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An Outline

- A brief personal introduction
- Trends in engineering education in the US
- MSE/CerE education in the US
 - Are industry needs met by MSE?
 - Role of industry specific graduate research
 - "The Corning Proposal"
- ACerS and potential partnerships with industry and universities
- What might we do from here?

I am a ceramic engineer- by training and choice

- BS in Ceramic Engineering, NYS College of Ceramics, Alfred Univ.
- MS in Glass Science, NYS College of Ceramics, Alfred Univ.
- PhD in Ceramic Science, Penn State University
- 12 years at Sandia National Labs (Albuquerque)- Ceramic Materials Division
- Missouri S&T (Missouri-Rolla) since 1998- Ceramic Engineering (now in an MSE Department)

So "yes, I think Ceramic Engineering really does matter".

My research group is interested in glass structure, properties and applications



So- what's the future of ceramic engineering?



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Accredited Ceramic Engineering Programs: 2007/20



There are two ABET-accredited, undergraduate ceramic engineering programs in the USA

Alfred University 1936 Missouri S&T 1936

Does this really matter to you?

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A similar situation exists for metallurgical engineering programs

•	University of Alabama	1949
•	Colorado School of Mines	1936
•	Missouri S&T	1936
•	Montana Tech	1937
•	South Dakota School of	1936
	Mines and Technology	
•	University of TX, El Paso	1947
•	University of Utah	1936



There has been steady growth in the numbers of MSE/MetE/CerE undergraduate degrees for the past decade



Engineering by the Numbers, ASEE (2012)

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BACHELOR'S DEGREES AWARDED BY ENGINEERING DISCIPLINE: 88,176*



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Engineering makes up 8% of BS degrees awarded in the US





https://nces.ed.gov/programs/digest/d11/figures/fig_16.asp?referrer=figures

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S&E bachelor's degrees, by field: 2000-09



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MSE is an engineering discipline that attracts women

PERCENTAGE OF BACHELOR'S DEGREES AWARDED TO WOMEN BY DISCIPLINE: 18.9% OF TOTAL



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Women's share of S&E bachelor's degrees, by field: 2000–09



Figure 2. Number of doctor's degrees awarded by degree-granting institutions in selected fields of study: Academic years 2000-01 and 2010-11



https://nces.ed.gov/programs/coe/indicator_ctb.asp

There has been growth in MSE degrees at all levels



Advanced degrees dominate MSE programs



Advanced degrees dominate MSE programs



MSE undergraduate curricula often reflect the graduate emphasis of an MSE program

Core Topics for MSE Curricula Other Introduction to Materials **Materials Science** Engineering **Experimental Techniques** and Engineering Thermodynamics General Social Science **Transport Properties** and Humanities Phase Equilibria Phase Transformation Kinetics Structure **Mathematics** Characterization **Mechanical Behavior** Electronic, Magnetic, and **Optical Behavior** Physics Synthesis, Processing, and Manufacturing **Materials Field** Materials Selection and Chemistry Specific

The Future of Materials Science and Materials Engineering Education- NSF, Sept. 2008

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Design

Failure Analysis

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What's Missing? In-depth training in ceramic-related topics

- Phase Diagrams, 3 hr/required
- Glass Sci&Tech, 3 hr/required
- Sintering/processing, 3 hr/required
- Thermodynamics- emphasis on ceramics
- Kinetics- emphasis on ceramics
- Analytical techniques- emphasis on ceramics
- Properties of ceramics (thermal, mechanical, electrical, etc)



A CerE curriculum has room for labs devoted to processing and properties of ceramic materials



An Aside- The Corning View of Glass Science in the United States

International Journal of Applied Glass Science, 5 [1] 2–15 (2014) DOI:10.1111/ijag.12058

Applied Glass SCIENCE

Glass Science in the United States: Current Status and Future Directions

John C. Mauro,* Charles S. Philip, Daniel J. Vaughn, and Michael S. Pambianchi

Science and Technology Division, Corning Incorporated, Corning, New York, 14831

- Reviewed 925 "glass" papers published between 2007 and 2013
- Classified papers based on types of glasses and subject matter

Results from the Corning analysis: Breakdown by the type of glass

Mauro, et al., IJAGS 5[1] (2014)



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"Less than one-quarter of students at US universities who are doing research in glass science are studying systems that would make them well-prepared for a future career in the glass industry"

Underserved research areas:

- Glass-ceramics and crystallization behavior
- Fracture mechanics
- Glass surfaces
- Acoustic properties and thermal conductivity
- Science & technology of glass melting and processing

Finish with a call for government and universities to focus on research relevant to the glass industry

Mauro, et al., IJAGS 5[1] (2014)

Some questions for those in the business of ceramic materials:

- Does a CerE BS degree really matter?
- What type of engineer will **you** need? Does interest in, or experience with, ceramic materials matter?
- How do you find those engineers?

Industry can be pro-active in the education of future engineers

Some thoughts on building industry-university partnerships...

- Hire interns and co-op students
- Sponsor senior design or senior thesis projects
- Support summer camps
- Serve on industrial advisory boards
- Participate in campus job fairs
- Provide samples and materials for displays or classroom discussions
- Host plant tours
- Donate equipment
- Provide seminars
- Get involved!







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Is there a role that ACerS can play?



President's Council of Student Advisors

Mission

The mission of PCSA is to engage students as active and long-term leaders in the ceramics community and to increase participation in ACerS at the local and national levels.

Goals

- To coordinate student-focused ceramic programming at technical meetings
- To develop and implement ceramics-focused outreach activities
- To facilitate industry-student relations
- To promote ceramic science and engineering at the university and local levels
- To provide a way for students and young professionals to become and remain actively engaged as leaders in the ceramic materials community

2012 PCSA Delegate Universities

Alfred University Univ. California-Irvine University of Delaware University of Florida Florida International University Georgia Tech Iowa State University McMaster Univ, Missouri S&T New Mexico Tech Oregon State University The Pennsylvania State University Purdue University Virginia Tech University of Washington



CERAMICANDGLASSINDUSTRY FOUNDATION



"Championing the unique materials and people with the power to change the world "

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CERAMICANDGLASSINDUSTRY FOUNDATION

- Global Internships
- Scholarships
- University-Industry Network
- Continuing Education and Training
- Student Outreach



MISSION: The mission of the **CGIF** is to ensure that industry is able to attract and train the highest quality talent available to work with engineered systems and products that utilize ceramic and glass materials.

The Foundry Educational Foundation is an interesting model for the CGIF



Mission

The Foundry Educational Foundation strengthens the metal casting industry by supporting unique partnerships among students, educators and industry, helping today's students become tomorrow's leaders.

- In place since 1947
- Each school has a "Key Professor" as student-industry liaison
- Accredited schools must have an industrial advisory committee or board focused on cast metals
- Primarily provides undergraduate scholarship support and discretionary spending support for the schools



FEF Corporate Donors-Widespread Support

	Donor Level	
Glass $\$500,000$ to $\$999,999$ 2Sapphire $\$250,000$ to $\$499,999$ 5Perovskite $\$150,000$ to $\$249,999$ 9Zr-diboride $\$100,00$ to $\$149,999$ 11Silicon Nitride $\$50,000$ to $\$99,999$ 38Alumina $\$20,000$ to $\$49,999$ 57Porcelain $\$10,000$ to $\$19,999$ 132Other $\le\$10,000$ 167	Glass Sapphire Perovskite Zr-diboride Silicon Nitride Alumina Porcelain Other	



FEF is Led by Industry

- Regional and at-large directors: 49 industrial leaders <u>NO FACULTY</u>
- Executive committee 10 industrial leaders, 1 faculty representative
- Advisory Committee meets annually on campus. This committee helps relate the concerns of the industry, as well as providing equipment, supplies, speakers, plant tours of local companies, etc.



Financial support is distributed by Key Professors

	Discretionary Funds	Scholarship Funds
•	 Typically \$20k-\$40K per year at each certified school Used for: Student travel Software purchases Laboratory supplies and safety equipment (although excess new safety equipment was also contributed by members) Match funding for new equipment purchases Cash for equipment purchases in pre-owned market 	

What if we had a "Key Professor" for ceramics in every MSE program?



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THE FUTURE OF MATERIALS SCIENCE AND MATERIALS ENGINEERING EDUCATION

A report from the Workshop on Materials Science and Materials Engineering Education sponsored by the National Science Foundation September 18-19, 2008 in Arlington, VA

- Public Education and Outreach
- K-12 Education
- Undergraduate Education





Discovering materials

"My freshman ceramics research experience at Purdue made me appreciate the diverse applicability and potential of ceramics. I was fascinated by how seemingly minor differences in the way a ceramic part was prepared could dramatically affect its final properties, making ceramics useful in applications ranging from medicine to aerospace." — Valerie Weisner, NASA Glenn Research Center

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There are opportunities to provide supplemental training for engineers in the workforce

- Short courses
- Web-based products
- Background information on ceramic materials
- In-depth CerE skills (i.e., phase diagrams)
- Introduction to new technologies, etc.



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So- Does Ceramic Engineering Really Matter?

This is a question that can only be answered by those who hire new engineers.....

.....but you will find willing partners in the universities, and in the American Ceramic Society.

Thank you for supporting the ceramics community

....and thanks for listening!

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