutes, museums, and professional associations. We are honored to serve as the chairs of this distinguished committee.

Many events to mark the occasion and to celebrate all things glass are being planned all over the world, and those that are known at this time are summarized in the sidebar table.

A key event in North America will be a "National Day of Glass" in April in Washington, D.C. We plan to bring together scientists, engineers, artists, academicians, students, and government institutions to celebrate the importance of glass in our lives. The National Day of Glass will be followed by the Annual Meeting of the Glass & Optical Materials Division of The American Ceramic Society in May in Baltimore.

At the international level, an inaugural conference will be held in the Human Rights Room in the Palace of Nations, Geneva, Switzerland, in February 2022. In addition, the International Congress on Glass will be held in Berlin to mark the 100th anniversary of the founding of the German Glass Society. The North American Steering Committee and ACerS will play major roles in these and other activities.

Besides the aforementioned events, the Society is working on other plans to commemorate IYOG, including a special issue of the International Journal of Applied Glass Technology*, special features in the* Bulletin*, and short courses on glass.*

We will be compiling activities related to IYOG on the website at www.ceramics.org/IYOG. All companies, organizations, and universities are welcome to contribute their IYOG-related activities. The webpage contains an online form for you to provide your details. Please watch the webpage, the Bulletin*, and the* Ceramic Tech Today *blog for future announcements.*

On behalf of the North American Steering Committee for IYOG, we seek your counsel, participation, and support of the events we are planning. We welcome your comments and inquiries.

Sincerely,

Manoj K. Choudhary
Chair, North American Steering Committee for the International Year of Glass 2022
Adjunct professor of materials science and engineering, The Ohio State University
Past president, International Commission on Glass (2015–2018)
mchoudhary61@gmail.com

Kathy Jordan, Co-chair
President, American Glass Guild
president@americanglassguild.org

Younès Messaddeq, Co-chair
Professor, Universitè Laval, Quèbec, Canada
younes.messaddeq@copl.ulaval.ca

UN International Year of Glass 2022 events*

Event	Dates in 2022	Location	Organizers
IYOG Inaugural Conference	February 10–11	Palace of Nations Geneva, Switzerland	IYOG
National Day of Glass	April 5–7	Washington, D.C.	ACerS
ACerS Glass & Optical Materials Division Annual Meeting	May 22–26	Baltimore, Md.	ACerS GOMD
International Congress on Glass and German Glass Society centennial recognition	July 3–8	Berlin, Germany	International Commission on Glass
American Glass Guild Annual Conference	July 14–17	Corning Museum of Glass, Corning, N.Y.	American Glass Guild

*as known at press time.

MicroRNA in medicine: A new therapeutic frontier in wound healing

By Elayaraja Kolanthai, Udit Kumar, and Sudipta Seal (University of Central Florida) and Kenneth W. Liechty (University of Colorado School of Medicine)

In this world of constant medical predicament, scientists are constantly in pursuit of new therapeutics to prevent and cure diseases. However, the process of bringing a new molecule to market takes nearly 10–15 years and requires a huge investment in excess of billions of dollars.

In the last two decades, ribonucleic acid (RNA)-based therapeutics have started to play a vital role in medicine. RNA-based treatments regulate gene expression to treat a plethora of diseases and ailments. They offer the ability to minimize production cost and time of new therapeutics while ensuring safe clinical use.

The vaccines developed by Pfizer-BioNTech and Moderna to treat COVID-19 infection are a current and significant example of the wonders offered by messenger ribonucleic acid (mRNA) vaccines. The projected market value of mRNA vaccines and therapies is slated to surpass $9.41 billion this year.[1]

One type of RNA-based therapeutic that has long been discussed but remains far from commercialization is microRNA (miRNA). miRNA, not to be confused with mRNA, is a subsection of noncoding RNA that is the most common regulator of gene expression. Globally referred to as the "next-generation" of therapeutics, miRNA-based treatments gained significant recognition due to their potential in addressing the "genetic framework" of the disease by targeting specific mRNAs for suppression or degradation.

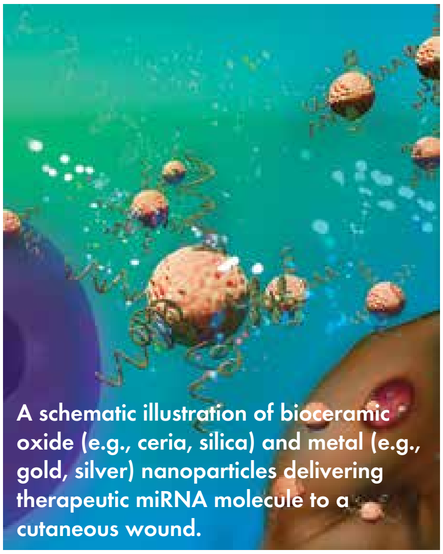
In 2020, the market value for miRNA therapeutics accounted for an estimated $854.6 million, and the compound annual growth rate will rise about 19.8% from the years 2021 to 2028.[2] This potential can be attributed to miRNA's mechanism of targeting specific mRNAs, which leads to potential biomedical applications either as diagnostic tool or active therapeutics. It is a diagnostic tool when there is a dysregulation of particular miRNA. It is an active therapeutic in diseases where alteration of gene expression is beneficial, such as in cardiovascular, Alzheimer's, rheumatoid arthritis, immune disorders, diabetics, and cancer. Further, it has been used to prevent inflammation during wound healing.

Overall, the field of miRNA diagnosis and treatment is a promising area within gene-based medicine. In particular, wound healing applications have emerged as one of the more promising uses of this technology.

Wounds are classified as either acute or chronic depending on the time of the wound healing rate. An acute wound is an injury that occurs in a shorter duration after an initial accident or surgery and normally heals with the possibility of natural scarring. A chronic wound is the anomalous healing of the acute wound as a result of comorbid conditions like diabetes, pressure ulcers, injury, larger wound size, or venous stasis. About 6.5 million patients in the United States suffer due to chronic wounds. Among them, patients more than 65 years old with diabetes (18%) develop nonhealing foot ulcers. According to the National Institute of Health in the U.S., the cost for treatment of diabetic foot ulcers per year alone approximates to around $9–13 billion.

Wound healing is a complicated process that involves the temporal and integrated regulation of multiples phases of healing. Following initial hemostasis, the subsequent phases consist of inflammation, proliferation, and remodeling. If this sequence becomes dysregulated, impaired healing or a complete failure of wound healing can occur.

The development of novel miRNA-



A schematic illustration of bioceramic oxide (e.g., ceria, silica) and metal (e.g., gold, silver) nanoparticles delivering therapeutic miRNA molecule to a cutaneous wound.

Credit: Ryan Dickerson, University of Central Florida

based diagnostics and therapeutics would have a tremendous impact on chronic wounds. The multiple healing phases are regulated by gene expression, which in turn is regulated by miRNA. Dysregulated gene expression and miRNA have been demonstrated in each phase of healing. Thus, focusing on miRNA wound healing therapy can significantly increase the wound healing speed and improve patients' health.

However, many factors hinder the effective delivery of RNA interference (RNAi) molecules. For instance, when naked RNAi enters an extracellular space, they are prone to the degradation by the endonucleases. Moreover, due to the physiological fluids and the negative surface charge on the cell membrane, the RNAi uptake by the cells becomes hindered and additionally causes many chances of off-target effects. Therefore, many technologies have been implemented for effective delivery of RNAi to preserve the integrity of the molecule in engaging their role and preventing (i) off-target effects, (ii) low cell uptake, and (iii) endosomal degradation. Nanoparticles such as gold, silver, and various bioceramics (e.g., hydroxyapatite, cerium oxide, silica) are currently being used to overcome this hindrance.

Our group recently featured an extensive discussion in *Wiley Interdisciplinary Reviews* over the application of miRNA for wound healing and the current trends that have been contended.[3] We used miRNA-146a for local treatment of diabetic wound healing with the rare earth oxide ceria, which has antioxidant properties. Manipulating this element into ceria nanoparticles resulted in the delivery assistance of miRNA. Subsequent publications involving the research of this miRNA treatment to improve wound healing used other biomaterial delivery strategies, including nano-silk or a novel zwitterionic gel.

Corporate Partner News

Allied Mineral Products celebrates 60 years in the industry


The current headquarters of Allied Mineral Products in Columbus, Ohio.

Allied Mineral Products is celebrating its 60th anniversary. In its early days, Allied sold minerals from a home office and garage in northwest Columbus, Ohio. The need for warehouse space led co-founders Bill Winemiller and Bob Scott to lease a downtown building off East Chestnut Street. Today, Allied's current headquarters and manufacturing campus spans 40 acres on the west side of Columbus. This flagship location houses a state-of-the-art research and technology center and a newly renovated monolithic and precast shapes manufacturing facility. Learn more about Allied at https://alliedmineral.com.

References

[1]https://www.imarcgroup.com/mrna-vaccines-therapeutics-market

[2]https://www.grandviewresearch.com/industry-analysis/microrna-market

[3]E. Kolanthai et al., "Nanoparticle mediated RNA delivery for wound healing," *Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology* (2021): e1741., https://doi.org/10.1002/wnan.1741

A new wiki on ceramics processing—ready to join us?

Credit: IEK-1

Example of an article featured on the new "Processing of Ceramics" wiki.

You cannot make it without materials, and you cannot make materials without processing. This phrase holds true for all material classes, and particularly for ceramics.

Research and development in the field of ceramics involves researchers from various fields—including materials scientists, chemists, physicists, and electrical and mechanical engineers—and a wide variety of educational and career backgrounds, including university students and academics, technicians, and laboratory assistants. However, as experienced researchers retire, young researchers may face old problems without necessarily having access to the knowledge accumulated over decades.

To date, there are few textbooks that cover the topic of ceramic processing well. In addition, few references elaborate the practical side of ceramic materials science. What are the important aspects of powder processing? How do I mix and mill raw materials? How do I shape a ceramic green body? How do I select the right sintering method? What are the guidelines to design a heat treatment for sintering? How do I characterize my sample?

Wikis such as wikiHow (https://wikihow.com) and Wikipedia (https://wikipedia.org) are collaborative websites that rely on their own audiences to provide knowledge and tutorials on a large number of subjects, for example, how to cook rice or make macaroni salad, compress a pdf file, preserve flowers, or step out of your comfort zone… But we are still missing a general "cookbook" for ceramics!

A new wiki initiated by ACerS members Wolfgang Rheinheimer and Olivier Guillon, both in the Institute of Energy and Climate Research—Materials Synthesis and Processing (IEK-1) at Forschungszentrum Jülich, Germany, provides such a platform.

The new "Processing of Ceramics" wiki provides a list of mostly practical articles to help anybody working on ceramics to set up their lab. Staff members at IEK-1 provided a core of articles open to everyone as the basis for the wiki, and the list now simply needs to be expanded. You are welcome to read and extend these articles—and to create new ones—for the benefit of the current and future ceramic community!

How to contribute

Go to https://apps.fz-juelich.de/ceramics and request an account by clicking on the link labeled "Request account," located in the top right corner of the web page. Follow the instructions to enter your name, email address, and desired username. You will receive an email containing a link to verify your email address.

After clicking on the link, our staff will check your request. Upon approval, you will receive an additional email with a one-time password and further instructions on how to log in. On your first login, the system will ask you to enter a new password. After that you can edit pages in the "Processing of Ceramics" wiki.

To see all pages currently available on the wiki, click on "Special pages" in the left sidebar and then on "All pages."

Olivier Guillon is director at the Institute of Energy and Climate Research—Materials Synthesis and Processing, Germany, and professor at the RWTH Aachen University, Germany. His research focuses on solid-state batteries, solid oxide fuel cells and high-temperature electrolysis, gas separation membranes, high-temperature materials, as well as advanced sintering processes. He is a member of the board of directors of the German Ceramic Society (DKG), World Academy of Ceramics, the International Institute for the Science of Sintering, and Fellow of the European Ceramic Society. Contact Guillon at o.guillon@fz-juelich.de.

Wolfgang Rheinheimer leads an Emmy-Noether Group funded by the German Research Foundation. He received his diploma and Ph.D. at the Karlsruhe Institute of Technology, Germany. He completed postdoctoral research at KIT and was a visiting professor at Purdue University. His research focuses on microstructure evolution in ionic materials, and the segregation and processing aspects during sintering and grain growth and the resulting functional properties. Contact Rheinheimer at w.rheinheimer@fz-juelich.de.

In vitro diagnostics: Technologies and global markets

By Jon Evans

In vitro diagnostics (IVD) are the highest revenue segment of the medical device market. The global market for IVD products is estimated to be $74.1 billion in 2020, and it is expected to grow at a compound annual growth rate of 6.7% to reach $102.4 billion through 2025.

IVD includes analyzers, reagents, disposable and reusable products, and accessory software products used by both clinical and research laboratories around the world. IVDs range from simple self-use tests to state-of-the-art genomic tests performed in laboratories, which can be used in the diagnosis of infectious and chronic diseases, as well as for preventive care and drug therapy monitoring.

Factors influencing the global IVD market include

- **Need for disease detection before appearance of symptoms**—Rapid advances in human genome sequencing enable the identification of faulty genes, increasing the probability of diagnosing a disease before its symptoms appear and thus starting treatment much earlier.
- **Need to identify the right patients for drug therapy**—New tests, known as companion diagnostics, generate critical data on a patient's rate of drug metabolism and efficacy, for example, thus enabling healthcare experts to identify the right patient for a specific drug.
- **Need for faster real-time tests that enable personalized treatment**—Faster tests provide real-time results and thus allow healthcare providers to make timely decisions, reduce chances of any adverse side effects of drugs, and educate and motivate patients to make lifestyle modifications for improving their health conditions.
- **Need to minimize dependence on lab testing**—Point-of-care tests provide critical information at the point of healthcare delivery, thus enabling timely diagnoses and treatment commencement by the medical care personnel, which in turn results in improved patient compliance with physicians' recommendations.

Table 1. Different types of coronavirus tests, 2020

	Molecular test	Antigen test	Antibody test
How it works	Detects the virus's genetic material	Detects specific proteins from the virus	Looks for antibodies that are made by the immune system in response to a threat
How the sample is taken	Nasopharyngeal (the part of the throat behind the nose), nasal or throat swab, saliva	Nasal or nasal pharyngeal swab	Finger stick or blood draw
What it shows	Diagnoses active coronavirus infection	Diagnoses active coronavirus infection	Shows if you've been infected by coronavirus in the past
What it can't do	Shows if you ever had COVID-19 or were infected with the virus that causes COVID-19 in the past	Antigen tests are more likely to miss an active COVID-19 infection compared to molecular tests. A healthcare provider may order a molecular test if an antigen test shows a negative result, but the person has symptoms of COVID-19.	Diagnose COVID-19 at the time or show that you do not have COVID-19.

Challenges affecting the global IVD market include

- **Declining reimbursement for IVDs in Europe**—In European countries such as Germany and the U.K., reimbursements were significantly reduced for tests such as glucose monitoring, hampering the growth of the point-of-care test segment. Similar trends in the U.S., such as Medicare cuts, were introduced, which may negatively affect the growth of certain IVDs.
- **U.S. medical device tax reduces profits for manufacturers**—In 2013, the U.S. government mandated a 2.3% excise tax on the sales revenues of medical devices. This tax put a significant burden on companies, especially those that are in early stages and are yet to begin a positive cash flow.
- **Stringent regulatory framework**—Since the beginning of 2005, the U.S. Food and Drug Administration's process of reviewing and approving medical devices became lengthy and difficult, delaying the commercial launch of new and innovative products to the market.
- **High R&D and marketing costs**—High research & development and marketing costs may result in an increase in partnerships and acquisitions to cut expenditures and enhance productivity. The number of mergers and acquisitions since the early 2000s has increased, and since 2010, the trend intensified.

Because of its large population and position as a medical technology innovation hub, North America is the global leader in terms of IVD use, accounting for roughly 42.0% of the total market in 2020. The emerging markets of India, China, Russia, and Brazil are poised to grow at double-digit growth rates due to rising incomes, growing healthcare budgets, and heightened health awareness among the population.

About the author

Jon Evans has been involved in business development and research for the medical industry since 1984. For more information, please contact Dr. Helia Jalili, director of advanced materials, at Helia.Jalili@bccresearch.com.

Resource

J. Evans, "In vitro diagnostics: Technologies and global markets" BCC Research Report HLC186C, May 2021. https://bit.ly/2X7OrOk.

By Lisa McDonald

Into the Bulletin Archives—A look back at our 100 years in print

Since May 1922, the *ACerS Bulletin* has served the ACerS community, providing them updates on member news, Division meetings, and the latest research in ceramics and glass.

In celebration of Volume 100 this year, the *Bulletin* editorial team is running a special column in each issue of the 2021 *Bulletin* that looks at the history of the *Bulletin* by decade. This issue highlights the 1990s.

We hope you enjoy following the journey of the *Bulletin* from its early years to today. As an ACerS member, you have access to all 100 years of the *Bulletin* on the *Bulletin Archive Online* at https://bulletin-archive.ceramics.org. 100

Into the Bulletin Archives—1990s

In November 1991, the "President's Letter" by Dennis W. Readey set the tone for following ones in the early 1990s when he announced the completion of a strategic planning exercise, the results of which would be used to chart the Society's course in the future.

The redesign of the *Bulletin* in July 1992 was one of the first visible changes of the strategy. Changes mainly involved the addition of several new sections, including

- An expanded Manufacturing section, which contained the previous "Manufacturing Focus" department (renamed "Manufacturing Briefs") plus products and processes.
- An "Environmental Update" department, to cover news in this area of interest to ceramic manufacturers.
- An Engineering section, to be managed by the National Institute of Ceramic Engineers.
- A Technology of Interest section, which contained the previous "Technology Update" department (renamed "Technology Briefs") as well as Material Innovations.

The establishment of a Ceramic Information Center (CIC) at the Society headquarters was another notable result of the strategy. As explained in the January 1993 issue, the "innovative" center offered a range of services for those requesting ceramic-related information.

> "We can perform all or any part of an information search and retrieval. The value of our service lies in our intimate knowledge of ceramic materials and applications. This knowledge produces information searches which are relevant, focused, accurate, cost efficient, and fast."
> –Chris Schnitzer, manager of CIC
>
> –*ACerS Bulletin, Vol. 72., Iss. 1., January 1993 (p. 105)*

In 1998, the Society witnessed an important milestone when it held its 100th Annual Meeting with the theme "A Century of Ceramics." The January 1998 issue contains details about the meeting, which took place that May, and a timeline of the Society. The issue also announced the publication of a coffee-table

Credit: ACerS Bulletin (March 1996) Vol. 75 Iss. 3, p. 31

Carol M. Jantzen became the first female president of the Society when she was sworn into office during the 98th Annual Meeting in April 1996. At the time, Jantzen was a senior fellow scientist in the Glass Technology Group at Westinghouse Savannah River Co., and a member of ACerS Nuclear & Environmental Technology, Basic Science, and Glass & Optical Materials Divisions.

First Subsidiary Approved

Acting on recent changes in the ACerS Constitution that allow the establishment of subsidiaries, the Board of Trustees approved the creation of the American Ceramic Industry Association (ACIA) when it met in August 1995.

The concept for ACIA evolved from ACerS' long-range strategic planning effort to meet more effectively the needs of the hundreds of private corporations that are part of ACerS. It is a 501(c)6 trade association.

ACIA's purpose is to develop policies and communicate with Congress, the Executive Branch and other key policy makers on ways to support the growth and enhance the competitiveness of all sectors of ceramics in the United States. Providing policy makers in Washington with a broad-based voice for our industry, ACIA will serve as a cost-effective forum and clearinghouse for addressing the legislative and regulatory issues that impact ceramics.

Credit: *ACerS Bulletin* (October 1995) Vol. 74 Iss. 10, p. 7

The Society approved its first subsidiary, the American Ceramic Industry Association (ACIA), in 1995. The October "President's Letter" by Delbert E. Day explains ACIA evolved from the long-range strategic planning effort launched earlier in the decade.

1990s

DIVISIONS OF THE SOCIETY

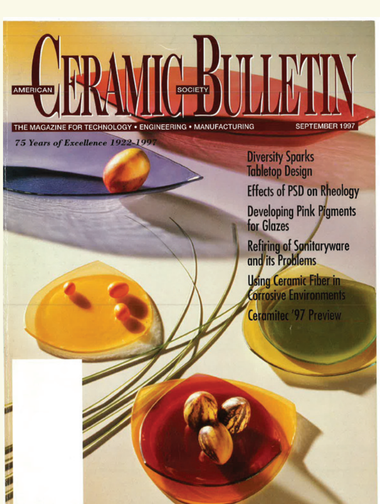
During the 1990s, the Society had 11 Divisions.

- Basic Science
- Cements
- Design
- Electronics
- Engineering Ceramics
- Glass & Optical Materials (previously Glass)
- Materials & Equipment
- Nuclear & Environmental Technology (previously Nuclear)
- Refractory Ceramics (previously Refractories)
- Structural Clay Products
- Whitewares

book called "American Ceramic Society: 100 Years" that was designed to celebrate "not only the history of the Society itself, but the history of ceramics in America." Copies of the book are still available for purchase through various online booksellers.

The Society changed the name of two Divisions during the 1990s. The Glass Division became the Glass & Optical Materials Division, with the new name first being used in the June 1990 issue. However, it took until 1994 for the Division to be consistently called by its new name. The Nuclear Division became the Nuclear & Environmental Technology Division in 1994.

One other Division name change—Refractories to Refractory Ceramics—occurred at the very end of the 1980s. The change was proposed because "major changes in the business climate of the refractories industry and its customers ... threaten to make the old practices less effective," the July 1988 issue explains. The change reflects the Division's expanded interest to include other high-temperature ceramics that "are at present not usually recognized as refractories." The change took place in 1989.



Credit: *ACerS Bulletin* (September 1997) Vol. 66 Iss. 1, p. 7

The *ACerS Bulletin* made its online debut with the September 1997 issue.

SOCIETY DIVISION SECTION CHAPTER NEWS

FOR MORE INFORMATION:

ceramics.org

Welcome new ACerS Corporate Partner

ACerS is pleased to welcome its newest Corporate Partner:

– **Free Form Fibers**

To learn about the benefits of ACerS Corporate Partnership, contact Kevin Thompson, membership director, at (614) 794-5894 or kthompson@ceramics.org.

Spain Chapter to participate in the SECV-Zero Emissions

The ACerS Spain Chapter will participate in the SECV-Zero Emissions Conference on **Oct. 4 and 5, 2021**. This hybrid event will offer an overview of promising technologies in the generation, storage, and distribution of renewable hydrogen, and the sources of financing for its industrialization. For more information, visit https://secv.es/emisiones0.

Spain Chapter to host event on sustainability in the ceramic sector

The ACerS Spain Chapter will co-sponsor an in-person event on sustainability in the ceramic sector on **Nov. 4, 2021**. Topics will include circular economy, industrial symbiosis, and hypocarbonic industry. Visit https://ceramics.org/spain-chapter for a complete schedule.

Colorado Section participates in Colorado Center for Advanced Ceramics Student Conference

The ACerS Colorado Section participated in the Colorado Center for Advanced Ceramics 2021 Student Conference on Aug. 17–18, 2021. The section hosted a booth in the exhibit hall where participants could review the CGIF's Materials and Mini Materials Science Classroom Kits.

Visit https://ceramics.mines.edu/annual-conference for more information about the conference.

Dayton/Cincinnati/Northern Kentucky hosts Virtual Ceramic Trivia and Cocktail Hour

The Dayton/Cincinnati/Northern Kentucky Section and members from all Ohio sections enjoyed a virtual Ceramic Trivia and Cocktail Hour on Wednesday, July 14. Fellow Ohioans and ceramists joined together for virtual fun, tested their ceramic knowledge, and networked with fellow Buckeyes. Trivia topics included ceramic knowledge, ACerS questions, and Ohio fun facts.

St. Louis Section welcomes new leaders

Welcome to the new leaders in the St. Louis Section:

Chair: **Zach Hall**, AluChem of Little Rock

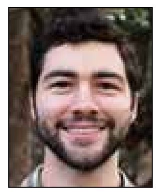
Vice Chair: **Ed Reeves**, Special Shapes Refractory Company

Treasurer: **Patty Smith**, Missouri University of Science and Technology

Secretary: **Rebecca Straw**, Mo-Sci Corporation

Washington, D.C./Maryland/Northern Virginia Section awards MS&T scholarships

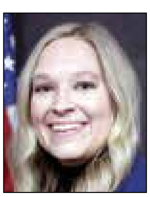

Luckhardt


Ridley

The Washington, D.C./Maryland/Northern Virginia section awarded MS&T Conference registration to two University of Virginia Ph.D. students, Clark Luckhardt and Mackenzie Ridley.

Volunteer spotlight

ACerS Volunteer Spotlight profiles a member who demonstrates outstanding service to the Society.


Hilmas

Ashley Hilmas is materials research engineer in the Composites Performance Branch at the Air Force Research Lab in Dayton, Ohio. She received her bachelor's degree in ceramic engineering from Missouri University of Science and Technology in 2015 and her master's and Ph.D. from the University of Michigan in May 2020.

Hilmas has been involved with ACerS for the last 10 years. While at Missouri S&T, she served as treasurer and president of the local Material Advantage chapter. As a graduate student, she served as finance chair and chair of the ACerS President's Council of Student Advisors.

She is currently a co-chair of the ACerS Education and Professional Development Council, which focuses on the advancement of education and professional development opportunities in the Society. She is also secretary of the Dayton/Cincinnati/Northern Kentucky Section of ACerS.

We extend our deep appreciation to Hilmas for her service to our Society!

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ACerS leaders for 2021–2022

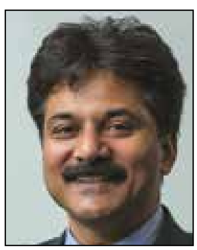
ACerS is pleased to introduce the 2021–2022 Society leadership. New officers and directors will be installed at the 123rd Annual Business Meeting on Oct. 18, 2021, at MS&T21 in Columbus, Ohio.

Society officers and directors

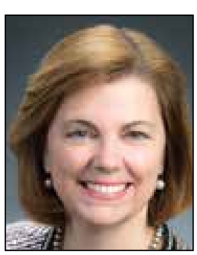
Executive Committee


Dickey

President
Elizabeth Dickey
Teddy & Wilton Hawkins Distinguished Professor
Head of the Department of Materials Science and Engineering
Carnegie Mellon University
Pittsburgh, Pa.


Mathur

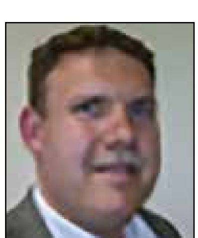
President-elect
Sanjay Mathur
Director and chair
Institute of Inorganic Chemistry
University of Cologne
Cologne, Germany


Goski

Past president
Dana Goski
Vice president of research and development
Allied Mineral Products Inc.
Columbus, Ohio


Houseman

Treasurer
Stephen Houseman
President
Harrop Industries Inc.
Columbus, Ohio


Tipsord

Treasurer-elect
Daniel Tipsord
General manager
Skyworks RF Ceramics/ Trans-Tech, Inc.
Middletown, Md.


Mecklenborg

Secretary
Mark Mecklenborg
Executive director
The American Ceramic Society
Westerville, Ohio

Board of Directors (new)


Breder

Kristin Breder
Senior principal scientist
Saint-Gobain Research North America
Northborough, Mass.

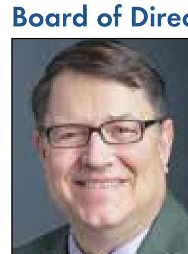

Graeve

Olivia Graeve
Professor in the Department of Mechanical and Aerospace Engineering
Director of the CaliBaja Center for Resilient Materials and Systems
University of California, San Diego
San Diego, Calif.


Jiang

Shibin Jiang
President and CEO
AdValue Photonics Inc.
Tucson, Ariz.

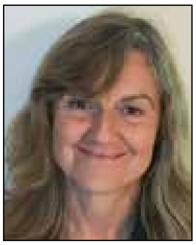
Board of Directors (returning)


Butt

Darryl Butt
Dean of the College of Mines and Earth Sciences
Director of the Energy Frontiers Research Center, MUSE
University of Utah
Salt Lake City, Utah

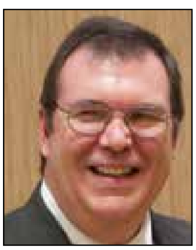
Chan

Helen Chan
New Jersey Zinc Professor
Lehigh University
Bethlehem, Pa.



Ferraris

Monica Ferraris
Full professor of science and technology of materials
Politecnico di Torino
Turin, Italy



Headrick

William Headrick
Head of R&D Alumina Silica – Americas
RHI Magnesita
Pevely, Mo.

Hemmer

Eva Hemmer
Assistant professor
University of Ottawa
Ottawa, Ontario,
Canada

Naito

Makio Naito
Professor
Joining and Welding Research Institute,
Osaka University
Osaka, Japan

Freiman

Parliamentarian
Stephen Freiman
Freiman Consulting Inc.
Potomac, Md.

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Free to ACerS members

Frontiers of Ceramics & Glass Webinar Series

OCTOBER 11, 2021
2-3 P.M. EASTERN U.S. TIME

Title: *Evaluating the Effect of Porosity and Mineralogy on Thermal Properties of Brick*

PRESENTER:
NATHANIEL C HUYGEN – Clemson University

Hosted by: Structural Clay Products Division

Professional Skills and Personal Development Webinar Series

SEPTEMBER 28, 2021 | 11 A.M. PT

Diversity and Inclusion Webinar

PANELISTS:

DR. KEITH BOWMAN	DR. KRISTIN BREDER
VICE CHANCELLOR RENETTA TULL	DR. DANA GOSKI
DR. KRISTEN BROSNAN	DR. BETH DICKEY

Hosted by Northern California Section

OCTOBER 12, 2021 | 5 P.M. EDT

Finding Your Community MODERATOR: DR. RAFAEL JARAMILLO – MIT

PANELISTS:
DR. PAUL EVANS – University of Wisconsin
DR. JESSICA RIMSZA – Sandia National Laboratories
DR. KRISTA CARLSON – University of Nevada, Reno
Hosted by ACerS Young Professionals Network (YPN)

AWARDS AND DEADLINES

Nomination Deadline: Jan. 15, 2022
Society awards will be presented at the Annual Awards Banquet in October 2022.

Contact: Erica Zimmerman | ezimmerman@ceramics.org | 614.794.5821

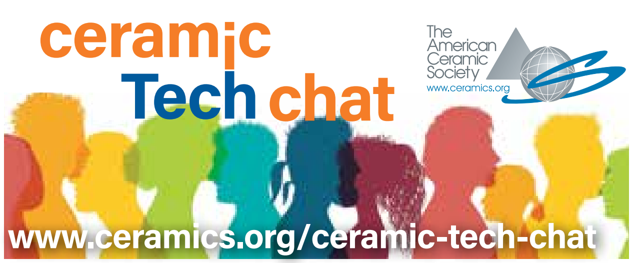
Society Awards	Description
Distinguished Life Membership	ACerS highest honor given in recognition of a member's contribution to the ceramics profession. Nominees need to be current members who have attained professional eminence because of their achievements in the ceramic arts or sciences, service to the Society, or productive scholarship.
W. David Kingery Award	Recognizes distinguished lifelong achievements involving multidisciplinary and global contributions to ceramic technology, science, education, and art.
John Jeppson Award	Recognizes distinguished scientific, technical, or engineering achievements in ceramics.
Greaves-Walker Lifetime Service Award	Presented to an individual who has rendered outstanding service to the ceramic engineering profession and who has exemplified the aims, ideals, and purpose of EPDC.
The European Ceramic Society-American Ceramic Society Joint Award	Recognizes individuals who foster international cooperation between The American Ceramic Society and the European Ceramic Society, in demonstration of both organizations' commitment to work together to better serve the international ceramics community.

Ceramic Tech Chat: Adelle Schade

Hosted by ACerS Bulletin editors, Ceramic Tech Chat talks with ACerS members to learn about their unique and personal stories of how they found their way to careers in ceramics. New episodes publish the second Wednesday of each month.

In the August episode of Ceramic Tech Chat, Adelle Schade, director of the Science Research Institute at Albright College, describes the importance of experiential learning in science education, her journey to founding SRI, some of the student successes from the program so far, and the valuable contributions of the late Ted Day to the program.

Listen to Schade's whole interview—and all of our other Ceramic Tech Chat episodes—at http://ceramictechchat.ceramics.org/974767. 100



Society Awards	Description
The Rishi Raj Medal for Innovation and Commercialization Award	Recognizes one individual whose innovation lies at the cusp of commercialization in a field related, at least in part, to ceramics and glass.
Medal for Leadership in the Advancement of Ceramic Technology	Recognizes individuals, who through leadership and vision in an executive role, have made significant contributions to the success of their organization and in turn have significantly expanded the frontiers of the ceramics industry.
Corporate Environmental Achievement Award	Recognizes an outstanding environmental achievement made by an ACerS corporate member in the field of ceramics.
Corporate Technical Achievement Award	Recognizes an outstanding technical achievement made by an ACerS corporate member in the field of ceramics.
Richard M. Fulrath Awards	Promote technical and personal friendships between Japanese and American ceramic engineers and scientists. The awards recognize individuals for excellence in research and development of ceramic sciences and materials. Nominees must be 45 or younger at the time of award presentation.

more AWARDS AND DEADLINES

Society Awards	Description
Karl Schwartzwalder-Professional Achievement in Ceramic Engineering Award	Recognizes an outstanding young ceramic engineer whose achievements have been significant to the profession. A nominee must be between 21 and 40 years of age, and must be a member of EPDC and ACerS.
Robert L. Coble Award for Young Scholars	Recognizes an outstanding scientist who is conducting research in academia, in industry or at a government laboratory. Candidates must be an ACerS member and must be 35 years old or younger.
Du-Co Ceramics Young Professional Award	Awarded to a young professional member of ACerS who demonstrates exceptional leadership and service to ACerS.
Frontiers of Science and Society - Rustum Roy Lecture	Given each year by a nationally or internationally recognized individual in the area of science, industry, or government. Generally the committee selects the lecturer, but suggestions from membership are invited.
Edward Orton, Jr. Memorial Lecturer	Selection is based on scholarly attainments in ceramics or a related field. Generally the committee selects the lecturer, but suggestions from membership are invited.
Arthur L. Friedberg Ceramic Engineering Tutorial and Lecture	Given to an individual who has made outstanding contributions to ceramic engineering that relate to the processing or manufacturing of ceramic products. The awardee must be a member of EPDC and ACerS.
Robert B. Sosman Award	Awarded by the Basic Science Division in recognition of outstanding achievement in basic science that results in a significant impact to the field of ceramics.
John E. Marquis Memorial Award	Given by ACerS Manufacturing Division to the author(s) of the paper on research, engineering, or plant practices relating to manufacturing in ceramics and glass published in the prior calendar year in a publication of the Society, which is judged to be of greatest value to the members and to the industry.
The Navrotsky Award for Experimental Thermodynamics of Solids	Awarded biennially to an author who made the most innovative contribution to experimental thermodynamics of solids technical literature during the two calendar years prior to selection.
Ross Coffin Purdy Award	Given to the author(s) who made the most valuable contribution to ceramic technical literature during the calendar year two years prior to the year of selection. The 2022 Purdy award is for the best paper published in 2020.
Richard and Patricia Spriggs Phase Equilibria Award	Given to the author(s) who made the most valuable contribution to phase stability relationships in ceramic-based systems literature during the previous calendar year (2021).
Education and Professional Development Council Outstanding Educator Award	Recognizes outstanding work and creativity in teaching, in directing student research, or in the general educational process (e.g., lectures, publications) of ceramic educators.
Morgan Medal and Global Distinguished Doctoral Dissertation Award	Recognizes a distinguished doctoral dissertation in the ceramics and glass discipline.
The Anna O. Shepard Award	Presented by ACerS Art, Archaeology & Conservation Science Division to an individual(s), this award recognizes outstanding contributions to materials science applied to art, archaeology, architecture, or cultural heritage.

2021 Division awardees

Bioceramics Division

Tadashi Kokubo Award
Steven Jung—Mo-Sci Corporation

The Larry L. Hench Lifetime Achievement Award
Bill Bonfield—Cambridge University

Young Scholar Award
Francesca Tallia—Imperial College London

Global Young Bioceramist Award
Fei Zhang—Katholieke Universiteit Leuven

Cements Division

Brunauer Award
Best paper: "Dissolution kinetics of calcined kaolinite andmont-morillonite in alkaline conditions: Evidence for reactive Al(V) sites," *Journal of the American Ceramic Society*, 2019;102:7720–7734; **Nishant Garg** and **Jorgen Skibsted**

2021 Virtual Student Poster Awards
First: **Karthik Pattaje**, University of Illinois at Urbana-Champaign
Effect of vibration on rheology of concrete for 3D printing

Second: **Aparna Lobo**, University of Colorado Boulder
Can a bioinspired mimic of antifreeze proteins inhibit freeze-thaw damage in cement paste?

Third: **Caitlin Adams**, Purdue University
Effects on flow and strength of mix design adjustments for mortar internally cured with superabsorbent polymers

Electronics Division

Edward C. Henry Award
Best paper: "Crystal structure and enhanced microwave dielectric properties of Ta^{5+} substituted $Li_3Mg_2NbO_6$ ceramics", *Journal of the American Ceramic Society*, 2020; 103:214–223; **Gang Wang, Dainan Zhang, Xin Huang, Yiheng Rao, Yan Yang, Gongwen Gan, Yuanming Lai, Fang Xu, Jie Li, Yulong Liao, Cheng Liu, Lichuan Jin, Vincent G. Harris, Huaiwu Zhang**

Lewis C. Hoffman Scholarship
Hugh Smith—Case Western Reserve University

Glass & Optical Materials Division

Norbert J. Kreidl Award
Collin Wilkinson—Coe College

IN MEMORIAM

Robert "Bob" Ruh

Some detailed obituaries can also be found on the ACerS website, www.ceramics.org/in-memoriam.

CERAMICANDGLASSINDUSTRY FOUNDATION

ACerS members help fund new materials science camp

Casey Schwarz, ACerS member and assistant professor at Ursinus College, launched the new GaMES (Glass and Materials Science to Engage Students) camp with the help of her community and funded by ACerS members through The Ceramic and Glass Industry Foundation.

GaMES was designed around the topics and activities from CGIF's Materials Science Classroom Kit. The week-long intensive camp successfully engaged middle and high school students targeting underrepresented STEM populations. Throughout the camp, the students learned the basic classes of materials with a special emphasis on ceramic and glass materials.

The camp was a big success! All the GaMES students showed increased knowledge of STEM topics and increased interest in pursuing a STEM career.

Schwarz and her colleagues will publish the results of the GaMES camp so others may learn about their model for teaching middle and high school students about materials science in an intensive camp setting.

If you would like to use CGIF's Materials Science Kits to perform outreach, contact program coordinator Amanda Engen at aengen@ceramics.org or visit http://teachmaterialscience.org to find out more.

You can support the CGIF's efforts to introduce more students to ceramic and glass materials science by donating at https://myacers.ceramics.org/donate.

Borate-based bioactive glass improves treatment of diabetic foot ulcers

In a recent open-access article, researchers looked to further investigate the potential of a borate-based bioactive glass to treat chronic diabetic foot ulcers.

Foot ulcers are a common complication of diabetes that can lead to hospitalization if an infection in the open wound occurs. When that happens, treatment typically involves removing pressure from the wound, removing dead skin and tissue, and wrapping the wound in specialized dressings that are designed to help the skin heal.

In the case of chronic foot ulcers that do not respond to treatment, patients sometimes must undergo amputation to stop the infection from spreading. To prevent this outcome, researchers are actively investigating new treatment options for diabetic foot ulcers to improve healing rates.

Bioactive glass is one material with potential for treating chronic diabetic foot ulcers. Researchers have traditionally explored the use of these biomaterials to develop scaffolds for tissue engineering, but more research on using bioactive glass to treat and/or heal wounds is taking place as well.

Borate-based bioactive glasses are a recent addition to the field of healing acute and chronic wounds. While the first clearance by the U.S. Food and Drug Administration (FDA) of a bioactive glass for medical treatment was in 1985, it was not until 2016 that a wound care product containing borate-based bioactive glass (13-93B3) received regulatory approval.

In 2017, the FDA cleared a new borate-based bioactive glass fiber called MIRRAGEN Advanced Wound Matrix. ACerS Fellow Steve Jung and Distinguished Life Member Delbert Day initially developed the material at the Missouri University of Science and Technology when Jung was a graduate student. After Jung graduated and went to work at bioactive glass manufacturer Mo-Sci, he and the late Ted Day, former CEO of Mo-Sci, developed the material to commercial readiness. Now, ETS Wound Care, a Mo-Sci spin-off company, distributes MIRRAGEN nationwide.

In 2019, plastic and reconstructive surgeon Donald W. Buck, a consultant for ETS Wound Care, used MIRRAGEN in a case study to treat diabetic foot ulcers. The patients in the study had failed to heal after multiple previous advanced therapeutics and surgeries.

In only 6–10 weeks, the wounds treated using MIRRAGEN healed. However, as the patients in the study numbered only three, "this unique material required further investigation with level one evidence to illustrate its effectiveness in hard-to-heal wounds," researchers of the new open-access paper write.

The researchers, who received funding through a research grant from ETS Wound Care, designed their study as a parallel, two-group, single-blind randomized controlled trial, in which patients received either current standard-of-care treatment (collagen alginate dressing) plus MIRRAGEN or standard-of-care treatment alone. If multiple diabetic foot ulcers were eligible for treatment, "the largest wound was selected provided it met area requirements (the index wound)," they write.

Image of the borate-based bioactive glass fiber MIRRAGEN Advanced Wound Matrix that researchers used to treat diabetic foot ulcers.

After 12 weeks, the researchers inspected the wounds and determined that 70% of the MIRRAGEN-treated wounds healed compared with 25% treated with standard-of-care alone. In addition, the mean percent area reduction for the MIRRAGEN-treated wounds was 79%, compared to 37% in the standard-of-care group.

While the researchers celebrated these successes, they also noted several limitations of the study, including lack of investigator blinding (it was not possible to create a sham product), as well as the need to withdraw subjects at six weeks if wounds were not sufficiently responding to treatment so that subjects could be offered an alternative and safer treatment pathway.

"Future trials should consider a larger more robust number of patients and include more complex wounds including ulcers down to tendon, capsule, and bone to determine if [boron-based bioactive glass] can be beneficial in helping these kinds of wounds heal," they conclude.

The open-access paper, published in *International Wound Journal*, is "A multi-centre, single-blinded randomised controlled clinical trial evaluating the effect of resorbable glass fibre matrix in the treatment of diabetic foot ulcers" (DOI: 10.1111/iwj.13675).

Africa—A wealth of resources and aspirations

The South African National Space Agency (SANSA), established in 2010, coordinates South Africa's involvement with space research and activities through four program areas: Earth Observation, Space Engineering, Space Operations, and Space Science. Pictured is one of the full-motion telemetry, tracking, and command antennas that SANSA Space Operations manages and maintains at the Hartebeesthoek Radio Astronomy Observatory.

By Alex Talavera and Randy B. Hecht

Africa sees its future in technological advance—and actively seeks global partners to help achieve its research and economic development potential.

Africa is home to 1.38 billion people, more than one-seventh of the world's population. From a foreign trade perspective, it is an enormous market—one whose potential large global economies are beginning to fully appreciate.

For example, in the United States, the U.S. Chamber of Commerce urged the Biden Administration to "make Africa engagement a presidential priority…[and] enhance the competitiveness of U.S. business in Africa." The organization endorses free trade agreement negotiations with Kenya and "capacity building to support a trade agenda in the African Continental Free Trade Area."[1]

Africa has long been mined for its raw materials.[2] The African continent, for example, is the preeminent source of critical materials such as nickel, cobalt, and rare-earth mineral ores and gold. Other valuable ores found in Africa include bauxite, iron ore, and uranium ore. But as international research and development collaborations demonstrate, Africa can be more than a node on the supply chain or a target for increased export activity.

R&D, with emphasis on development

France's National Centre for Scientific Research (CNRS) is collaborating with researchers in South Africa on INFINITE-CELL,[3] a project focused on developing next-generation solar cells. According to its website, the project "proposes extending the very high efficiency tandem device concepts to emerging thin film PV technologies with high potential for reduction of costs and avoiding the use of critical raw materials." The goal is to bring to market "cost-efficient photovoltaic tandem devices based in the combination of wide band-gap kesterite absorbers as top cell, and low-cost c-Si [crystalline silicon] thin film as bottom cell"—and its performance targets include "using only fully sustainable materials and processes."

Throughout Africa, researchers are working on strategies for converting agricultural waste from an ecological problem to a sustainable materials solution.

In Madagascar, the French National Research Institute for Sustainable Development hopes to use a “large supply of organic materials and waste, coming mainly from the fruit industry.” Its initiative for identifying and recycling agro-industrial waste and biomolecules seeks to address the challenge that “Madagascar does not have a developed chemical industry and it imports most of its drugs but also a large number of compounds and active ingredients in special chemicals (surfactants, cosmetics, paints, pesticides, dyes, polymers, etc.).”[4]

CNRS issues rolling calls for proposals[5] to support “development of long-term scientific partnerships with African institutions” and has worked with academic institutions worldwide (including the University of Chicago and the University of Arizona) on Ph.D. joint programs.

China is also prominent among international actors seeking to tap Africa’s research potential. In September 2019, the Chinese Academy of Sciences signed a memorandum of understanding with the African Academy of Sciences in Nairobi to promote “collaborative research, skills development, and technology transfer.”[6]

The Academy’s Sino-Africa Joint Research Center is collaborating in Kenya on an effort to address the increasing use of treated and untreated wastewater for irrigation in farming as freshwater resources dwindle.[7] The wastewater is often polluted with heavy metals that build up over time in soil and plants and may reach toxic levels.

U.S. interest in the region is not exclusively economic. The U.S. Geological Survey’s international programs in Africa include mitigating carbon dioxide buildup in Cameroon’s Lake Nyos; conducting geochemical mapping in Morocco; and, in partnership with the Department of State and the Geothermal Energy Association, developing Africa’s geothermal energy resources.[8]

Developing foreign trade and homegrown talent

Kenya, which is in the early stages of negotiating a Free Trade Agreement with the U.S., launched Vision 2030 “to transform Kenya into a newly industrializing, middle-income country.”[9] Integral to this initiative is its Nano-Sciences, Material Science and New Production Technologies Programme,[10] which calls for the establishment of the Kenya Institute of Technology and the National Physical Science Research Laboratory for Engineering and New Production Technologies.

Similarly, Nigeria’s Federal Ministry of Science and Technology seeks to integrate science, technology and innovation within the country’s socioeconomic development efforts through advocacy, capacity building and commercialization of R&D outcomes.[11] Its National Board for Technology Incubation operates 27 incubation centers located throughout Nigeria,[12] while the Nigerian Institute for Science Laboratory Technology seeks to provide researchers with a “bridge between the laboratory and the economy.”

Most of these are early-stage initiatives that will need bilateral cooperation in know-how, market access, and basics such as equipment and supplies to come to fruition. We spoke with ceramic innovators to get their insights on where the sector stands in Africa today—and how they see its future on this continent. Their interviews appear on the following pages.

Acknowledgements

We thank Sossina Haile, Walter P. Murphy Professor of Materials Science and Engineering at Northwestern University, for her help in connecting us to knowledgeable sources for this article.

Learn more about Haile in the September episode of Ceramic Tech Chat at https://ceramictechchat.ceramics.org.

References

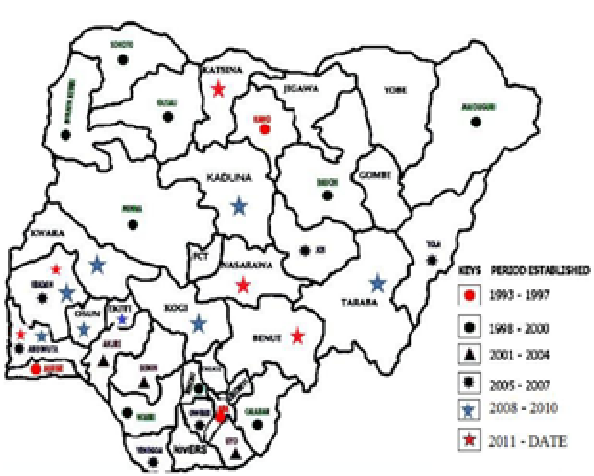
[1]U.S. Chamber of Commerce, “Policy recommendations for the new U.S. Administration: Africa.” February 25, 2021. Accessed August 2021. https://www.uschamber.com/report/policy-recommendations-the-new-us-administration-africa

[2]Mining Africa, “Natural resources in Africa.” Accessed August 2021. https://miningafrica.net/natural-resources-in-africa

[3]Project: INFINITE-CELL—Development of next-generation solar cells, November 2017–October 2021, South Africa. Accessed August 2021. https://en.ird.fr/project-infinite-cell-development-next-generation-solar-cells

[4]Project: Identification and recycling of agro-industrial waste and biomolecules in Madagascar, International Joint Research Project (PICS) 2019–2021. Accessed August 2021. https://en.ird.fr/project-identification-and-recycling-agro-industrial-waste-and-biomolecules-madagascar

[5]CNRS Calls for proposals. Accessed August 2021. https://international.cnrs.fr/en/campagne-cnrs



A 2013 map of incubation centers operated by the National Board for Technology Incubation. At that time, the Board operated 29 incubation centers; they currently operate 27.

Example of terraced agricultural land in Madagascar.

[6]"Chinese, African science academies ink deal to strengthen collaboration," September 3, 2019. Accessed August 2021. http://english.cas.cn/newsroom/news/201909/t20190903_216187.shtml

[7]"SAJOREC assesses remediation efficiency of heavy metals and health risk assessment in Kenya," January 19, 2019. Accessed August 2021. http://www.sinafrica.cas.cn/English/Research/Research/201902/t20190220_475955.html

[8]United States Geological Survey, "International Programs: Africa." Accessed August 2021. https://www.usgs.gov/about/organization/science-support/international-programs/africa

[9]Kenya Vision 2030. Accessed August 2021. https://vision2030.go.ke

[10]Kenya Vision 2030, "Nano-Sciences, Material Science and New Production Technologies Programme." Accessed August 2021. https://vision2030.go.ke/project/establishment-of-kenya-institute-of-nanotechnology-kion

[11]Federal Ministry of Science and Technology. Accessed August 2021. https://scienceandtech.gov.ng/science-and-technology-promotion

[12]National Board for Technology Incubation, Federal Government of Nigeria. Accessed August 2021. https://nbti.gov.ng

[13]Council for Scientific and Industrial Research. Accessed August 2021. https://www.csir.co.za

[14]Cermalab Materials Testing Laboratory. Accessed August 2021. https://cermalab.co.za

ACerS International Chapters—Serving members in their local communities

Nearly 40% of ACerS members are located outside the United States. To better serve members around the world, ACerS supports the formation of International Chapters where concentrations of ACerS members reside outside the U.S.

Learn more about ACerS International Chapters at https://ceramics.org/international-chapters.

Phylis Makurunje, researcher inspired by South Africa space program


Phylis Makurunje

If you express surprise that her native South Africa has a space program that inspired a young woman to become a materials engineer working on aerospace composite materials, Phylis Makurunje does not hesitate in her response. "South Africa is one ambitious country," she says. "Ambitious in that it's serious about research and development and how it plays in the ecosystem of the economy and industry."

Her own ambitions led her to pursue a Ph.D. in materials engineering at the University of the Witwatersrand in South Africa, working with ceramics for aerospace applications. After completion, she moved to Wales to join the Nuclear Futures Institute at Bangor University as a post-doctoral research officer, where she explores how aerospace materials and nuclear energy can converge.

Although her research at Bangor has its genesis in a request from a commercial entity in the military and security industry, that company ultimately opted out of the collaboration. Makurunje continued the research in collaboration with the Council for Scientific and Industrial Research (Pretoria, South Africa),[13] which has "a department that specifically looks at commercializing aerospace materials composites efficiently."

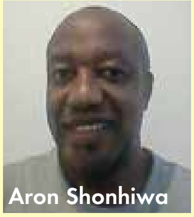
"I focus on ultrahigh-temperature ceramics that have an unusually high melting point. We're talking about above 2,000°C, but especially above 3,000°C," she says. "Few materials can withstand those temperatures without melting or even without vaporizing. So, that's the leading quality that we look for, but also related to that quality is the robustness."

Those characteristics are priorities because they help to identify which materials may be candidates for reuse in aerospace vehicles. Increasing the number of reusable materials and components furthers progress toward commercializing space travel.

That awareness of commercial potential hints at Makurunje's dual ambitions for her future work. "I see myself in an industrial kind of setting more than an academic one. I've always loved the real engineering side of things," she says. "In the academic field, you get the opportunity to really try out new things—anything that you can think of most of the time—and that is an amazing opportunity and something that I love. But I also love seeing the ideas going commercial. That's what really drives me to, at some point be in industry again."

That career shift may entail a return to South Africa. "We have a lot of new space players coming from the African continent, and already South Africa is a leading player in for a number of decades in the space arena," she says. "A lot of changes are happening. A lot of developments are happening globally from countries that were not there. That means that anything can happen, really."

Aron Shonhiwa, business development manager, Cermalab Materials Testing Laboratory


Aron Shonhiwa

Mining is the single biggest component of South Africa's GDP. With mining/metallurgical operations and refractories in such a prominent position, quality assurance for those sectors plays an important role in the country's continued development.

Cermalab Materials Testing Laboratory[14] is engaged in materials testing, improving process technology, and evaluating final products. Its focus within the sphere of ceramics is cement and concrete.

"There are a lot of refractories being used in South Africa—some made locally and some imported," says Aron Shonhiwa. "We assist our clients in testing their materials, researching new products, and ensuring that their materials are conforming to the required standards and specifications."

One of the challenges the company faces is a shortage of professionals in ceramics. "Not many colleges or universities around us offer ceramics as a discipline," Shonhiwa says. "Companies like ours have been sourcing some young professionals with chemical, metallurgical, materials science, or engineering training, and then we groom them. At the end of the day, it's a question of training them into the real testing of ceramics." Cermalab's affiliated Institute of Ceramic Education offers a 16-week brick-making course and a three-day quality control course.

Some of South Africa's refractories are subsidiaries of companies based abroad. Although that sets the stage for Cermalab to engage in cross-border collaboration, those opportunities go untapped when the companies send samples overseas for testing.

"This is both time consuming and a financial constraint," Shonhiwa says. "It would be ideal if we collaborate with the mother company overseas, so that we do the product development in testing for their subsidiaries in Africa, instead of shipping raw materials all the way to Europe or America."

He notes that Cermalab's equipment conforms to global standards and that the company conducts most of its tests in accordance with ASTM and European standards. With that in mind, he sees the company as offering companies in the U.S. and Europe a locally based resource that will allow them to attain their testing and quality assurance standards without having to set up a testing facility on the continent.

The company uses proficiency testing to promote that strategy. "You compare results and do statistical analysis to see if there is any discrepancy. That is the only way you can be in a position to say there's no compromising quality if the testing is done in Africa or in the States," Shonhiwa says. "There won't be any compromise as far as procedures are concerned."

See Cermalab's accreditations page for further details, https://cermalab.co.za/Pages/Accreditation.asp.

Oluwagbenga Johnson, mechanical and metallurgical engineering professor, School of Engineering and the Built Environment, The University of Namibia

While challenges such as agricultural waste may be more acute in Africa, these issues transcend borders and require a global perspective. “We can see the local problems. We can adapt science and technology to help our people,” says Oluwagbenga Johnson. But equipment and facility limitations constrain his research capacity, so he has looked abroad for collaboration support.

“I see what they present, and I see what I’m presenting,” he says of his experiences at conferences in Europe. “It’s not that we can’t reach that height that they have. But unfortunately, we don’t have those capacities in terms of equipment.” He believes that multilateral collaboration would make better use of Africa’s mineral wealth, provide a better job market within engineering, and secure the continent’s future.

Johnson is no stranger to working across borders. Born in Nigeria, he earned his M.S. and Ph.D. in South Africa and now works in Namibia. One area of focus in his ceramic material research is cutting tools applications, and he believes his team was among the first in the world to conduct extensive research for this purpose into boron suboxide (B_6O).

“We were basically looking at improving some of the properties of the fracture toughness of the material,” he says. His work continues to explore “the relationship between the processes, structure, properties, and performance of these engineering materials.”

One recent area of emphasis in his work is developing engineering materials from locally sourced raw materials such as rice husks. The university’s agricultural campus operates a rice farm, and the husks presented a waste management challenge. Johnson and his colleagues developed a process for converting those husks into silicon carbide, which they then combine with aluminum to create a composite. In this way, they simultaneously reduce agricultural waste and make silicon carbide—which does not occur in nature—more economically accessible on the local market.

While the U.S. eyes Africa as an export market, Johnson notes that the continent has equally strong potential as a supplier of goods in demand. Namibia, for example, has the largest deposit of uranium oxide. “But if we produce the uranium cake, there’s nothing much we can do with it,” he says. “It has to


Oluwagbenga Johnson

go overseas.” As a result, he recognizes that moving from research to commercialization requires value-added steps that depend on cross-border partnerships.

To ensure that its students keep pace with industry developments and can contribute meaningfully to those partnerships, the university revamps its curriculum every five years, a process that it completed most recently in August. The latest enhancements focus on problem-solving and digital skills as well as the soft skills necessary to keep pace with changes in the industry and the work environment. This focus is intended to help students and next-generation professionals meet international expectations and take their place in the global market. 100

AFRICA MARKET SNAPSHOTS

A wealth of contradictions: in Africa, resource-rich countries seek an end to their economic struggles

By Alex Talavera and Randy B. Hecht

We look at six of the continent’s biggest economies and the challenges they face in converting national wealth to household prosperity

Africa is home to a formidable collection of natural assets: 30% of the world’s mineral reserves, 12% of its oil reserves, and 8% of its natural gas. Add to that 40% of the global supply of gold and as much as 90% of the world’s chromium and platinum—plus the largest reserves of cobalt, diamonds, and uranium on the planet.[a]

But while these resources could be engines of development throughout the continent, the United Nations Environment Programme notes that a “significant share of these resources” is “used unsustainably” or “lost through illegal activities,” with the result that “the stream of benefits generated from these resources is being reduced over time.” The UN agency estimates that each year, Africa loses $195 billion of its natural capital “through illicit financial flows, illegal mining, illegal logging, the illegal trade in wildlife, unregulated fishing and environmental degradation and loss.”[a]

That lost revenue reduces Africa’s investment in its own development—with consequences that further hamper its capacity for economic growth and progress. For example, the World Bank notes that in recent decades, Africa’s food import bill has more than tripled to $35 billion a year, even though “much of this imported food could be produced locally, creating much needed jobs and incomes.”[b]

The global pandemic dealt a further blow to African countries’ plans for development and economic growth. Despite that, Statista reports that for 2020, there were six countries in Africa that had a GDP in excess of US$100 billion: Nigeria, Egypt, South Africa, Algeria, Morocco, and Kenya.[c] Here, we look at market conditions in each of those countries. Note that we have eliminated GDP reporting because as throughout the planet, 2020 figures are not representative.

If your company is considering doing business with a partner in Africa, you may also find it useful to consult the U.S. Africa Business Center’s Investor Confidence Indicator for Africa. (https://www.usafricabusinesscenter.com/investor-confidence-indicator-for-africa)

Algeria: Hydrocarbon-fueled foreign commerce

Algeria’s fortunes rise and fall with hydrocarbons, which generate approximately 30% of GDP, 60% of budget revenue, and nearly 95% of export earnings, according to the CIA’s *World Factbook*. The country has the world’s tenth-largest reserves of natural gas and third-largest reserves of shale gas, ranks 16th in proven oil reserves, and is the sixth-largest gas exporter.

While oil prices were high, these assets “enabled Algeria to maintain macroeconomic stability, amass large foreign currency reserves, and maintain low external debt,” the *World Factbook* notes, but “since 2014, Algeria’s foreign exchange reserves have declined by more than half and its oil stabilization fund has decreased from about $20 billion at the end of 2013 to about $7 billion in 2017.” Since 2015, the country has instituted protectionist policies—including import restrictions—and in 2018, the government announced the indefinite suspension of 850 products.

Services account for 47.4% of GDP, followed by industry (39.3%) and agriculture (13.3%). The industrial sector is led by petroleum, natural gas, light industries, mining, electrical, petrochemicals, and food processing. The labor force of 10.8 million is employed in services (58.4%), industry (30.9%), and agriculture (10.8%).

Exports of crude and refined petroleum, natural gas, fertilizers, and ammonia generated $34.37 billion in 2017. Leading export partners include Italy, France,

AFRICA MARKET SNAPSHOTS **A wealth of contradictions (cont.)**

Spain, the United States, the United Kingdom, India, and South Korea. Imports for the year totaled $48.54 billion, led by refined petroleum, wheat, packaged medical supplied, milk, and vehicle parts. Principal import partners include China, France, Italy, Spain, Germany, and Turkey.

To learn more about this market, see the U.S. International Trade Administration's *Algeria Country Commercial Guide*,[d] the World Bank's Doing Business guide for Algeria, and resources available through the U.S.–Algeria[e] Business Council,[f] which is hosting a Green Economy Forum & Expo on Nov. 15–17, 2021, in Algiers.

Egypt: Facing economic hurdles to manufacturing progress

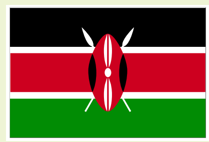
Although hydrocarbons are a factor in Egypt's finances, the country's economy is more diverse than Algeria's; drivers also include agriculture, manufacturing, tourism, and other service sectors. However, that diversity does not translate to freedom from significant economic challenges that have created manufacturing and business difficulties.

"In late 2016, persistent dollar shortages and waning aid from its Gulf allies led Cairo to turn to the IMF for a 3-year, $12 billion loan program. To secure the deal, Cairo floated its currency, introduced new taxes, and cut energy subsidies—all of which pushed inflation above 30% for most of 2017, a high that had not been seen in a generation," the CIA *World Factbook* notes. "Since the currency float, foreign investment in Egypt's high interest treasury bills has risen exponentially, boosting both dollar availability and central bank reserves. Cairo will be challenged to obtain foreign and local investment in manufacturing and other sectors without a sustained effort to implement a range of business reforms."

Services generate 54% of GDP, followed by industry (34.3%) and agriculture (11.7%). Chief industrial sectors include textiles, food processing, tourism, chemicals, pharmaceuticals, hydrocarbons, construction, cement, metals, and light manufacture. The labor force of 24.11 million is employed in services (49.1%), industry (25.1%), and agriculture (25.8%).

Egypt's 2018 export volume was $87.89 billion. Crude and refined petroleum, gold, natural gas, and fertilizers are among the chief exports, and leading export partners include the United States, United Arab Emirates, Italy, Turkey, Saudi Arabia, and India. Imports for the year were $115.34 billion. Refined and crude petroleum, wheat, cars, and packaged medicines lead import activity, and major import partners include China, Russia, the United States, Saudi Arabia, Germany, and Turkey.

To learn more about this market, see the U.S. International Trade Administration's *Egypt Country Commercial Guide*,[g] the World Bank's Doing Business guide for Egypt,[h] and resources available through the U.S.–Egypt Business Council[i] and the American Chamber of Commerce in Egypt.[j]



Kenya: High rates of GDP growth—and unemployment

In 2014, Kenya achieved a milestone: its per capita GDP rose above a World Bank threshold that earned the country for status as a lower-middle-income country. It was a qualified victory for the country the *World Factbook* dubs "the economic, financial and transport hub of East Africa."

Although the authors note that Kenya had achieved real GDP growth that averaged over 5% for a decade and that it "has a growing entrepreneurial middle class," negative indicators are equally striking. Estimates of under-employment/unemployment have been as high as 40%. Weak governance, corruption, and inadequate infrastructure are cited as obstacles to improved annual growth and capacity to "meaningfully address poverty and unemployment." The government's planned growth initiatives focus on universal healthcare, food security, affordable housing, and expansion of manufacturing.

Services generate 47.5% of GDP, followed by agriculture (34.5%) and industry (17.8%). Agriculture provides at least part-time employment to approximately 75% of Kenyans, and the *World Factbook* notes that "small-scale, rain-fed farming or livestock production" is responsible for 75% of agricultural output. Services provide employment to 32.2% of the labor force, while industry employs just 6.7%. Strongholds of the industrial sector include small-scale consumer goods (plastic, furniture, batteries, textiles, clothing, soap, cigarettes, and flour), agricultural products, horticulture, oil refining, aluminum, steel, lead, cement, commercial ship repair, tourism, and information technology.

In 2019, Kenya's export volume was $10.07 billion, led by tea, cut flowers, refined petroleum, coffee and titanium. Uganda, the United States, the Netherlands, Pakistan, the United Kingdom, United Arab Emirates and Tanzania are Kenya's biggest export partners. Import volume for the year was $18.73 billion, driven by imports of refined petroleum, cars, packaged medicines, wheat, and iron products. Leading import partners include China, United Arab Emirates, India, Saudi Arabia, and Japan.

In 2020, the U.S. and Kenya announced that they had entered into free trade negotiations. These negotiations marked the first time the U.S. had launched trade talks of this kind with a country in sub-Saharan Africa. The U.S. Chamber of Commerce published U.S.–*Kenya Trade Negotiations: Implications for the Future of the U.S.–Africa Trade Relationship* in April 2021; the report is available for free download at https://www.uschamber.com/report/us-kenya-trade-negotiations.

To learn more about this market, see the U.S. International Trade Administration's *Kenya Country Commercial Guide*,[k] the World Bank's Doing Business guide for Kenya,[l] and resources available through the American Chamber of Commerce Kenya.[m]

Morocco: Free trade champion faces poverty challenges

At its narrowest point, the Strait of Gibraltar separates Morocco from Spain by just 8 miles.[n] This geographic proximity is complemented by the nation's efforts to build a diverse, open, market-oriented economy—one that emulates those found in Europe. Investments in its port, transportation, and industrial infrastructure and development of a free trade zone near Tangier have enabled Morocco to become more competitive and "position itself as a center and broker for business throughout Africa," the CIA *World Factbook* notes. A bilateral Free Trade Agreement with the U.S. has been in force since 2006, and Morocco entered into an Advanced Status agreement with the European Union in 2008.

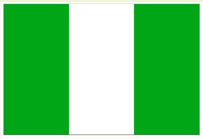
Its future development plans include expansion of its renewable energy capacity toward a goal of generating more than 50% of installed electricity from renewable sources by 2030. But alongside these sophisticated targets are more traditional and entrenched challenges—high unemployment, poverty, and illiteracy rates, which are particularly acute in rural areas—and priorities include reform of the education system and the judiciary.

Agriculture, tourism, aerospace, automotive, phosphates, textiles, apparel, and subcomponents are among Morocco's key economic sectors. Services generate 56.5% of GDP, followed by industry (29.5%) and agriculture (14%). Dominant industries include automotive parts, phosphate mining and processing, aerospace, food processing, leather goods, textiles, construction, energy, and tourism. Within the labor force of 10.4 million, services employ 40.5%, followed by agriculture (39.1%) and industry (20.3%).

In 2019, Morocco's export volume was $48.56 billion, led by cars, insulated wiring, fertilizers, phosphoric acid, clothing, and apparel; Spain and France are its key export partners. For that year, import volume was $64.12 billion. Key imports were refined petroleum, cars and vehicle parts, natural gas, coal, and low-voltage protection equipment, and leading import partners were Spain, France, China, the United States, Germany, Turkey, and Italy.

AFRICA MARKET SNAPSHOTS **A wealth of contradictions (cont.)**

To learn more about this market, see the U.S. International Trade Administration's *Morocco Country Commercial Guide*,[o] the World Bank's Doing Business guide for Morocco,[p] and resources available through the American Chamber of Commerce in Morocco.[q]



Nigeria: Strong in fundamentals—and in need for reform

Oil-rich Nigeria, the largest economy in sub-Saharan Africa, has sought to diversify its engines of economic growth since the global financial crisis of 2008–2009. However, growth in agriculture, telecommunications, and services since that time have not delivered prosperity at the household level: "over 62% of Nigeria's over 180 million people still live in extreme poverty," the CIA *World Factbook* reports.

"Despite its strong fundamentals," the authors add, "Nigeria has been hobbled by inadequate power supply, lack of infrastructure, delays in the passage of legislative reforms, an inefficient property registration system, restrictive trade policies, an inconsistent regulatory environment, a slow and ineffective judicial system, unreliable dispute resolution mechanisms, insecurity, and pervasive corruption."

Services generated 56.4% of GDP in 2017, followed nearly neck-and-neck by industry (22.5%) and agriculture (21.1%). Leading industries include crude oil, coal, tin, columbite, rubber products, wood, hides and skins, textiles, cement and other construction materials, food products, footwear, chemicals, fertilizer, printing, ceramics, and steel. The labor force numbers 60.08 million, with 70% employed in agriculture, 20% in services, and 10% in industry.

Export volume was $34.54 billion in 2020, down sharply from $62.52 billion in 2019 (which had seen a rise from $60.54 billion in 2018). Leading export commodities are crude petroleum, natural gas, scrap vessels, flexible metal tubing, and cocoa beans. Chief export partners include India, Spain, the U.S., France, and the Netherlands. The most recent data for import volume is $32.67 billion in 2017, led by refined petroleum, cars, wheat, laboratory glassware, and packaged medicines. China, the Netherlands, the United States, and Belgium are major import partners.

To learn more about this market, see the U.S. International Trade Administration's *Nigeria Country Commercial Guide*,[r] the World Bank's Doing Business guide for Nigeria,[s] and resources available through the Nigerian–American Chamber of Commerce[t] and the Nigerian–USA Chamber of Commerce.[u]

South Africa: Can this emerging economy continue to ascend?

This middle-income emerging market has both natural resource wealth and well-developed financial, legal, communications, energy, and transport sectors. Its stock exchange is Africa's largest and ranks in the top 20 globally. But South Africa also is distinguished by having one of the world's highest persistent inequality rates. The pandemic exacerbated the country's chronic problem of unemployment, which reached 32.5% at the end of 2020—and that rate skyrockets to 63% for workers age 24 or younger.

The CIA *World Factbook* lauds South Africa's "modern infrastructure," which "supports a relatively efficient distribution of goods to major urban centers throughout the region," but also notes the negative impact of "unstable electricity supplies" as well as "skills shortages, declining global competitiveness, and frequent work stoppages due to strike action."

South Africa is the world's largest producer of platinum, gold, and chromium. In addition to mining, major industries include automobile assembly, metalworking, machinery, textiles, iron and steel, chemicals, fertilizer, foodstuffs, and commercial ship repair. For 2017, services generated 67.5% of GDP, followed by industry (29.7%) and agriculture (2.8%). The majority of the labor force of 14.68 million is employed in services (71.9%), followed by industry (23.5%) and agriculture (4.6%).

In 2019, export volume was $123.86 billion, driven by gold, platinum, cars, iron products, coal, manganese, and diamonds. The biggest export partners are China, the United Kingdom, Germany, the United States, and India. Import volume for the year was $131.72 billion, led by crude and refined petroleum, cars and vehicle parts, gold, and broadcasting equipment. Chief import partners include China, Germany, the United States, and India.

To learn more about this market, see the U.S. International Trade Administration's *South Africa Country Commercial Guide*,[v] the World Bank's Doing Business guide for South Africa,[w] and resources available through the U.S.–South Africa Business Center[x] and the American Chamber of Commerce in South Africa.[y]

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[t]Nigerian–American Chamber of Commerce, https://nigerianamericanchamber.org

[u]Nigeria–USA Chamber of Commerce, https://nusacc.us

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[w]The World Bank, "Ease of doing business in South Africa," https://www.trade.gov/south-africa-country-commercial-guide

[x]U.S.–South Africa Business Center, https://www.usafricabusinesscenter.com/u-s-south-africa-business-council

[y]American Chamber of Commerce in South Africa, https://amcham.co.za 100

Africa—A wealth of resources and aspirations

Directory of ceramic and glass enterprises, institutes, universities, and government agencies in Africa

REGIONAL

African Academy of Sciences

Website: https://www.aasciences.africa

Contact page: https://www.aasciences.africa/contact-us

This pan-African nonprofit has no political affiliations and seeks to use science to transform lives on the continent. Its mission is threefold: to grant fellowships and awards; provide "advisory and think tank functions for shaping Africa's Science, Technology, and Innovation strategies and policies"; and implement programs that address Africa's developmental challenges. The Academy has five strategic focus areas: environment and climate change, health and wellbeing, natural sciences, policy and governance, and social sciences and humanities. Its initiatives include the Alliance for Accelerating Excellence in Science in Africa (https://www.aasciences.africa/aesa).

Mining Review Africa

Website: https://www.miningreview.com

Contact page: https://www.miningreview.com/info/contact-us

Webinars: https://www.miningreview.com/webinars

ALGERIA

Abdelhafid Boussouf University–Mila

Website: http://www.centre-univ-mila.dz/?lang=en

Natural Sciences and Materials Research Laboratory: http://lsnm.centre-univ-mila.dz/?page_id=208&lang=en

Email: lab.lsnm@centre-univ-mila.dz

The lab's 14 teacher-researchers and two Ph.D. students are assigned to research teams focused on sedimentary basins and natural resources, natural plant substances, bioecology and means of control, and materials sciences and application processes.

Center for Development of Advanced Technologies

Website: https://www.cdta.dz/en

Email: contact@cdta.dz

The CDTA "supports at the national level the development of state-of-the-art technologies in multi-disciplinary thematic fields." Among these are optics, photonics, and lasers; materials sciences; microelectronics and microsystems; design and development of integrated circuits; and nanomaterials and nanotechnology. It targets six areas of impact: health, energy, environment, water, digital, and industrial technologies.

University of Bejaia Algeria

Website: http://univ-bejaia.dz/en

Website of *Algerian Journal of Natural Products*: http://univ-bejaia.dz/ajnp/index.php/ajnp

Email of journal director Kamel Belhamel: kamel.belhamel@yahoo.fr or ajnp2014@gmail.com

This free, open-access journal is published twice annually by the University's Laboratory of Organic Materials. Topics it covers include phytochemistry; antimicrobial, antiviral, or antiparasite activities; biopolymers and biocomposites; electrochemical processes using natural products; separation processes using natural products; and environmental impact and risk assessment.

EGYPT

British University in Egypt

Website: https://www.bue.edu.eg

Email: info@bue.edu.eg

Nanotechnology Research Centre website: https://www.bue.edu.eg/nanotechnology-research-centre

The Nanotechnology Research Centre focuses on nanoscience advances that reflect "critical community needs, such as water and medicine." Links from https://ntrc-info.wixsite.com/ntrc/research lead to information about work by the NanoMaterials & Biosensing, Biomaterials for Medical and Pharmaceutical Applications, Applied Nano-Catalysis and Polymeric, Advanced Nanomaterials, and Industrial Catalysis research groups. The University's Centre for Advanced Materials provides a list of its projects at https://www.bue.edu.eg/research/research-centers/centre-for-advanced-materials-cam.

Cairo University

Website: https://cu.edu.eg/Home

Email: fnt@cu.edu.com

The College of Graduate Studies for Nanotechnology is a regional leader in this field of study and offers research and consulting services through "alliances with major economic entities in the local, regional and global market."

Egypt Nanotechnology Center

Website: http://www.egnc.gov.eg/egnc

Email: inquiry@egnc.gov.eg

The Center is working with IBM teams in the U.S. and Switzerland with an initial research focus on thin film silicon photovoltaics, graphene transparent electrodes for thin film photovoltaics, energy recovery from concentrator photovoltaics for water desalination, computational modeling and simulation, and biosensors. "These areas have been selected because of their scientific relevance and their potential impact on the economic development of Egypt."

El Nasr Glass & Crystal Co.

Website: https://www.elnasrglass-eg.com/en-gb/home

Contact page: https://www.elnasrglass-eg.com/en-gb/Contact-us

Founded in 1932, this subsidiary of Metallurgical Industries Holding is "one of the first specialized companies in the production of glass tools." In 2012, the company "replaced and renovated all its production lines using the latest European technology" (from Germany and Italy) to remain competitive and keep pace with the sector's technological developments.

The General Co. for Ceramic and Porcelain Products

Website: http://www.sheeni-egypt.com/en

Contact page: http://www.sheeni-egypt.com/en/contact-us.html

A subsidiary of Metallurgical Industries Holding, this Egyptian Stock Exchange-listed company manufactures porcelain tableware, sanitaryware, and ceramics for floors and walls.

German University in Cairo

Website: https://www.guc.edu.eg

Contact page: https://www.guc.edu.eg/en/contact.aspx

Studies and research clusters in advanced engineering materials cover materials processes and analysis, structure–property relationship in engineering materials, and engineering polymers and advanced materials.

NanoTechnology and Advanced Materials Central Lab

Website: http://www.arc.sci.eg/InstsLabs/Default.aspx?OrgID=627&TabId=0&lang=en

Email: abdo@claes.sci.eg

"NAMCL is the first specialized lab in Egypt work in the nano agro field," designs nano systems for agricultural and food applications, and "plays an official monitoring role through the full characterization of the manufactured nanomaterials including the safety evaluations."

National Research Centre

Website: https://www.nrc.sci.eg

Email: info@nrc.sci.eg

Egypt's largest multidisciplinary R&D center is devoted to basic and applied research. Its Engineering Research Division has departments for chemical, civil, and mechanical engineering as well as solar energy and systems and information.

Credit: Ahmed El Amine Nakib, Unsplash

KENYA

Dedan Kimathi University of Technology

Website: https://www.dkut.ac.ke

Contact page: https://stp.dkut.ac.ke/contacts

The University is establishing a Science and Technology Park as "an engine for innovation, incubation, development and commercialization of technology" that will integrate academic and entrepreneurial pursuits on campus. Its goals include employing research and innovation "to create intellectual property rights, spin-off companies and entrepreneurship" in three thematic areas: agri-tech (food bioresources and natural products value-addition), information and communication technology and design, and materials and manufacturing. Its initial anchor clients are

Directory of ceramic and glass enterprises, institutes, universities, and government agencies in Africa (cont.)

Credit: Nupo Deyon Daniel, Unsplash

Snowcap Development Limited, Asytec, and Semiconductor Technologies Limited.

Jomo Kenyatta University of Agriculture and Technology

Website: http://www.jkuat.ac.ke

SMARTEC staff page: http://jkuat.ac.ke/departments/smartec/staff

The University's Sustainable Materials Research & Technology Centre engages in research related to chemical analysis of concrete cores, DCP testing of subbase and subgrade layers, and extraction of aggregates in chemical analysis.

STL Semiconductor Ltd

Site: https://stlsemiconductor.com

Mail: info@stlsemiconductor.com

STL Semiconductor and the BG Ndegwa Center for Nano-Materials and Semiconductor Technologies is "the first of its kind advanced nano-technology and semiconductor laboratory in Kenya and indeed in Africa…a first-generation materials sciences facility offering scientific innovations targeted for semiconductor, agri-technology, biotechnology, energy, and any other large verticals. We aim to be the catalyst for cutting edge R&D innovation, intellectual property and proof of concepts for the semiconductor and related industries."

Technical University of Kenya

Website: http://tukenya.ac.ke

Email: vc@tukenya.ac.ke

The University is home to faculties of Applied Sciences and Technology, Engineering and the Built Environment, and Social Sciences and Technology.

MOROCCO

The International University of Rabat

Website: https://www.uir.ac.ma/en

Email: contact@uir.ac.ma

The University's College of Engineering and Architecture offers programs in automotive, aerospace, and energy engineering.

Kessy Beldi

Website: https://kessybeldi.com/en

Contact page: https://kessybeldi.com/en/contact

"A genuine Moroccan institution," the beldi tea glass was created in 1946 and is mouth blown from recycled glass.

Le Verre Beldi

Website: http://en.verrebeldi.com

Contact page: http://en.verrebeldi.com/contact.php

"Respecting the essential standards of recycling, job creation for craftsmen with strong skill, and quality products, Le Verre Beldis upgrades traditional Moroccan handmade and blown glass."

NIGERIA

University of Nigeria

Website: https://www.unn.edu.ng

Email: camillus.obayi@unn.edu.ng

The Faculty of Engineering encompasses departments of agricultural and bioresources, civil, electrical, electronic, mechanical, and metallurgical and materials engineering. From July 19–23, the University hosted the fourth Africa Nano Conference/Workshop (https://www.unn.edu.ng/4th-african-nano-conference), which focused on the application of nanotechnology in energy, environment, agriculture, and health. The conference theme was "Nanotechnology: A Springboard for National Development."

Federal University of Technology, Akure

Website: https://www.futa.edu.ng

The School of Engineering and Engineering Technology encompasses departments of agricultural and environmental, civil and environmental, electrical/electronics, industrial and production, mechanical, and metallurgical and materials engineering. The metallurgical and materials engineering curriculum covers mineral processing, extractive metallurgy, physical and mechanical metallurgy, production metallurgy, alloy development, corrosion engineering, polymeric materials, glass and ceramic materials, refractory materials, composite materials, nanotechnology, and process and plant design.

SOUTH AFRICA

Central University of Technology

Website: https://www.cut.ac.za

Contact page: https://www.cut.ac.za/contact-us

The University has programs designed to facilitate the transfer of technology to industry and notes: "The ideal would be for completed research by CUT researchers to be commercialized in the form of new inventions. Hence, the Technology and Innovation unit is supporting staff and students with the protection of intellectual property and by providing incubation facilities and commercialization support." Its Centre for Rapid Prototyping and Manufacturing specialized in additive manufacturing, while its Product Development Technology Station works in product design, prototyping, and short-run production.

Consol

Website: https://www.consol.co.za

Contact page: https://www.consol.co.za/contact

The company manufactures glass packaging for the food, beverage, pharmaceutical, and cosmetics industries and serves a mix of local and global customers.

University of Cape Town

Website: http://www.uct.ac.za

Centre for Materials Engineering Website: http://www.mateng.uct.ac.za

Email: robert.knutsen@uct.ac.za

"The research activities of the Centre are aimed at addressing national needs in terms of both the provision of technological solutions and the development of skilled graduates…Current research interests at the Centre for Materials Engineering at UCT are aimed at addressing the need to develop competitive niche areas in the production and application of light metal alloy products for the transport, medical and chemical industries…The Centre is involved in the development of new metal alloys, polymers, ceramics, and hard materials in cooperation with the materials manufacturing industries, and the optimum choice of these materials for the mining, marine, agricultural, processing, and energy-producing sectors of South Africa."

Thermomechanical processing is a key area of research focus, as is "optimization of titanium alloy properties through the process of tailoring the metal's composition and microstructure." Further details about these projects are available on the Department's research page (http://www.mateng.uct.ac.za/mateng/research).

University of Johannesburg

Website: https://www.uj.ac.za

The Department of Chemical Sciences houses the Centre for Nanomaterials Science Research, whose focus is on the synthesis, functionalization, characterization, and applications of carbon-based nanomaterials such as carbon nanotubes and strong composites. Its research priorities include bionanomaterials as well as nanomaterials for water treatment, catalysis applications, and sensors and photovoltaic applications. Further details about this work are available at https://bit.ly/3B9n5pO.

South African Department of Mineral Resources and Energy

Website: https://www.dmr.gov.za

Contact: https://www.dmr.gov.za/contact

This government agency has the mission to "regulate, transform, and promote the minerals and energy sectors, providing sustainable and affordable energy for growth and development, and ensuring that all South Africans derive sustainable benefit from the country's mineral wealth." Resources on the site cover mineral regulation and policy as well as a 21-page report on 53 minerals that are indigenous to South Africa (https://bit.ly/3Bj2lqz).

South African Institute of Mining and Metallurgy (SAIMM)

Website: https://www.saimm.co.za

Contact page: https://www.saimm.co.za/about-saimm/saimm-contacts

"The SAIMM is a professional institute with local and international links aimed at assisting members source information about technological developments in the mining, metallurgical and related sectors." Its website provides directories of journal and conference papers that are accessible at no cost. 100

Directory of African refractories

EGYPT

Alexandria Co. for Refractories

Website: https://mih.eg/myservice/alexandria-co-for-refractories

Contact form: https://mih.eg/contact

The company operates factories in Alexandria (for refractories) and Sornaga (for ceramics). Its primary products include aluminosilicate; high alumina; insulating, chemically bonded, and castable refractories; as well as mortars. Metallurgical Industries Holding, the parent company, provides its full list of subsidiaries in iron, steel, aluminum, copper, glass and crystal, porcelain ceramics, and more at https://mih.eg/subsidiaries.

Asfour for Mining & Refractories

Website: https://asfourmr.com

Email: info@asfourmr.com

Dolomita Industrial Solutions

Website: https://dolomita.com.eg/refractories

Email: info@dolomita.com.eg

The company provides high-performing refractory solutions to customers worldwide and in multiple industries. The raw materials it works with include calcined dolomite, flint pebbles, calcium carbonate, talc powder, iron oxide, and chamotte.

Korra Tradi

Website: http://korra-holding.com/refractories-profile

Contact form: http://korra-holding.com/contact

The company installs, repairs, maintains, and dismantles production linings. Products for the cement and foundries sectors include all types of refractory bricks, monolithics, all types of ferro alloys, pig iron, recarburizers, cored wires, nickel, inoculants, steel shots, cobalt, metallurgical coke, and magnesium metal.

Nile Co. for Refractories

Website: https://refnile.com/about-refractories-refractory

Email: info@refnile.com

The company's brick products include fire clay, high alumina, chemically bonded high-alumina, insulation, silica, expansion joint, anchor, ISO-shape, key, magnesite, magnesia carbon, spinel, dolomite, magnesia dolomite, magnesia chrome, zirconia, and anti-acid (blue bricks). In addition, it offers refractory, low cement and insulation castables, heat set and air wet mortars, kaolin, silica, ball clay, talc, feldspar, folorspar, quartz, dolomite, ferro alloys, coke, kiln furniture, pig iron, steel shoot, steel grit, grinding balls, and steel scrap.

Thermal for Ceramic Refractory & Metallurgical Products

Website: http://www.thermal-refractory.com

Email: Thermal_2000@hotmail.com or m.amer@thermal-refractories.com

Products include high- and low-alumina, insulating and anti-acid bricks; mortars; castables for a variety of applications; and ceramic insulators, tiles, and shisha stone. The company also offers inspection and consulting services.

Wataneyia for Refractories SAE

Website: https://www.w4r-eg.com

Contact page: https://www.w4r-eg.com/contact-us

The company's monolithic refractories serve cement plants, steel mills, and most high-temperature industrial uses. It also offers intumescent and cementitious fireproofing materials for the protection of steel.

KENYA

Citizen Cooling Solutions

Website: http://citizen-coolingsolutions.co.ke/refractory-materials

Contact page: http://citizencoolingsolutions.co.ke/contacts

The company's products include high-temperature refractory materials such as castable cement, fire bricks, insulating cement, refractory mortar, binder cement, fondu cement, chrome magnesite bricks and cement, silicon manganese 60/14, tapper bricks, hearth blocks and acid resistant bricks, tiles, cement, and mortar. It supplies and installs thermal insulation and acoustic insulation materials such as ceramic fiber products, rockwool (mineral wool) blankets, fiber glasswool blankets, and polyethelane foam.

Kingsman Engineering & Industrial Insulation

Website: https://kingsmanengineering.co.ke/refractory-materials

Email: info@kingsmanengineering.co.ke

Firebricks, refractory castable cements, conventional dense refractories, insulating, and low cement are among the company's products. In addition, it provides CAD and fabrication solutions.

NIGERIA

Eunaco Refractories Limited

Website: https://eunacorefractories.com.ng

Email: info@eunacorefractories.com.ng

The company provides iron, steel aluminum, lead, zinc, copper, cement, and lime refractories services.

SOUTH AFRICA

Delta Refractories

Website: http://www.deltaref.com/company-profile

Contact page: http://www.deltaref.com/contact-details

The company's offerings include dense and lightweight castables and special monolithics as well as production of acid and basic monolithic refractories, design and development of custom mixes, and design and estimation (including CAD drawing). It maintains an independent testing laboratory and can provide turnkey project management and refractory consultation and arbitration. See its brochures page (http://www.deltaref.com/product_brochures) for information about its RH-degasser, casting and transfer ladles, cement industry, Delta Fiber Crete composite castables, wear resistant, pumpable, and grouting products.

Durocast

Website: https://www.durocast.co.za/refractory-products/home

Contact page: https://www.durocast.co.za/refractory-products/contact-durocast

The company lists the following in its description of its product range: aluminosilicate, basic, silicon carbide, fused silica, insulation, preformed shapes, refractory materials, insulating materials, corrosion / chemical resistant material, casting, gunning, ramming, mortars, pumping, refractory anchors, chemical resistant products, bricks, castables, guniting, concrete products, fire protection, abrasion resistant flooring, grouts, testing and consulting, tiles, mortars, and monolithic refractory products.

Credit: Dan Grinwis, Unsplash

National Refractory Industries

Website: https://www.caperef.co.za

Contact page: https://www.caperef.co.za/index.php/contact-us

The company describes itself as a "net importer of a wide range of refractory brick, specialized refractories and insulation materials." Its ceramic fiber line encompasses blankets, boards, paper, vacuum-formed shapes, ropes, braids, textiles, and modules. Its product list also includes basic brick, aluminosilicate firebrick, insulation brick, refractory castables, guniting materials, insulation castables, refractory mortars, rammables, precast and fired refractory shapes, foundry products, crucibles, crucible furnaces, mineral wool insulation mat and pipe sections, cold insulation, silicon carbide shapes, fondu cement, refractory metallic anchors and studs and shear studs.

Refraline

Website: https://refraline.com

Contact page: https://refraline.com/contact-us

The company's areas of specialization include material development, manufacture, supply, demolition, installations, and maintenance of refractory and corrosion solutions for such industries as iron and steel, ferro-alloys, nonferrous metals, platinum group metals, aluminum, chemical and petrochemical, cement and lime, power generation, mining, paper and pulp, clay brick, glass, and ceramics. It also employs specialists in lagging and cladding.

Tecera Africa

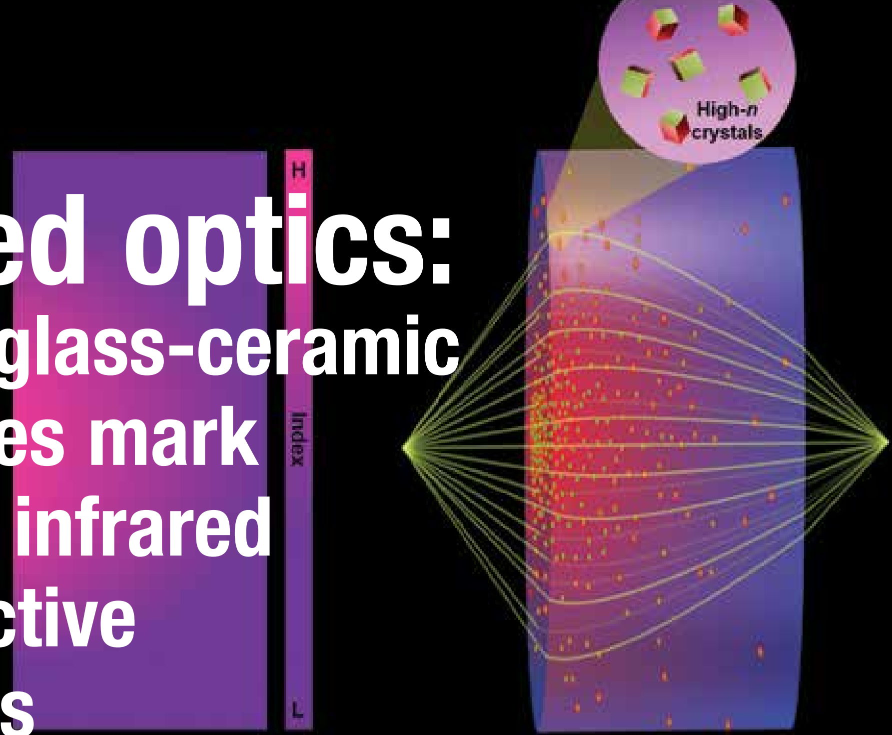
Website: https://www.tecera.co.za

Email: https://www.tecera.co.za/contact-us.html

The company notes that it supplies alumina ceramics with 92% alumina content and high-quality wear resistance, mechanical, electrical, thermal, and chemical properties. Frequently manufactured items include plait flat tiles, weld-on tiles, pre-engineered pipe tiles, impact blocks, pulley lagging tiles, and cylinders. Its product lines also include silicon carbide and basalt linings, ultrahigh molecular weight polyethylene sheets and epoxy wearing compounds, as well as a wide range of ceramic and silicon carbide lined dense medium cyclones and classifying cyclones. 100

Bioinspired optics:

Chalcogenide glass-ceramic nanocomposites mark a milestone in infrared gradient refractive index materials



Infrared gradient refractive index media are realized through spatially modulated novel chalcogenide glass–ceramic nanocomposites. The gradation in color (left) corresponds to the variation in effective refractive index associated with the volume fraction of high refractive index crystals (right).

By Myungkoo Kang and Kathleen A. Richardson

A combination of multicomponent chalcogenide nanocomposites and laser/thermal processes enables a transformative opportunity to bring gradient refractive index lenses one step closer to commercialization.

Refractive optical lenses are entrenched throughout our lives.

We encounter them in our daily use of eyeglasses and camera phones as well as more advanced applications involving security and surveillance. Air, land, sea, and space-based vehicles equipped with imaging systems monitor both near and distant environments. Microscopes and telescopes employ lenses to see objects at a scale and distance far below and beyond those enabled by the human eye, respectively.

The development of these imaging systems dates to 1280 CE with the invention of eyeglasses.[1,2] Since then, researchers have made a series of breakthroughs, including the invention of the microscope in 1595 and the telescope in 1608.[1,2] However, few significant advances in lenses took place over the past century. Today's spherical lenses, made from a homogeneous medium (usually glass) with a fixed refractive index, are not appreciably different from those invented during the revolutionary era of the 1200s–1600s. While manufacturing methods have evolved from manual techniques to use of computer numerical control and precision glass molding tools, spherical and aspheric monolithic bulk optics of fixed index materials remains the fabrication strategy largely employed today.

Unfortunately, spherical lenses with uniform refractive index suffer from chromatic aberration, i.e., color distortion.[1] This distortion arises due to a material's fixed index and shape, which focuses different colors at varying physical positions in space. To solve the issue, additional corrective lenses with different shapes and refractive indices are often inserted into the optical system, as exemplified by the double-Gauss lens.[1] However, multistacked lenses typically made of high-density crystalline materials inevitably make it very challenging to minimize the size, weight, power consumption, and cost (SWaP-C) factor of entire imaging systems.

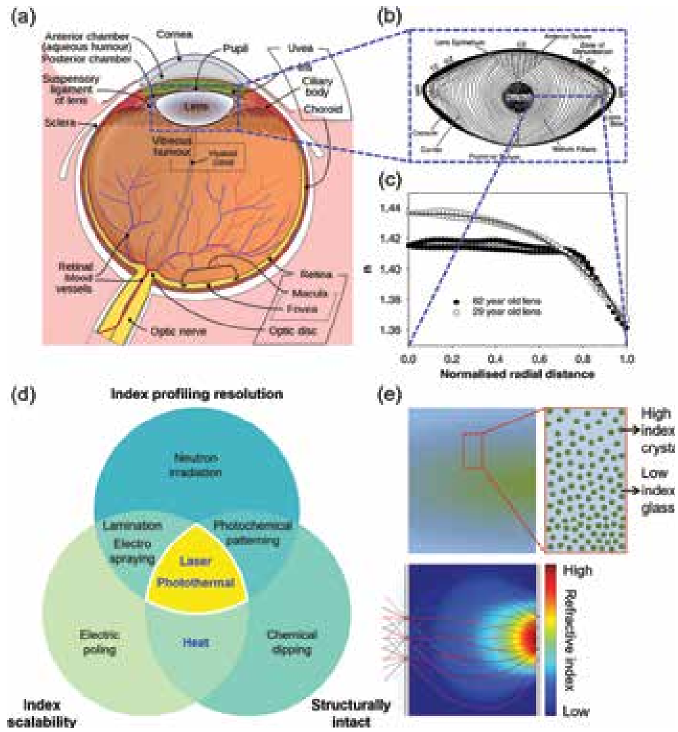


Figure 1. (a) The anatomy of a human eye. Adapted from Ref. 3 [open source]. (b) A close view of a lens in the human eye. Adapted with permission from Ref. 4, Copyright 2011 IOP Publishing. (c) The index profile of the lens. Adapted with permission from Ref. 5, Copyright 2002 Elsevier. (d) Experimental techniques to induce GRIN profiles and their assessment, and (e) A nanocomposite-based biomimetic flat GRIN lens. Credit: Kang and Richardson.

This issue is compounded in the infrared (IR) portion of the electromagnetic spectrum, where high-density single crystal materials (i.e., germanium and silicon) serve as the material of choice in legacy optical systems. The need to minimize the SWaP-C factor for multicomponent lens systems thus requires today's optical community to rethink the strategy of both material choice and form factor.

Bioinspired optics: Gradient refractive index materials

Nature often inspires efficient structural designs for man-made products. We can again rely on bioinspired examples for possible solutions to the lens distortion issue.

The microstructure of lenses within human eyes have a spatially varying mass density that correspondingly gives rise to a gradient refractive index (GRIN) ranging from 1.386 to 1.406, as illustrated in Figs. 1a–c.[3-5] The GRIN profile removes much of the chromatic aberration, allowing the eye to image with good resolution.

The significant advantages of GRIN lenses include[6-8]

1) Single component required to correct the chromatic aberration,
2) Flat or arbitrary shape,
3) Enables optical platforms with a substantially reduced SWaP-C factor as well as new design degrees of freedom, and
4) Opens previously uncharted novel optical functions.

Since Wood's pioneering work experimentally realized the creation of a man-made GRIN profile,[6] researchers proposed a wide variety of methods to develop similar optical function in applications that span the visible and IR spectral regions.[6-8] Meanwhile, it was only during the recent two decades when technological advances first became feasible, due to the challenge of finding suitable target materials that can enable such methods.

Three key criteria of a candidate GRIN solution include the abilities to

1) Create an arbitrary GRIN profile in a 3D volume;
2) Create a GRIN profile throughout the entire volume of a target material to maximize a resulting phase shift of propagating light; and
3) Induce minimal optical and structural defects, thereby maintaining a lens' optical transparency within the component's environment of use.

Figure 1d shows a series of methods that were experimentally demonstrated and their assessments based on the aforementioned criteria. Notably, spatially controlled direct laser writing,[9] gradient heat treatment,[10] and the photothermal method (a sequential hybrid form of these two processes)[11,12] recently gained interest due to their ability to mitigate issues associated with structural defects often induced in other techniques. These issues can induce artifacts associated with interfaces from neighboring layers (lamination[13] and electro-spraying[14]), damage/modification from long-range macroscopic bombardment/diffusion of ions (neutron irradiation[15] and electro-poling[16]), and a limited diffusion-defined index modification within a near surface volume (ion exchange/chemical dipping[7] and photochemical[17]).

The photo (laser), thermal (heat), and photothermal processes use either crystallization or amorphization to convert a starting material into a nanocomposite consisting of coexisting high index crystalline phases and low index amorphous phases. The refractive index of a nanocomposite with multiple coexisting subwavelength phases can be approximated as an effective medium as formulated by $n_{\text{effective}} \approx \sum_{i=1}^{N}(V_{i_{\text{th}}}\ \text{phase} \times n_{i_{\text{th}}}\ \text{phase})$, where n and V correspond to the refractive index and volume fraction of each phase within a nanocomposite, respectively. The formulation assumes that spatial variation in the volume density of high index nanocrystalline phases leads to a transmissive effective medium with a GRIN profile, with low loss.

Figure 1e shows an example of such a microstructure where the number density of high index nanoparticles (green) varies spatially within a low index matrix (blue),[8] resulting in a single-component flat GRIN lens in which propagating light is guided along curved trajectories.

Candidate materials and processes

Efforts to find a material system that allows for the aforementioned microstructure/index modification processes in the IR spectral region have resulted in significant progress over the past two decades.

In 2007, researchers at the University of Rennes (France) reported that heat treatment of a bulk chalcogenide $GeSe_2$–As_2Se_3–PbSe glass could result in the formation of a glass-ceramic nanocomposites containing high index crystals.[18] Motivated by this finding, a collaborative group of teams at Clemson

University (now at the University of Central Florida), The Pennsylvania State University, and Lockheed Martin Corporation extended this study to show how direct laser writing, heat treatment, or a hybrid process could be used as a versatile, scalable, and tailorable method enabling spatial refractive index modification of chalcogenide glass matrices in both bulk and thin film forms.[6,8–12,19,20]

Understanding why the material system is suitable for the specific types of external stimuli and is uniquely poised as a promising GRIN medium candidate requires a close look at the glass's phase diagram. Figures 2a and 2b show horizontal and vertical components of the $GeSe_2$–As_2Se_3–PbSe bulk material's phase diagram, respectively.[10,19,20]

Following a rapid quenching of a melted compound, the chalcogenide glass's resulting room temperature microstructure is composition-dependent, as indicated by the glass-forming and crystal-forming regions in the horizontal ternary phase diagram. Resulting materials with compositions on the crystal-forming region exhibit randomly distributed crystals with a large size distribution, whereas those on the glass-forming region can show a well-defined composition-dependent microstructural evolution. Specifically, the vertical composition–temperature phase diagram is constructed along the dotted blue line drawn within the glass-forming region on the horizontal diagram.

A prominent feature in the vertical phase diagram is an immiscibility dome spanning over compositions ranging from about 10–45 mol% of PbSe at room temperature.[8] The immiscibility dome indicates that an increase in PbSe content involves microstructural transitions from a homogeneous medium (~0–10 mol% PbSe) to a nanocomposite medium consisting of lead-rich particles in a lead-deficient matrix (~10–30 mol% PbSe) to a nanocomposite medium consisting of lead-deficient particles in a lead-rich matrix (~30–45 mol% PbSe) back to a homogeneous medium (~45–50 mol% PbSe). The four blue stars correspond to representative compositions in each regime, and their expected microstructures are illustrated schematically in Fig. 2c.

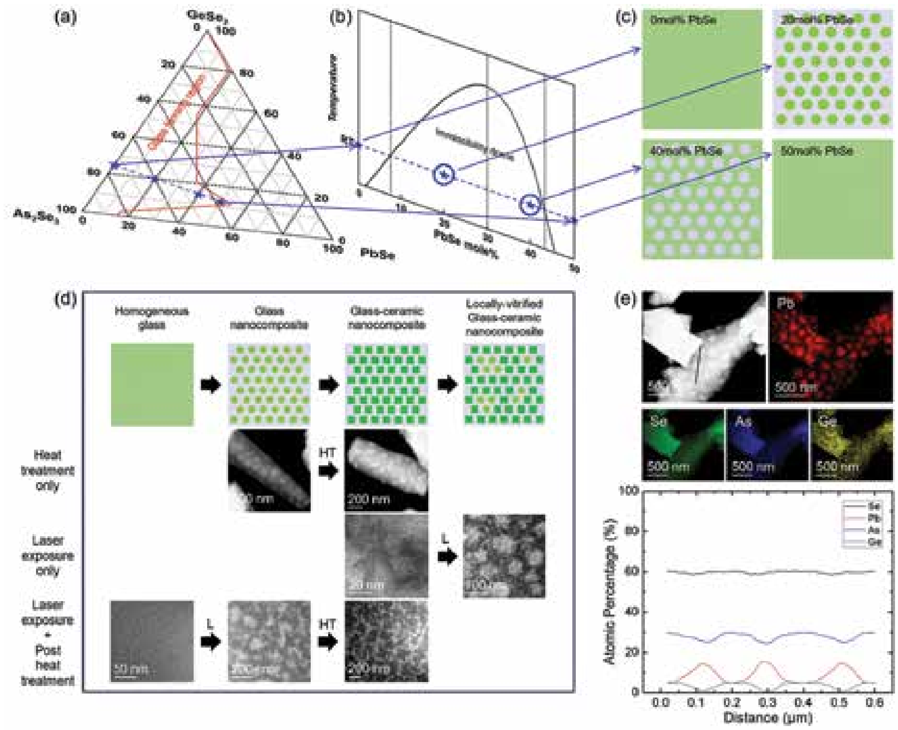


Figure 2. (a) $GeSe_2$–As_2Se_3–PbSe glass' ternary compositional phase diagram at room temperature, and (b) The glass's composition-temperature phase diagram. Adapted with permission from Ref. 20, Copyright 2021 Wiley. (c) Expected microstructures of glasses with four representative compositions. Credit: Kang and Richardson. d) A summary of starting morphology-stimulation method-resulting evolution correlation. Adapted with permission from Ref. 9, Copyright 2018 OSA Publishing; Ref. 10, Copyright 2020 Wiley; and Ref. 11, Copyright 2018 Wiley. (e) Spatial composition analysis of a nanocomposite. Adapted with permission from Ref. 10, Copyright 2020 Wiley.

Here, nanocomposites with a composition within the immiscibility dome are of particular interest as a starting point toward a candidate GRIN material. Within these regions, the Pb-rich phases existing as either particles (~10–30 mol% PbSe) or a matrix (~30–45 mol% PbSe) in the starting glassy nanocomposites are inherently unstable and prone to crystallization while their counterpart lead-deficient phases remain amorphous upon heat treatment. The exclusive crystallization of lead-rich phases induces the formation of high index $Ge_{0.1}Pb_{0.9}Se$ (~10–30 mol% PbSe) or PbSe (~30–45 mol% PbSe) nanocrystals with indices far greater than those of a coexisting lead-deficient amorphous phase and other induced crystals.[10,19] The lead-rich phases in the starting nanocomposites are uniformly dispersed/sized and their average size is orders of magnitude smaller (at most up to ~200 nm) than the wavelength of IR light.[10,19,20] These characteristics allow the effective refractive index of the nanocomposite to increase while it remains as a low-loss transmissive effective medium in the IR upon heat treatment.

Meanwhile, inspired by phase change materials, an alternative approach was used to induce a reverse transition from a glass-ceramic back to a glassy state.[9] The rationale behind this approach is that a spatial control of the degree of crystallization within a starting glass-ceramic matrix would lead to a local decrease in refractive index, thereby creating a GRIN structure. The method would not only switch between extremes in fully crystalline and amorphous states, but it would also reach intermediate states, thereby allowing a fine control of refractive index within a material. The process uses precisely controlled laser irradiation to melt the glass-ceramic, thereby re-amorphizing the local region and reversing the cumulative extent of crystallization. The amorphization is spatially controlled by the fluence and movement of the laser writing process, representing how the term laser-induced vitrification (LIV) was coined by our team.[9]

As chalcogenide $GeSe_2$–As_2Se_3–PbSe glasses in a thin film form undergo a thermal history vastly different from that of a bulk solid, such processing results in morphologically homogeneous media across a wide range of compositions.[11,12] This difference is directly associated with their typical deposition technique. In efforts by our team, chalcogenide films are deposited predominantly using thermal evaporation where evaporated source materials experience excessively fast cooling as they are deposited on a substrate maintained at either room or a cold temperature. As a result of the process, the source materials are instantaneously frozen into a highly metastable amorphous phase. Because there is no time for constituent atoms/molecules to rearrange during the fast condensation process, their resulting morphology exhibits that of the "parent" vapor phases. As the medium is homogeneous, this situation necessitates a different strategy to functionalize the material toward a GRIN medium.

The highly metastable, homogeneous films have a strong tendency to separate into lead-rich and lead-deficient phases at an activation energy lower than that required for as-quenched bulk glasses. Meanwhile, the facile phase transformation comes with a caveat. Relying only on heat treatment would induce the spontaneous formation of crystals with a large size distribution. Crystallites with sizes in the upper part of the size distribution, outside the effective media approximation's regime, are likely to scatter incident IR light, leading to optical loss. Also, their random spatial and size distributions leave none to very little controllability over the formation of GRIN profiles.

To overcome the challenge, direct laser writing was introduced and sequentially combined with heat treatment.[11,12] The rationale behind an addition of the laser process includes

1) It activates the process whereby a starting homogeneous film can be separated into lead-rich and lead-deficient glassy phases;

2) Tunability of the magnitude and location of phase separation by controlling fluence and laser exposure;

3) Post heat treatment of the laser-induced nanocomposite allows energetically unstable lead-rich phases to be exclusively converted into high index crystals while keeping the lead-deficient low index phases glassy at a temperature lower than that required for a heat treatment-only condition; and

4) The size of the high index crystalline phases within the resulting glass-ceramic film is small and narrowly distributed, allowing the nanocomposite to remain transparent.

This approach enables GRIN layers to be applied to bulk spherical optics, thereby creating aspheric optical functions. Such an approach can result in considerable cost savings in the manufacturing process.

The three representative cases discussed above indicate that a specific choice of post stimulation process suitable for the realization of GRIN media is largely determined by the starting medium's morphology (phase separated or homogeneous) and microstructure (glassy or glass-ceramic). The starting morphology-stimulation method correlation is summarized in Fig. 2d. Here, the top row illustrates morphological/microstructural transitions that the material system can undergo: from i) a homogeneous glass to ii) a glass nanocomposite to iii) a glass-ceramic nanocomposite to iv) a partially vitrified glass-ceramic nanocomposite.

No matter where the starting point is, a key requisite for the realization of GRIN media is to convert a starting morphology into a glass-ceramic nanocomposite consisting of small (sub-100 nm) monosized high index crystallites within a low index glassy phase. The transmission electron microscope images in Fig. 2d summarize how three post-stimulation processes including heat treatment-only, laser-only, and a hybrid of these two processes (i.e., photo-thermal process) are coupled with the specific starting stages of target materials and induce them to evolve into glass-ceramic media.[9–12,19,20]

Figure 2e shows a TEM image and corresponding X-ray energy dispersive spectroscope maps collected from a nanocomposite with 20 mol% PbSe as a representative composition within the material system's immiscibility dome.[10] The presence of phase separation into lead-rich particles and a lead-deficient matrix is clearly indicated by the red map corresponding to lead. To quantify the extent of phase separation, the atomic percentages of four constituent elements were extracted along the black line in the TEM image. The spatial profiles in Fig. 2e show how each element's quantity varies over the distance across particle and matrix regions, highlighting a large difference in local atomic percentages of lead in particle and matrix regions.

Refractive index modifications

How the microstructural/morphological evolution leads to changes in the composite's refractive index is presented for heat treatment-only (Figs. 3a–c), photo-thermal (Figs. 3d–f), and laser-only processes (Figs. 3g–i). The heat treatment of bulk glasses converts them into glass-ceramics whereby the type and volume fraction of each crystalline phase is dictated by the composition of the parent glasses, as shown in Fig. 3a.[10]

It is important to note that the volume fraction of lead-containing crystalline phases (either $Ge_{0.1}Pb_{0.9}Se$ or PbSe) increases with lead content of starting glasses. Because the refractive indices of these phases in the mid-wave IR for $Ge_{0.1}Pb_{0.9}Se$ (4.81) and PbSe (4.90) crystals are far greater than those of As_2Se_3 (2.41), selenium (2.65) crystals as well as the parent glass matrices (nominally around 2.48) at a wavelength of 4.515 μm as an example, the lead-containing crystals are clearly responsible for an increase in effective refractive index upon conversation of glasses into glass-ceramics.[10] The impact of starting composition and heat treatment on an increase in effective refractive index of nanocomposites is summarized in Fig. 3b, highlighting an ability to target a specific index through a specific choice of "knobs" of the composition and thermal processing.[10] Also, Fig. 3c shows that while there is an optical loss in the short-wave IR originated from scattering of incident light at interfaces between high index crystals and a low index matrix, the nanocomposite media still retain their mid-wave IR transparency upon glass to glass-ceramic conversion.

Figures 3d and 3e show an example of such index tailorability via a photo-thermal process carried out on films.[9] Specifically, an increase in laser exposure fluence followed by a fixed heat treatment protocol leads to a greater volume fraction of lead-containing high index nanocrystals, thereby increasing the effective refractive index of films, as shown in Fig. 3d.[11] Figure 3e shows the extensive impact of laser exposure fluence on a net change in index of films reaching about 0.08 with respect to those with no laser exposure at a wavelength of 4 µm.[11] The well-defined monotonic relationship serves as a "design curve" that quantifies a specific laser exposure fluence required to induce a target index change. Further to the controllability of index and the maintenance of optical transparency upon glass to glass-ceramic conversion, it is imperative to test whether a GRIN structure minimizes a chromatic aberration of an optical media, as one of the key promised benefits for the employment of GRIN. We assume a radial GRIN structure where its effective refractive index continuously varies over the range shown in Fig. 3d. We then extract a GRIN Abbe number of the medium.[11] Figure 3f shows the magnitude of Abbe numbers for the radial GRIN medium and compares the values with those for its homogeneous counterparts as well as other materials over three spectral ranges of short-wave IR, mid-wave IR, and long-wave IR. Materials that are less dispersive and correspondingly lower chromatic aberration have a greater magnitude of Abbe number. The orders of magnitude increase in the absolute value of the GRIN Abbe number observed in Fig. 3f indicates that the GRIN medium should experience far less chromatic aberration than its counterpart homogeneous medium.

Figs. 3g–i.[9] present the ability to locally tailor the effective refractive index using a laser-only process. Figure 3g shows an array of laser-written structures and corresponding Raman spectra collected from three locations on (A), near (B), and away from (C) a pillar.[9] The clear differences in their spectral features indicate the different extents of laser-induced vitrification.

To quantify the extent of vitrification in each region, the spectra in Fig. 3g are compared to those collected from a starting glass-ceramic (i.e., no vitrification) and a glass (i.e., a complete vitrification) in Fig. 3h.[9] Because the two reference states in Fig. 3h correspond to specific

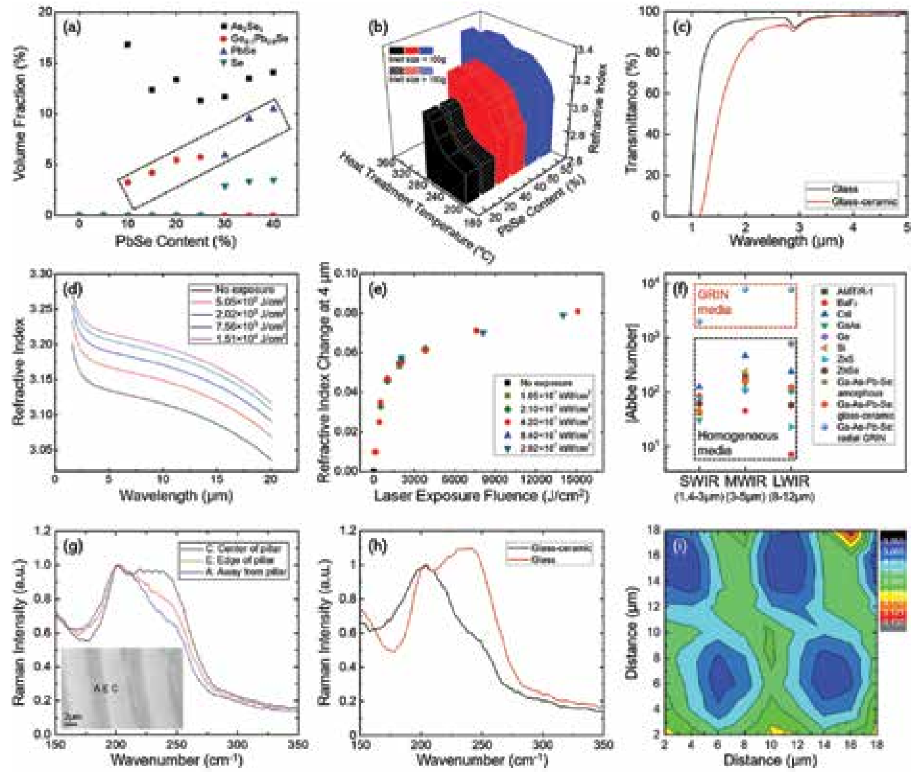


Figure 3. (a) Types of crystalline phases formed upon heat treatment of bulk materials, and (b) A starting composition-heat treatment temperature-resulting refractive index correlation for bulk materials. Adapted with permission from Ref. 10, Copyright 2020 Wiley. (c) The heat treatment-induced evolution of transmittance for a bulk material. Credit: Kang and Richardson. The impact of laser dose on (d) index dispersion of thin films and (e) index changes of thin films at a wavelength of 4 µm, and (f) Abbe numbers of various homogeneous and GRIN media. Adapted with permission from Ref. 11, Copyright 2018 Wiley. (g) Raman spectra of glass and glass-ceramic materials; (h) Raman spectra collected from regions on, near, and away from a laser-vitrified pattern within a glass-ceramic material; and (i) A corresponding Raman-converted index map on the surface of the material. Adapted with permission from Ref. 9, Copyright 2018 OSA Publishing.

effective indices, the quantitative comparison of the spectra in Figs. 3g and 3h allows us to extract the effective refractive indices of three local regions where the spectra in Fig. 3g were collected.

Based upon this approach, Raman spectra collected from multiple locations over a large area are converted into a map of effective refractive index, as shown in Fig. 3i.[9] Each blue "chain" corresponds to each laser-written structure where the lateral succession of circular features represents the movement of a laser spot to write such an array. Importantly, the indices of laser-written arrays are lower than those outside the regions, showing the ability to spatially tune effective refractive index within a single optical medium.

Realization of GRIN structures

The process–structure–property relationships defined for the three approaches were used to create functional optical media with specifically programmed GRIN profiles in both radial and axial directions. As an example of a GRIN profile created within a bulk specimen using a thermal-only process, the inset in Fig. 4) illustrates a 50 mm-long rod that underwent a gradient heat treatment where the specimen experienced spatially varying temperatures from 225°C at the left cold end to 260°C at the right hot end.[10] We sliced a resulting glass-ceramic rod into multiple discs and measured refractive indices for four representative discs. Figure 4a shows that a disc whose original location is closer to the hot end exhibits a greater index, indicating the formation of an axial GRIN profile within the bulk rod specimen.[10]

Meanwhile, the photothermal process offers spatially more options thanks to the versatility and spatial resolution of the laser beam's movement. The laser

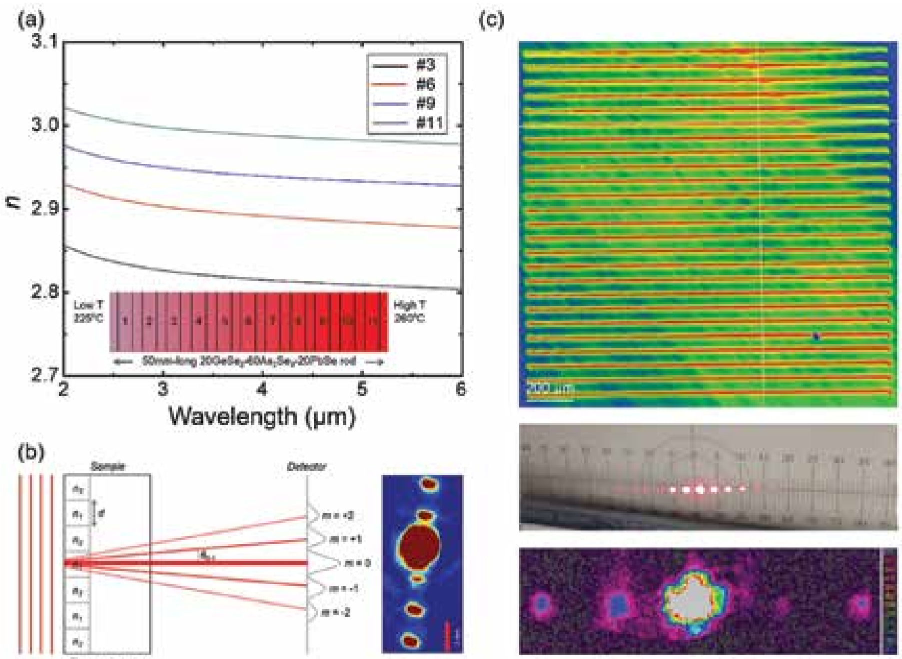


Figure 4. (a) A 50 mm-long rod subjected to a gradient heat treatment and corresponding refractive indices collected from various slices from the rod. Adapted with permission from Ref. 10, Copyright 2020 Wiley. (b) Arrays of photothermally-induced glass-ceramic patterns within a glass thin film functioning as a diffraction grating. Adapted with permission from Ref. 11, Copyright 2018 Wiley. (c) Arrays of laser-vitrified patterns within a bulk glass-ceramic matrix functioning as a diffraction grating in both reflection and transmission modes. Adapted with permission from Ref. 9, Copyright 2018 OSA Publishing.

exposure, which is the first stage of the two-step process, can be done with an optical mask as well. For example, we used an optical mask that allows laser beams to reach the surface of a film in a laterally discrete fashion, where the film has alternating laser-exposed and unexposed regions. Subsequently, the film underwent a heat treatment to convert the laser-exposed regions into glass-ceramics while the laser-unexposed regions remained glassy, which led to formation of a grating with spatially alternating high and low index regions.

Figure 4b illustrates the grating structure we fabricated and shows diffraction spots created at a detector with the transmission of 2 μm laser light through the structure.[11] The diffraction spots can be used to extract a difference in indices of laser-exposed and unexposed regions within the grating structure. The index change is extracted to be 0.077 for the specific case in Fig. 4b and closely matches a value of 0.08, which was targeted based on a specific choice of laser exposure and post heat treatment parameters.[11]

The formation of a grating structure was also realized using a spatially modulated LIV (i.e., laser-only) process on a bulk glass-ceramic specimen, as shown in Fig. 4c.[9] The LIV-induced structure subjected in transmission (λ = 2 μm) and reflective (λ = 0.632 μm) modes leads to the generation of spots, confirming the functionality of the structure as a grating. An extracted difference in indices of laser-vitrified glassy and unexposed glass-ceramic regions within the grating structure is –0.056. The value is consistent with a change (–0.062) extracted from the Raman-converted index map of gratings in Fig. 3i.[9] Therefore, three examples demonstrated in Figs. 4a–c confirm that thermal-only, photothermal, and laser-only processes are capable of creating GRIN structures with spatially and optically great precisions.

Remaining challenges and outlooks

While the work reported here focused on a specific chalcogenide material system to demonstrate how glass science can be used to design new optical materials with diverse functions, the premise whereby low-loss nanocomposites can be created to yield tunable optical functions in a thin and/or flat form factor is an attractive approach to enable more compact optical components and systems. We have just begun to explore a small fraction of this chalcogenide material's phase diagram, and much of its further potential has yet to be discovered.

Along the way, key information to identify the medium's resulting phases as well as their size, shape, volume fraction, connectivity, and composition is needed because these factors collectively determine the medium's resulting optical performance. Such information is vital to construct a predictive quantitative process–structure–property relationship that can serve as a "look-up table of processing metrics" for the realization of optical components with target optical behavior. Meanwhile, a challenge to identify the microstructure of this material system still leaves us room for improvement. Specifically, widely used TEM has an intrinsic limitation to characterize its microstructure in a 3D space due to its 2D projection method where coexisting phases are often seen overlapped or partially revealed. Also, the material is substantially sensitive to ion irradiation, making it challenging to prepare destruction/contamination-minimized cross-sectional TEM specimens during an ion beam-assisted milling process. Additionally, optical characterization methods to accurately measure arbitrary GRIN profiles still require further improvement to see such an optical function in actual discrete components.

As one feasible solution, atom probe tomography (APT) has gained interest in the optical materials community due to its ability to identify the microstructure and chemistry of target specimens in a reconstructed 3D volume.[20] In addition, the metrology method allows high spatial resolution and high detection sensitivity to be achieved simultaneously, thereby overcoming the trade-off relationship that is well known for other micro- and nanoscale analytical instruments.

To better understand the chalcogenide nanocomposites' microstructures and chemistries, endeavors to optimize parameters for both focused ion beam-assisted APT specimen preparation and data collection are in progress.[20] Especially, we foresee that by using plasma- or cryo-focused ion beam, undesirable ion-matter interactions beyond intended milling, which often induce microstructural defects, can be minimized during an APT tip preparation stage, thereby allowing APT to retain 3D data as close as that of an original specimen.

Findings from the spatially improved microstructural analysis combined with enhanced optical metrology tools for GRIN characterization will not only reveal further insight into the material system's response to laser and thermal treatments, but it will also refine the predictive quantitative process–structure–property relationship, facilitating the design, fabrication, and expanded use of GRIN optical components.

Acknowledgments

This work was supported in part by the Defense Advanced Research Projects Agency under Air Force Research Laboratory contract FA8650-12-C-7225 through the M-GRIN Tech Area 2 program. The authors gratefully acknowledge the role of our partners in this effort, including Theresa S. Mayer at Purdue University, Clara Rivero-Baleine at Lockheed Martin Corporation, Ilya Mingareev at Florida Institute of Technology, Carlo G. Pantano at Pennsylvania State University, Hugues Francois-Saint-Cyr at Thermo Fisher Scientific, Isabelle Martin at CAMECA Inc., Juejun Hu at Massachusetts Institute of Technology, and Martin C. Richardson at the University of Central Florida. We also recognize the significant contributions of the numerous former students and research staff who contributed to this work.

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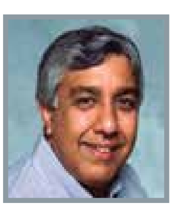

Anil K. Sachdev
Principal Technical Fellow and lab group manager at GM Global Research and Development

Iron–The ubiquitous element

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Clive Randall
Director of Materials Research Institute at The Pennsylvania State University

Turning down the heat in sintering to enable the unification of all materials

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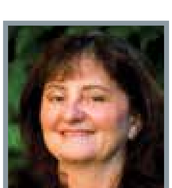

Tresa Pollock
Alcoa Professor of Materials at the University of California, Santa Barbara

New superalloys in the Co-Ni design space for 3D printing

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SUNDAY, OCT. 17 5–6 P.M.
MS&T WOMEN IN MATERIALS SCIENCE RECEPTION

MONDAY, OCT. 18 1–2 P.M.
ACerS 123RD ANNUAL MEMBERSHIP MEETING

MONDAY, OCT. 18 5–6 P.M.
WELCOME RECEPTION HOSTED BY THE MS&T PARTNERS

MONDAY, OCT. 18 7:30–10 P.M.
ACerS ANNUAL HONOR AND AWARDS BANQUET

MONDAY, OCT. 18–THURSDAY, OCT. 21
VARIOUS HOURS
ACerS BASIC SCIENCE DIVISION CERAMOGRAPHIC EXHIBIT & COMPETITION

TUESDAY, OCT. 19 VARIOUS HOURS
GENERAL POSTER SESSION WITH PRESENTERS

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Xin Qian, Georgia Institute of Technology, USA

MONDAY, OCT. 18 9–10 A.M.

ACerS/EPDC ARTHUR L. FRIEDBERG CERAMIC ENGINEERING TUTORIAL AND LECTURE

Elizabeth Opila, University of Virginia, USA

ACerS RICHARD M. FULRATH AWARD SESSION

Postponed to MS&T22 due to COVID-related travel restrictions.

Surojit Gupta, University of North Dakota, USA
Elizabeth Paisley, Sandia National Laboratory, USA
Tsuyoshi Honma, Nagaoka University of Technology, Japan
Kenichi Okazaki, Semiconductor Energy Laboratory, Japan
Hirokazu Sasaki, Shoei Chemical, Inc., Japan

TUESDAY, OCT. 19 1–2 P.M.

ACerS FRONTIERS OF SCIENCE AND SOCIETY — RUSTUM ROY LECTURE

Alexander Michaelis, Fraunhofer Institute for Ceramic Technologies & Systems IKTS, Germany
Advanced ceramics for energy and environmental technology

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ACerS GOMD ALFRED R. COOPER AWARD SESSION COOPER DISTINGUISHED LECTURE

Efstratios I. Kamitsos, National Hellenic Research Foundation, Greece

ACerS GOMD ALFRED R. COOPER YOUNG SCHOLAR AWARD PRESENTATION

Jacob M. Lovi, Iowa State University, USA
Graham Beckler, Coe College, USA
Lauren Y. Moghimi, Stanford University, USA

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Wayne Kaplan, Israel Institute of Technology, Israel
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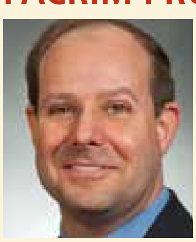
PACRIM PROGRAM CHAIR



Michael C. Halbig
NASA Glenn Research Center
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- → Biomaterials, Biotechnologies, and Bioinspired Materials

PACRIM PLENARY SPEAKERS

MONDAY, DEC. 13

MELISSA ORME
Vice president, Boeing Additive Manufacturing, The Boeing Company, USA

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Professor, Tokyo University of Science, Department of Physics, Japan; Laboratory Head of Macroscopic Quantum Coherence Research, RIKEN Center for Quantum Computing (RQC), Japan

Superconducting quantum computer and its future issues

MARY ANNE WHITE
Harry Shirreff Professor of Chemical Research (Emerita), Department of Chemistry, Dalhousie University, Canada

Thermal properties of advanced ceramics

SANG IL SEOK
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Halide perovskite-based photovoltaics—from materials to devices

ACerS is excited to announce the addition of a hybrid option for PACRIM 14 to allow participation by individuals who cannot attend in-person due to travel restrictions. We plan to provide a hybrid solution that will incorporate prerecorded talks from virtual attendees into the live onsite programming. All live sessions will be recorded for all attendees to view at the conclusion of the live conference, available until Feb. 28, 2022.

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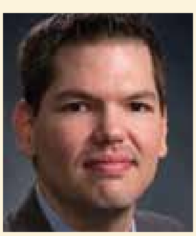

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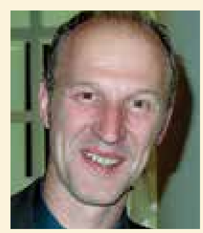
- → S4: Glass Technology Aand Cross-cutting Topics
- → S5: Glass Education

GOMD 2021 AWARD SPEAKERS

MONDAY, DEC. 13

VARSHNEYA GLASS SCIENCE AWARD



Professor Joachim Deubener
Institute of Non-Metallic Materials, Clausthal University of Technology, Germany

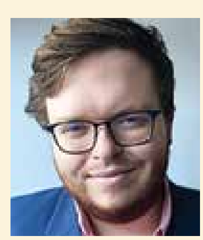
Mechanical properties and thermal behavior of hydrous glasses

GEORGE W. MOREY AWARD

Professor Walter Kob
University of Montpellier, France

Glass: We love it, but it breaks

NORBERT J. KREIDL AWARD FOR YOUNG SCHOLARS



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Confirming classical nucleation theory with novel energy landscape methods

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Electronic Materials and Applications 2022 (EMA 2022) is an international conference focused on electroceramic materials and their applications in electronic, electrochemical, electromechanical, magnetic, dielectric, biological, and optical components, devices, and systems. Jointly programmed by the Electronics Division and Basic Science Division of The American Ceramic Society, EMA 2022 will take place at the DoubleTree by Hilton Orlando at Sea World, Jan. 19–21, 2022.

EMA 2022 is designed for scientists, engineers, technologists, and students interested in basic science, engineering, and applications of electroceramic materials. Participants from across the world in academia, industry, and national laboratories exchange information and ideas on the latest developments in theory, experimental investigation, and applications of electroceramic materials.

Students are highly encouraged to participate in the meeting. Prizes will be awarded for the best oral and poster student presentations.

The technical program includes plenary talks, invited lectures, contributed papers, poster presentations, and open discussions. EMA 2022 features symposia focused on dielectric, piezoelectric, pyroelectric, magnetoelectronic, (multi)ferroic, quantum, relaxor, optoelectronic, and photonic ceramics; complex oxide thin films, heterostructures, and nanocomposites; semiconductors; superconductors; ion-conducting ceramics; 5G materials for millimeter-wave technology; and functional biological materials. Other symposia emphasize broader themes covering processing, microstructure evolution, and integration; effects of surfaces and interfaces on processing, transport, and properties; point defects, dislocations, and grain boundaries; mesoscale phenomena; and advanced characterization and computational design of electronic materials.

EMA includes several networking opportunities to facilitate collaborations for scientific and technical advances related to materials, components, devices, and systems. The Basic Science Division will again host a tutorial session in addition to the regular conference programming.

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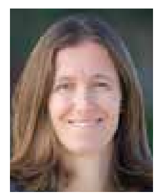
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TECHNICAL PROGRAM

- **S1 – Characterization of Structure–Property Relationships in Functional Ceramics**
- **S2 – Advanced Electronic Materials: Processing Structures, Properties, and Applications**
- **S3 – Frontiers in Ferroic Oxides: Synthesis, Structure, Properties, and Applications**
- **S4 – Complex Oxide Thin Films and Heterostructures: From Synthesis to Strain/Interface-engineered Emergent Properties**
- **S5 – Mesoscale Phenomena in Ferroic Nanostructures: From Patterns to Functionalities**
- **S6 – Emerging Semiconductor Materials and Interfaces**
- **S7 – Superconducting and Related Materials: From Basic Science to Applications**
- **S8 – Structure–Property Relationships in Relaxor Ceramics**
- **S9 – Ion-conducting Ceramics**
- **S10 – Point Defects and Transport in Ceramics**
- **S11 – Evolution of Structure and Chemistry of Grain Boundaries and Their Networks as a Function of Material Processing**
- **S12 – 5G Materials and Applications Telecommunications**
- **S13 – Agile Design of Electronic Materials: Aligned Computational and Experimental Approaches and Materials Informatics**
- **S14 – Functional Materials for Biological Applications**
- **S15 – Advanced Microelectrics**

SAVE THE DATE JAN. 23–28, 2022

46TH INTERNATIONAL CONFERENCE AND EXPOSITION ON ADVANCED CERAMICS AND COMPOSITES

Hilton Daytona Beach Resort and Ocean Center | Daytona Beach, Fla., USA

We are pleased to announce that the 46th International Conference & Exposition on Advanced Ceramics & Composites (ICACC 2022) will be held from Jan. 23–28, 2022, in Daytona Beach, Fla. This conference has a strong history of being the preeminent international meeting on advanced structural and functional ceramics, composites, and other emerging ceramic materials and technologies. The Engineering Ceramics Division (ECD) of The American Ceramic Society has organized this esteemed event since 1977. Due to the high quality of technical presentations and unique networking opportunities, this event has achieved tremendous worldwide interest and has attracted active participation from ceramic researchers and developers from the global technical community thanks to the dedication and support of our membership.

We look forward to seeing you in Daytona Beach, Fla., in January 2022!

Palani Balaya
Program chair, ICACC 2022
National University of Singapore
mpepb@nus.edu.sg

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PLENARY SPEAKERS

Monday, Jan 24

THOMAS SPECK

University of Freiburg and Cluster of Excellence Living, Adaptive and Energy-autonomous Materials Systems (livMatS), Germany

Plant materials systems and structures: Bio-inspiration for a "greener" technology in the 21st century

Y. SHIRLEY MENG

Zable Chair Professor in Energy Technologies and professor in Materials Science & NanoEngineering, University of California San Diego, USA

Designing better ceramic materials for future batteries

GLOBAL YOUNG INVESTIGATOR AWARD

Sunmi Shin

National University of Singapore, Singapore

Thermal engineering using infrared photonic structures: probing coherent thermal emission in a single nano-object

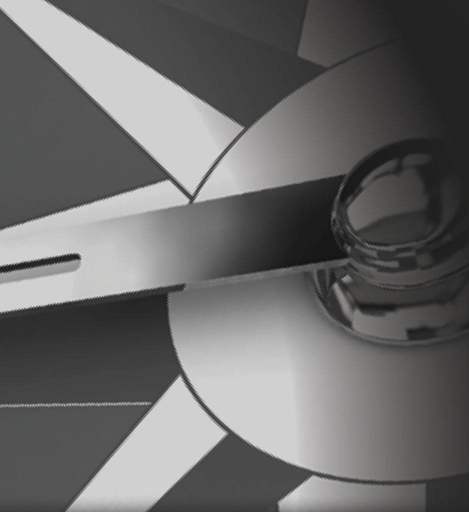
MECHANICAL PROPERTIES OF CERAMICS AND GLASS 2022 SHORT COURSE

Jan. 27–28, 2022 | 8:30 a.m. – 5 p.m.; 8:30 a.m. – 5 p.m.

Location: In conjunction with ICACC2022, Hilton Daytona Beach Resort and Ocean Center, Daytona Beach, Fla., USA

Instructor: **George D. Quinn, NIST**

If you are an engineer, scientist, student, technician, or manager interested in the mechanical properties of glasses and ceramics, testing procedures, and the meaning of testing results, then this is an excellent option for you. A preeminent leader of the industry teaches this two-day short course that will be held in conjunction with the 46th International Conference on Advanced Ceramics and Composites (ICACC22).



ACerS is pleased to announce the addition of a hybrid option for ICACC '22 to allow participation by individuals who cannot attend in-person due to travel restrictions. We plan to provide a hybrid solution that will incorporate prerecorded talks from virtual attendees into the live onsite programming. All live sessions will be recorded for all attendees to view at the conclusion of the live conference, available until March 31, 2022.

ceramics.org/icacc2022

ORGANIZED BY THE ENGINEERING CERAMICS DIVISION OF THE AMERICAN CERAMIC SOCIETY

SYMPOSIA

S1: Mechanical Behavior and Performance of Ceramics and Composites

S2: Advanced Ceramic Coatings for Structural, Environmental, and Functional Applications

S3: 19th International Symposium on Solid Oxide Cells (SOC): Materials Science and Technology

S4: Armor Ceramics – Challenges and New Developments

S5: Next Generation Bioceramics and Biocomposites

S6: Advanced Materials and Technologies for Rechargeable Energy Storage

S7: 16th International Symposium on Functional Nanomaterials and Thin Films for Sustainable Energy Harvesting, Environmental and Health Applications

S8: 16th International Symposium on Advanced Processing and Manufacturing Technologies for Structural and Multifunctional Materials and Systems (APMT16)

S9: Porous Ceramics: Novel Developments and Applications

S10: Modeling and Design of Ceramics and Composites

S11: Advanced Materials and Innovative Processing Ideas for Production Root Technologies

S12: On the Design of Nanolaminated Ternary Transition Metal Carbides/Nitrides (MAX Phases) and Borides (MAB Phases), Solid Solutions thereof, and 2D Counterparts (MXenes, MBenes)

S13: Development and Applications of Advanced Ceramics and Composites for Nuclear Fission and Fusion Energy Systems

S14: Crystalline Materials for Electrical, Optical, and Medical Applications

S15: 6th International Symposium on Additive Manufacturing and 3D Printing Technologies

S16: Geopolymers, Inorganic Polymers, and Sustainable Materials

S17: Advanced Ceramic Materials and Processing for Photonics and Energy

S18: Ultrahigh-temperature Ceramics

HONORARY SYMPOSIUM AND FOCUSED SESSIONS

Emergent Materials and Sustainable Manufacturing Technologies in a Global Landscape: International Symposium in Honor of Dr. Tatsuki Ohji

Special Focused Session on Diversity, Entrepreneurship, and Commercialization

11th Global Young Investigator Forum

FS1: Bio-inspired, Green Processing, and Related Technologies of Advanced Materials

FS2: Materials for Thermoelectrics

FS3: Molecular-level Processing and Chemical Engineering of Functional Materials

FS4: Ceramic/Carbon Reinforced Polymers

FS5: Current Challenges in Microstructural Evolution: From Fundamentals to Engineering Applications

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Make reservations online under Hotel and Travel link at ceramics.org/icacc2022 or reserve by telephone, mention The American Ceramic Society to obtain the special rate.

Room rates are effective until Jan. 1, 2022, and are based on availability.

Calendar of events

October 2021

12–15 ➨ International Research Conference on Structure and Thermodynamics of Oxides/carbides/nitrides/borides at High Temperature (STOHT) – Arizona State University, Ariz.; https://mccormacklab.engineering.ucdavis.edu/events/structure-and-thermodynamics-oxidescarbidesnitridesborides-high-temperatures-stoht2020

17–21 ➨ ACerS 123rd Annual Meeting with Materials Science & Technology 2021 – Greater Columbus Convention Center, Columbus, Ohio; https://ceramics.org/mst21

18–20 Flourine Forum 2021 – Pan Pacific Hanoi, Vietnam; http://imformed.com/get-imformed/forums/fluorine-forum-2020

25–27 China Refractory Minerals Forum 2021 – InterContinental, Dalian, China; http://imformed.com/get-imformed/forums/china-refractory-minerals-forum-2020

November 2021

1–4 ➨ 82nd Conference on Glass Problems – Greater Columbus Convention Center, Columbus, Ohio; http://glassproblemsconference.org

15–17 ➨ ACTSEA 2021 7th International Symposium on Advanced Ceramics and Technology for Sustainable Energy Applications toward a Low Carbon Society – National Taipei University of Technology, Taiwan; https://materweek2021.conf.tw

December 2021

12–17 14th Pacific Rim Conference on Ceramic and Glass Technology (PACRIM 14) – Hyatt Regency Vancouver, Vancouver, British Columbia, Canada; www.ceramics.org/PACRIM14

January 2022

18–21 Electronic Materials and Applications 2022 (EMA 2022) – DoubleTree by Hilton Orlando at Sea World Conference Hotel, Orlando, Fla.; https://ceramics.org/ema2022

23–28 46th International Conference and Expo on Advanced Ceramics and Composites (ICACC2022) – Hilton Daytona Beach Oceanfront Resort, Daytona Beach, Fla.; https://ceramics.org/icacc2022

March 2022

15–18 17th Biennial Worldwide Congress Unified International Technical Conference on Refractories – Hilton Chicago, Chicago, Ill.; https://ceramics.org/unitecr2021

May 2022

22–26 Glass & Optical Materials Division Annual Meeting (GOMD 2022) – Hyatt Regency Baltimore, Baltimore, Md.; https://bit.ly/3ftnJql

9–12 ACerS 2022 Structural Clay Products Division & Southwest Section Meeting in conjunction with the National Brick Research Center Meeting – Omni Charlotte Hotel, Charlotte, N.C.; https://bit.ly/31zyfob

June 2022

13–15 12th Advances in Cement-Based Materials (Cements 2022) – University of California, Irvine; https://ceramics.org/event/12th-advances-in-cement-based-materials

July 2022

3–8 ➨ ICG Annual Meeting 2022 – Berlin, Germany; https://ceramics.org/event/icg-annual-meeting-2022

10–14 International Congress on Ceramics (ICC9) – Krakow, Poland; https://ceramics.org/event/international-congress-on-ceramics-icc9

24–28 Pan American Ceramics Congress and Ferroelectrics Meeting of Americas (PACC-FMAs 2022) – Hilton Panama, Panama City, Panama; https://ceramics.org/PACCFMAs

October 2022

14–19 ACerS 124th Annual Meeting with Materials Science & Technology 2022 – David L. Lawrence Convention Center, Pittsburgh, Pa.; https://ceramics.org/event/acers-124th-annual-meeting-with-materials-science-technology-2022

July 2024

14–19 International Congress on Ceramics – Hotel Bonaventure, Montreal, Canada; www.ceramics.org

Dates in **RED** denote new event in this issue.

Entries in **BLUE** denote ACerS events.

➨ denotes meetings that ACerS cosponsors, endorses, or otherwise cooperates in organizing.

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Benard Tabu and **Michael Spencer**
Guest columnists

Innovative approach to learning and teaching of sciences in Africa

Despite concerted efforts to adopt the United Nations' 17 sustainable development goals (SDGs),[1] Africa still lags the rest of the world. In fact, 90% of Africans currently live in extreme poverty,[2] which affects access to quality education, good health, and other SDGs.

Although the literacy rate has steadily increased to 66% over the last four decades,[3] access to quality education, particularly in Sub-Saharan Africa, remains low. Furthermore, institutions for higher education continue to endure inadequate access to teaching and learning resources, such as laboratory equipment, internet, human resources, and physical infrastructure. This access barrier inevitably compromises the quality of teaching and learning of science, technology, and mathematics (STEM) disciplines, which demand additional teaching and learning tools for effective learning.

In 2013, Veronica Augustyn (NC State University, U.S.) and John-Paul Eneku (Makerere University, Uganda) initiated a collaborative effort with six partner universities to enhance the quality of STEM learning in African universities.[4] Called the SciBridge project (scibridge.org), this student-led organization develops low-cost experiment kits focusing on energy technologies.

SciBridge volunteers in the U.S. form groups specific to each experiment kit and proceed with three stages of kit development. First, students learn the basic scientific principles and background associated with the technology of interest. This information is then used to design a prototype kit that enables students to observe the relationship between material properties and device performance. Once a successful prototype is established, students prepare an experiment manual complete with fundamental scientific principles, experiment procedures, and questions for the participants. Finally, kits containing the necessary supplies, experiment manual, and video tutorial of the experiment are packaged with enough materials to support a full classroom.

Faculty members at African universities coordinate SciBridge activities that are integrated into undergraduate curricula. Students gain hands-on experience with the materials through the instructor-led experiments, strengthening their understanding and building a solid foundation for future studies. Access to equipment provided in the SciBridge kits also enables research capabilities beyond the classroom as students perform research at the bachelor's and master's level in energy-related areas such as solar electrical performance of different leaves and low-cost technology to harness solar energy. To reach more students and classrooms, SciBridge has added four partner universities and has partnered with other organizations offering similar initiatives, such as JUAMI,[5] SciFro,[6] and WS2,[7] by contributing experiment kits, learning materials, and kit development support.

The approach that SciBridge uses for kit design and exchange broadly impacts students in both Africa and the U.S. More learning resources in the classrooms at African universities create environments that are conducive to strengthening the learner–instructor rapport. In the U.S., the students that are developing kits learn the scientific principles while gaining leadership skills and research experience as they go through the scientific process. Bridging students from the U.S. and Africa broadens individual perspectives and encourages new possibilities for research collaborations and careers in STEM.

Credit: Michael Spencer

Figure 1. Schematic illustrating the SciBridge development and implementation process.

References

[1]UN General Assembly, *Transforming our world: the 2030 Agenda for Sustainable Development*, 21 October 2015, A/RES/70/1, available at: https://www.refworld.org/docid/57b6e3e44.html [accessed 25 August 2021]

[2]The Sustainable Development Goals Center for Africa and Sustainable Development Solutions Network (2020): Africa SDG Index and Dashboards Report 2020. Kigali and New York: SDG Center for Africa and Sustainable Development Solutions Network.

[3]World Bank (2021): Literacy rate, adult total (% of people ages 15 and above) Sub-Saharan Africa. Retrieved on July 23, 2021. Available from https://data.worldbank.org/indicator/SE.ADT.LITR.ZS?locations=ZG

[4]V. Augustyn & J. P. Eneku, "Building the SciBridge between Africa and the United States," *Science & Diplomacy*, Vol. 4, No. 4 (2015).

[5]https://www.juami.org

[6]http://www.scifro.org

[7]https://ws2global.org/about-us

Benard Tabu is a doctoral student in mechanical and energy engineering at University of Massachusetts Lowell, working under Prof. Juan Pablo Trelles. His research focuses on applications of low-temperature atmospheric plasma for chemical synthesis, particularly solid waste recovery. He was formerly an assistant lecturer in the Department of Physics at Gulu University (Uganda), where he served as SciBridge Coordinator.

Michael Spencer is a Ph.D. candidate in materials science and engineering at NC State University, working under Prof. Veronica Augustyn. His research focuses on understanding the influence of confinement on electrochemical reactivity. He served on the SciBridge executive committee for three years and contributed to developing two experiment kits.

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