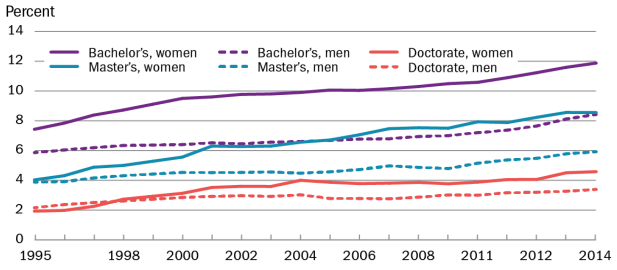
SAND2017-10988C

Exceptional service in the national interest

Sandia National Laboratories

Science and engineering degrees earned by underrepresented minority women and men: 1995–2014



NOTE: Data not available for 1999.
Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017
Special Report NSF 17-310

Diversity in STEM: Measures, Means and a Path Forward

Technical Meeting and Exhibition
MS&T17
MATERIALS SCIENCE & TECHNOLOGY

OCTOBER 8 – 12, 2017
DAVID L. LAWRENCE CONVENTION CENTER
PITTSBURGH, PENNSYLVANIA, USA

Jonathan D. Madison, Ph.D.
Sandia National Laboratories, Albuquerque, NM

U.S. DEPARTMENT OF ENERGY
NNSA National Nuclear Security Administration

Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Acknowledgements

- Liz Holm – Carnegie Mellon University
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- Keivan Stassun & Dina Stroud – Fisk-Vanderbilt Master's-to-Ph.D. Bridge Program
- Lynette Madsen – National Science Foundation

- Mike Bazzy – TMS
- Beate Helsel – TMS
- Justin Scott – TMS
- Susan Davis – ASM

- Data Sources:
- NSF, National Center for Science and Engineering Statistics – *Women, Minorities and Persons with Disabilities in Science and Engineering, 2017,* Special Report NSF 17-310
- US Bureau Labor Statistics, 2016
- US Census Bureau, Quick Facts, 2016
- TMS Member Statistics, 2016
- US Department of Education, 2016
- NSF, HBCU Report, 2015
- National Center for Education Statistics (NCES), 2015
- American Institutes for Research, 2014

Outline

Sandia National Laboratories

I. WHERE ARE WE? – BY THE NUMBERS

II. WHAT THE DATA SUGGESTS REGARDING POSITIVE OUTCOMES

III. SUCCESS STORIES

- *Linda Abriola – Tufts University*
- *Dina Stroud – Fisk/Vanderbilt Partnership*

IV. SUGGESTED PATHS FORWARD

IV. DMMM3

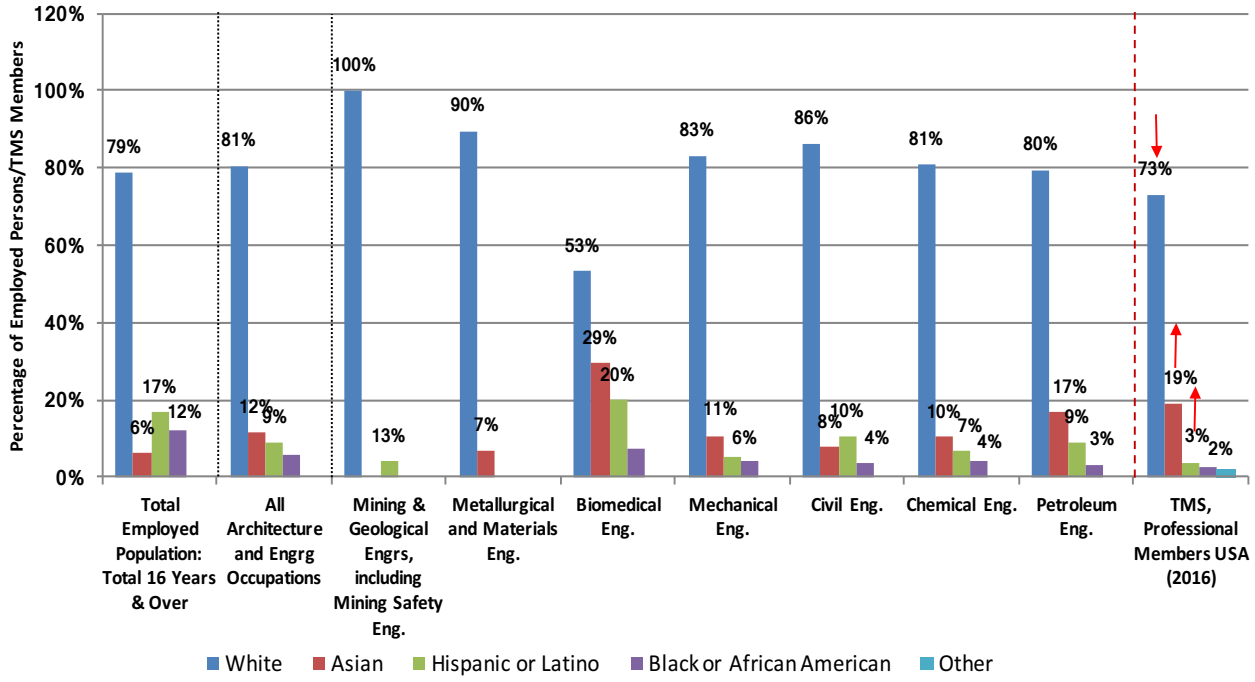
V. CONCLUDING THOUGHTS

Data – Employment by Discipline I

According to Ethnicity

Sandia National Laboratories

Employed Persons in Metallurgical and Materials and Other Engineering Disciplines by Ethnicity

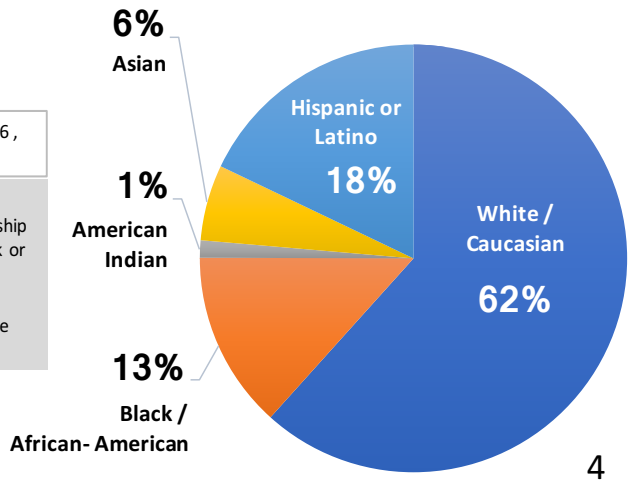


Source: BLS Table 1. Employed and experienced unemployed person by detailed occupation, sex, race, and Hispanic or Latino ethnicithy, Annual Average 2016 , Current Population Survey; TMS Membership Statistics, 2016

Note:
- The percentage of "White" TMS Professional Members (USA) decreased from 81% in 2017 to 73% in 2016. An increase can be noted in the "Asian" membership from 13% in 2014 to 19% in 2016. The percentage of "Hispanic/Latino" TMS Professional Members increased from 2% to 3% in 2016. The percentage of "Black or Afrian/American" and the "Other" category remained the same.
- Totals may not add up to 100% per category. Statistics based on the CPS are subject to both sampling and nonsampling error. **The estimates shown in this graph are from unpublished data tables and should be viewed with extra caution, as some are based on a very small number of observations**. Generally, the BLS will not publish percents or medians for occupations or industries with a base of less than 50,000 for annual averages and 75,000 for quarterly averages.

Source: U.S. Census Bureau, Quick Facts, 2016

US Population by Ethnicity (2016)

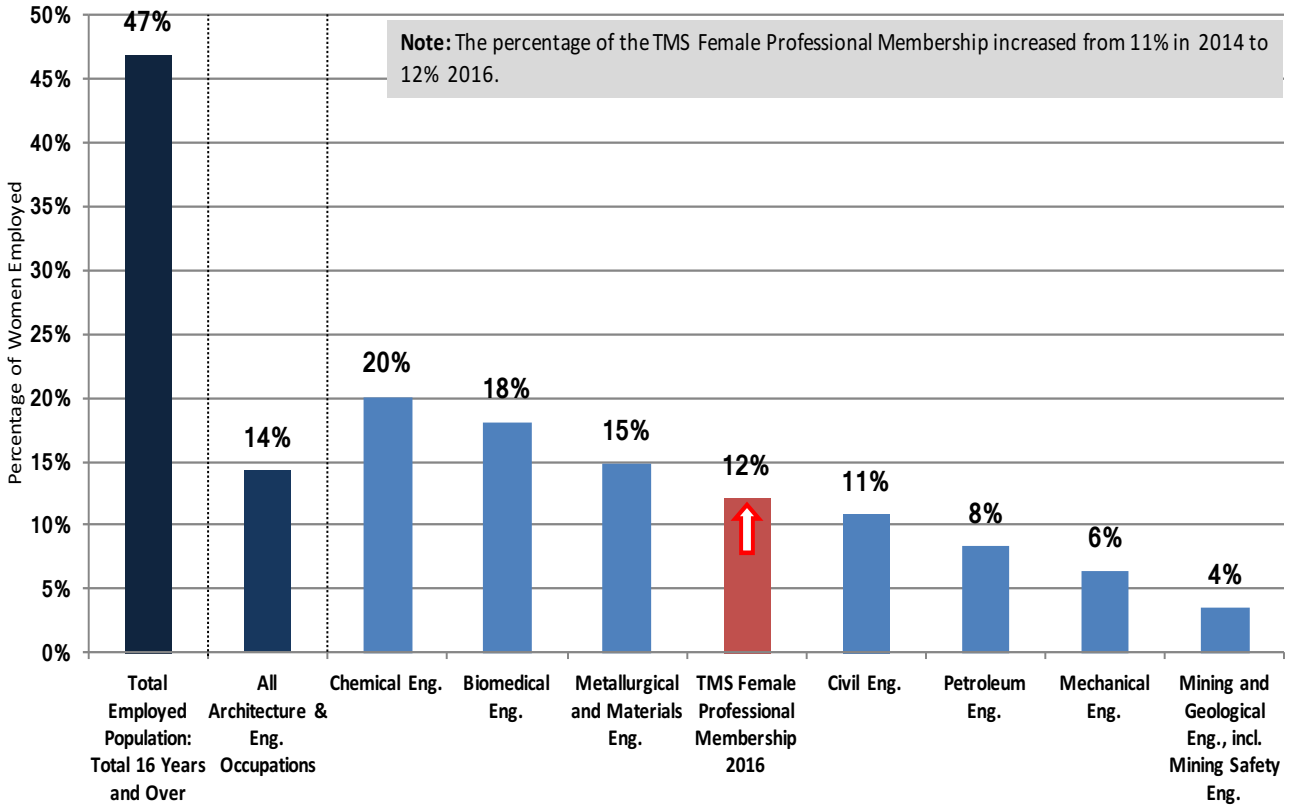


Data – Employment by Discipline II

According to Gender

Sandia National Laboratories

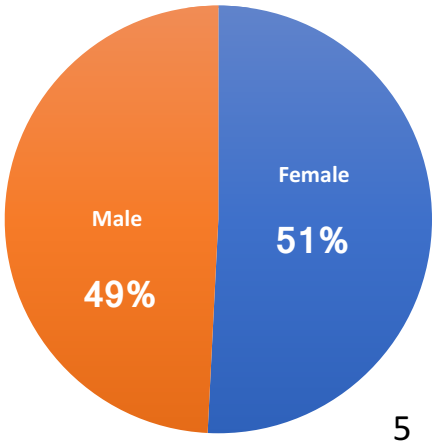
Employed Women in Materials Science and Engineering and Other Engineering Disciplines



Source: BLS Table 1. Employed and experienced unemployed person by detailed occupation, sex, race, and Hispanic or Latino ethnicithy, Annual Average 2016, Current Population Survey; TMS Membership Statistics, 2016

Source: U.S. Census Bureau, Quick Facts, 2016

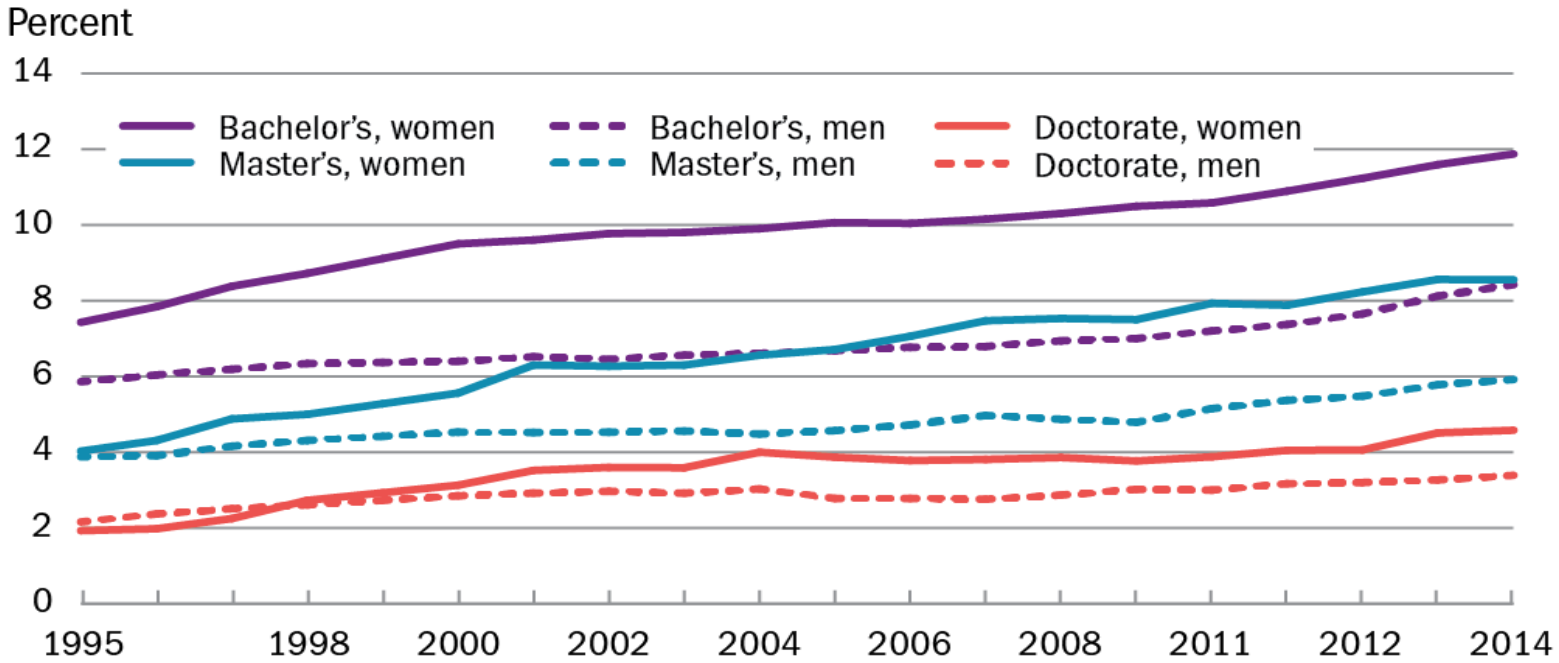
US Population by Gender (2016)



Data – % Share Degrees Earned I

Underrepresented Populations Across All Degree Levels of STEM

Science and engineering degrees earned by underrepresented minority women and men: 1995–2014



NOTE: Data not available for 1999.

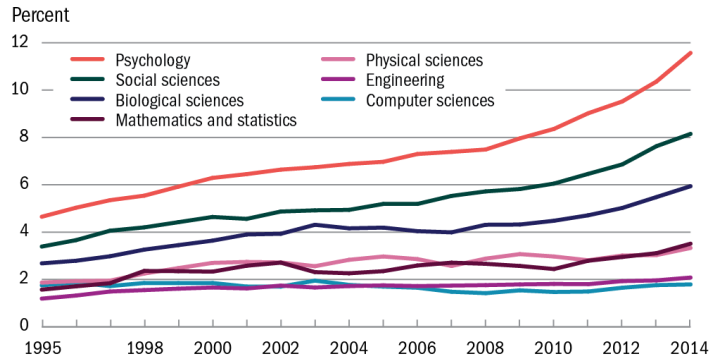
Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017

Source: National Science Foundation, National Center for Science and Engineering Statistics. 2017. *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017.* Special Report NSF 17-310. Arlington, VA. Available at www.nsf.gov/statistics/wmpd/.

Data – % Share Degrees Earned II

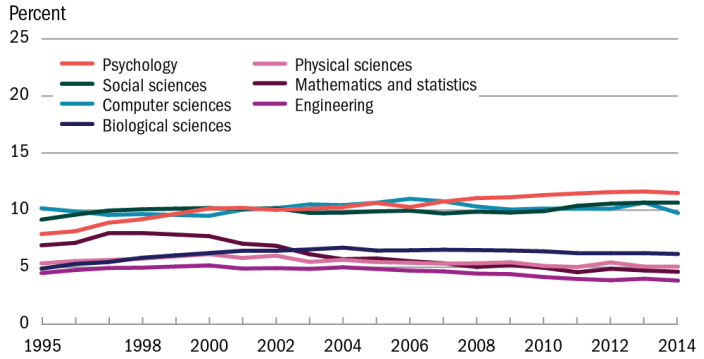
Select Underrepresented Populations Across All STEM Fields

Science and engineering bachelor's degrees earned by Hispanic women, by field: 1995–2014



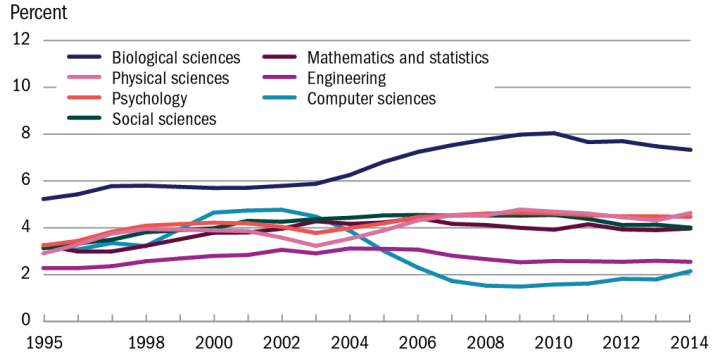
NOTES: Data not available for 1999. Hispanic may be any race.
Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017

Science and engineering bachelor's degrees earned by blacks or African Americans, by field: 1995–2014



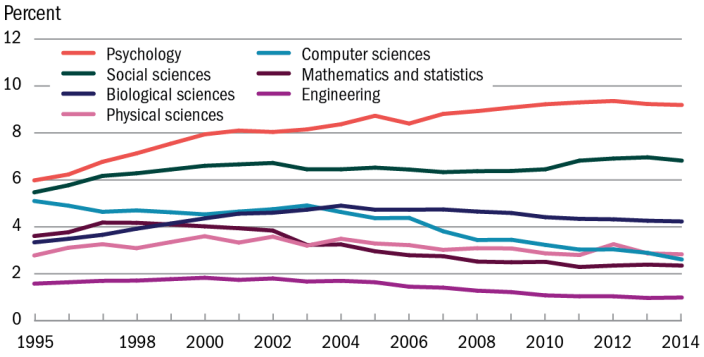
NOTE: Data not available for 1999.
Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017

Science and engineering bachelor's degrees earned by Asian women, by field: 1995–2014



NOTE: Data not available for 1999.
Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017

Science and engineering bachelor's degrees earned by black or African American women, by field: 1995–2014



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Source: National Science Foundation, National Center for Science and Engineering Statistics. 2017. *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017*. Special Report NSF 17-310. Arlington, VA. Available at www.nsf.gov/statistics/wmpd/.

“Numbers provide information regarding the state of things but numbers do not necessarily tell us the why”

– Liz Holm –

Professor, Materials Science & Engineering, Carnegie Mellon University

“We must unravel the differences between correlation and causation in our diversity efforts. Failure to do so can often result in policy too broad or policy that is improper in its implementation”

– David Bahr –

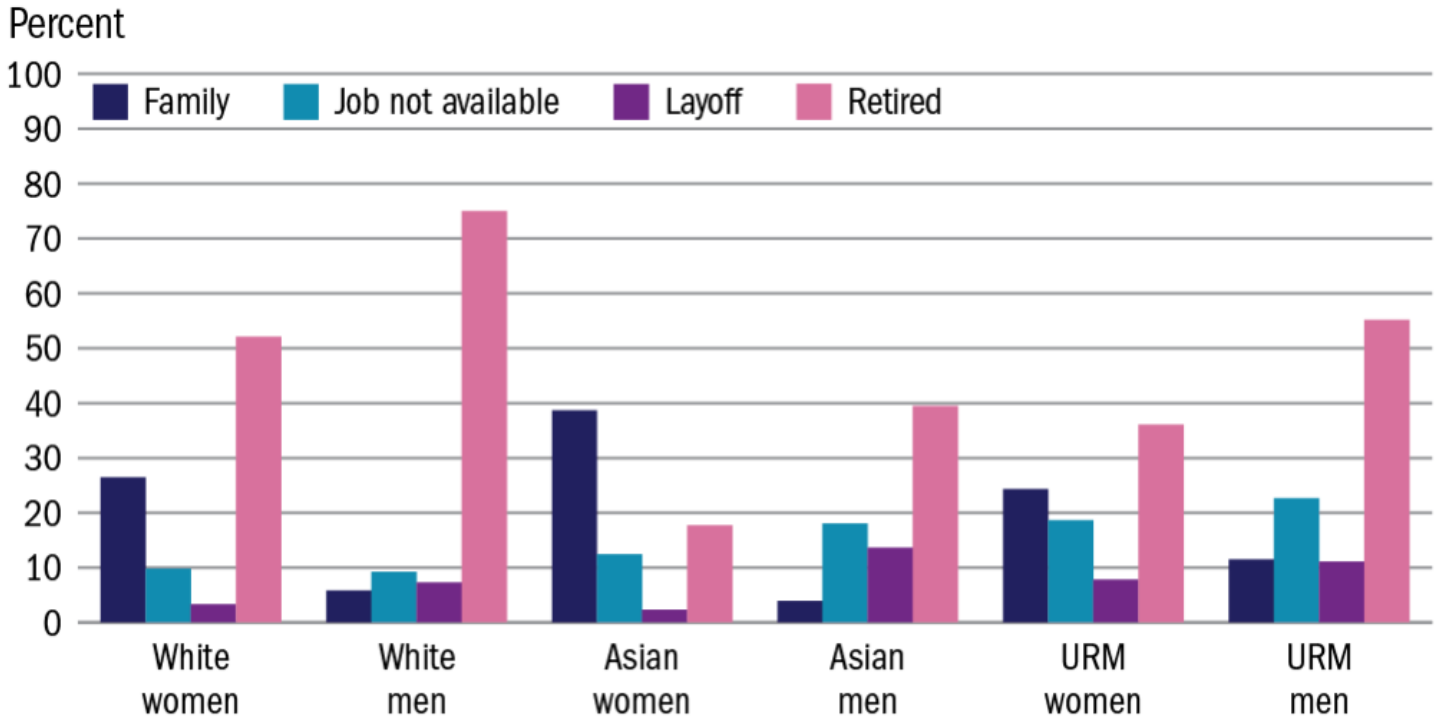
Chair & Professor, Materials Engineering, Purdue University

Data – Workforce Departure

Across Varying Populations

Sandia National Laboratories

Reasons for not working among scientists and engineers: 2015



URM = underrepresented minority.

NOTE: Not all reasons are shown; respondents could select more than one reason.

Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017

Source: National Science Foundation, National Center for Science and Engineering Statistics. 2017. *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017.* Special Report NSF 17-310. Arlington, VA. Available at www.nsf.gov/statistics/wmpd/.

Quotes to Consider

"Culture is contextual, fluid and tremendously complex, as such the approaches used to shape, influence and impact the cultures of diversity and inclusion must possess similar traits"

- Chris Yates -

Director of Organizational Development, Caterpillar

"Policies may start at the top; however, we are all responsible for taking action to help shift the culture"

- Daniel Linzer -

Provost, Northwestern University

jdmadis@sandia.gov

SUCCESS STORY I

Tufts UNIVERSITY | School of Engineering

Recruitment and Attrition

- 59% increase in applications to the SOE in the past five years, 102% increase in the last 10 years
- Over the past ten years, female enrollment has increased from 26% for the class of 2009 to 33% for the class of 2018
- We graduate as may engineers as we matriculate – ZERO NET ATTRITION
- 99% of our freshmen in engineering graduate in 4 years
- Women are performing as well as the men – average GPA (combined grads 2001-05) :
  - females: 3.30/4.0 (29.1% of 973 grads)
  - males: 3.24/4.0

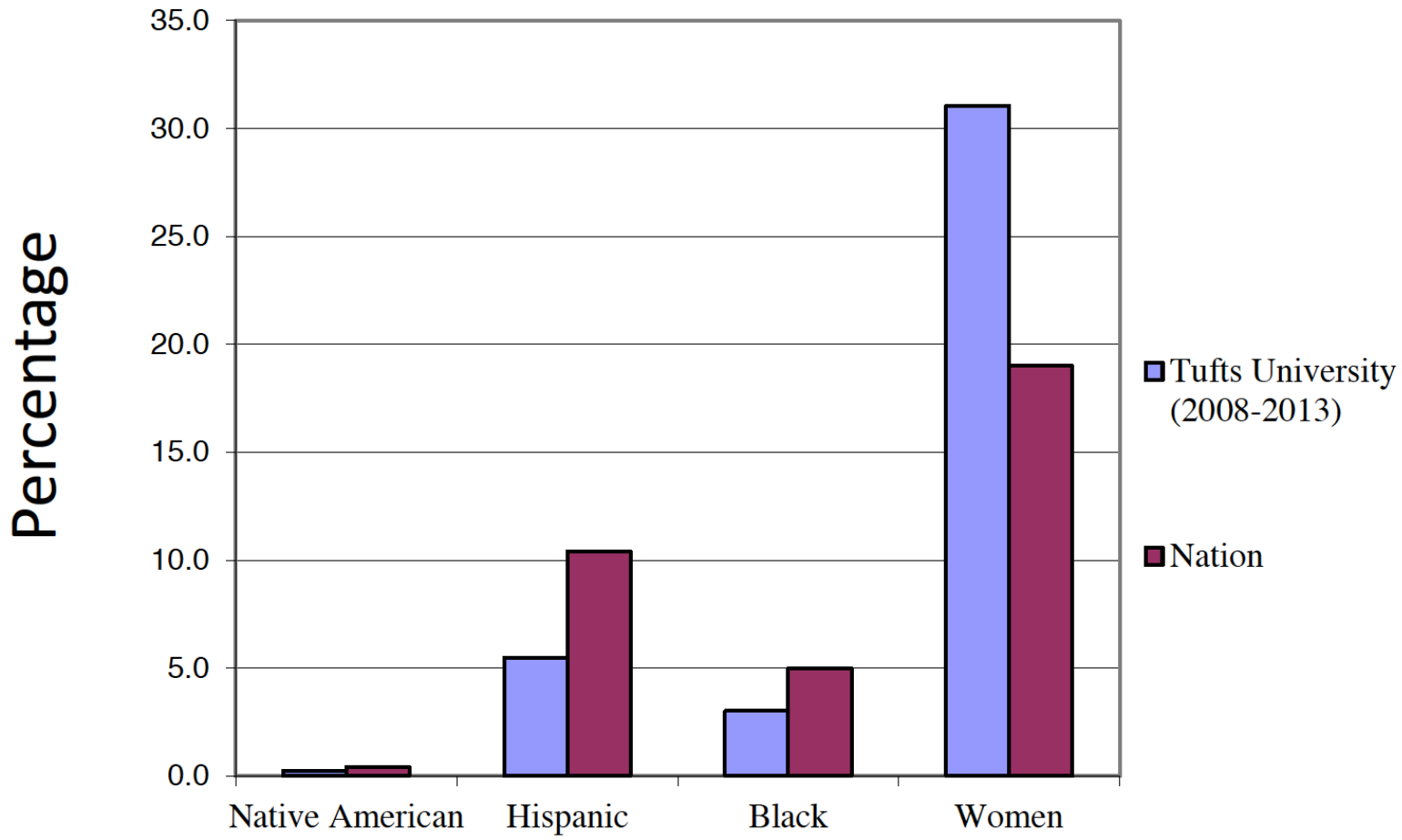
Female Faculty Comparison

	Top 50 Departments in Selected Disciplines*				School of Engineering Tufts University (AY 2013-14)		
	Asst Prof	Asso Prof	Full Prof	All Levels	Asst Prof	Asso Prof	Full Prof
ENGINEERING ** (all schools 2013)	22.8	17.0	9.4	14.5	23.5 (4 of 17)	20.0 (6 of 30)	25.0 (8 of 32)
Biomedical	n.a.	n.a.	n.a.	n.a.	33.3 (1 of 3)	100.0 (1 of 1)	0 (0 of 4)
Chemical	23.7	17.8	8.3	12.9	33.3 (1 of 3)	0 (0 of 5)	50.0 (1 of 2)
Civil	25.3	14.3	7.1	12.7	33.3 (1 of 3)	12.5 (1 of 8)	25.0 (2 of 8)
Electrical	14.5	14.1	6.2	9.7	0 (0 of 3)	50.0 (2 of 4)	16.7 (1 of 6)
Mechanical	18.2	12.0	4.9	9.0	50.0 (1 of 2)	0 (0 of 6)	0 (0 of 5)
COMPUTER SCIENCE	19.5	11.3	11.5	13.5	0 (0 of 3)	33.3 (2 of 6)	57.1 (4 of 7)

* ***Nelson and Brammer, 2010; ** ASEE, 2013***

At 22.8% female, Tufts ranks 12th out of 242 institutions in 2013

Other Under-Represented Groups



Although we can still do much better, why have we had this level of success?

It may be the result of many factors……

Leading By Example

- The University's Provost & Senior Vice President, the Chief Diversity Officer & Associate Provost, the Director of the Institute for Global Leadership and at least one of the Deans of Tuft's 8 schools are African-American and/or female

- 45% of the University's Administration team are female including:
  - Executive Vice President
  - Associate Treasurer
  - Senior Vice President for University Relations and General Counsel
  - Vice President for Communications and Marketing
  - Vice President for Operations

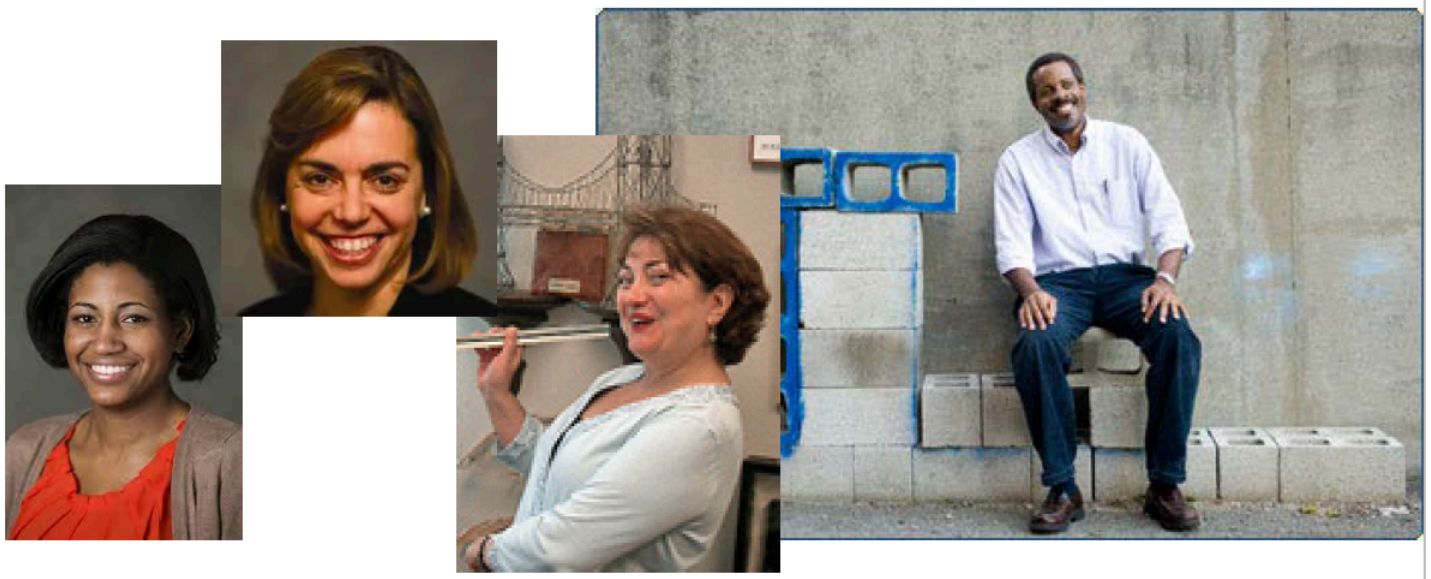
- 63% of the School of Engineering's Leadership Team hail from under-represented population and are female or African-American

Faculty Role Models

- Approximately ¼ of tenure track engineering faculty are women

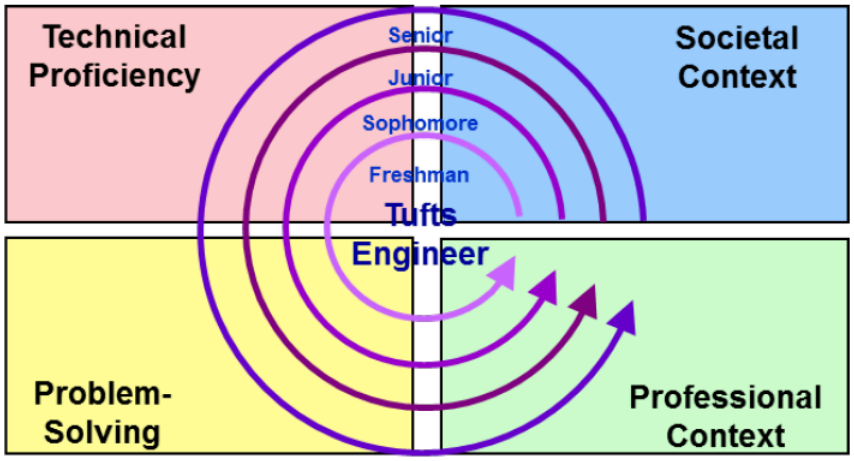
Student Advising

- Full time Associate Dean for Undergraduate Advising
- Faculty assigned for both pre-major and major advising
- Fulltime internship coordinator
- Targeted Programs for support of first generation and underrepresented students through Center for STEM Diversity



Educational Innovation

- New first year courses
- Project-based learning and design experiences throughout the curriculum
- Multigenerational teaching and mentoring
- Team leadership experiences
- An understanding of engineering in its societal context



Service Learning

- Student Teacher Outreach Mentorship Program
- NERD Girls
- Engineers Without Borders
- Tisch Scholars

The Center for STEM Diversity

- Created in 2008 to help Tufts University better recruit and retain underrepresented students in the STEM disciplines
- Helps coordinate efforts around STEM diversity on the Tufts Medford Campus
- Advise undergraduates and grad students, and work with faculty and staff on creating a more inclusive, supportive STEM community
- Programs include cohort weekly meetings and workshops, science study groups, and a bridge program

Faculty Hiring

The Dean and Associate Dean for Faculty Affairs monitor all searches very carefully:

- Review/approve membership of search committee and text of position announcement
- Encourage extensive outreach, including outside of academia
- Review/approve demographics of total pool and those who survive the “first cut”
- Review/approve candidates proposed for on-campus interviews, the “second cut”
- Encourage welcoming interview climate
- Dean meets all interview candidates
- Review/approve candidate proposed for hire
- Dean makes position offer personally

Faculty Mentoring

- Reduced course load for new faculty – 2 courses/year
- Junior faculty research leave (one semester) for all junior faculty
- Formal mentoring program – junior faculty paired with one senior faculty from within department, one senior faculty from outside department
- Regular junior faculty social luncheons
- Informal support from faculty/administrators in both SOE and A&S, thanks to integration of schools
- Regular, formal reviews (2nd and 4th years) with written feedback
- Opt out tenure clock stoppage of one year for primary caregiver

SUCCESS STORY II

FISK-VANDERBILT
Master's-to-Ph.D.
BRIDGE PROGRAM

VANDERBILT
UNIVERSITY

FISK-VANDERBILT Master's-to-Ph.D. BRIDGE PROGRAM

Origins

- The **idea was initially conceived in 2002** by Dr. David Ernst (Vanderbilt University), Dr. Eugene Collins (Fisk University) and Dr. Arnold Burger.
- Dr. Keivan Stassun joined the Vanderbilt faculty in 2003 and worked to formalize the idea and was named a co-director with Dr. Burger in 2004.
- The Fisk-Vanderbilt program enrolled its **first student** in the **Fall of 2004**.
- Since its initiation, funding for the program has including NASA, NSF CAREER, IGERT and institutional contributions from both Fisk and Vanderbilt

Outcomes

- **As of 2017**, the program has produced **27 Ph.D. graduates** in Physics, Astronomy and Materials Science
- **100%** of all students in the program have acquired STEM-related employment prior to graduation
- Program graduates include the **first African-American female astronomer to publish in Nature**
- Averaging continuous production of 3-5 Ph.D.s **per year**
- Fisk is the number one producer of African American earned Master's Degrees
  - **83% retention rate to the Ph.D.**
  - **97% overall student retention rate**

FISK-VANDERBILT Master's-to-Ph.D. BRIDGE PROGRAM

Learnings

- Substantial consulting for other programs and institutions seeking to replicate the success of the Fisk-Vanderbilt model including:
  - The Architect's Council
  - The APS Minority Bridge Program

- Generation of a publicly available toolbox containing operational protocols and philosophy regarding the execution of the Fisk-Vanderbilt bridge program

- Scholarly work effectively documenting how "cognitive" and "non-cognitive factors" in combination are far more effective indicators of success than commonly utilized measures (e.g. GRE scores) among women and persons of color in STEM
  - R. Roach, "Tennessee Schools Expand Minority STEM Ph.D. Effort" ***Diverse Issues in Higher Education,*** Aug. (2015)
  - S. Haruch, "A Graduate Program Works to Diversity the Science World" ***NPR: Code Switch,*** Jan. (2014)
  - C. Miller, K. Stassun, "A Test That Fails" **NATURE**, vol. 510, (2014) pp. 303-304
  - K. Powell, "On the Lookout for True Grit" **NATURE**, vol. 504, (2013) pp. 471-473
  - K. Stassun, K. Holley-Bockelmann, A. Burger, D. Ernst, D. Webb, "Fisk-Vanderbilt Master's-to-Ph.D. Bridge Program: Recognizing, Enlisting and Cultivating Unrealized or Unrecognized Potential in Underrepresented Minority Students" **Am. Journal of Physics**, vol. 79, 4, (2011) pp. 374-379

FISK-VANDERBILT Master's-to-Ph.D. BRIDGE PROGRAM

Pipeline Indicators

- Even though our nation's HBCUs make up just 3 percent of colleges and universities, they produce 27 percent of African-American students with bachelor's degrees in STEM fields.

- A recent report from the National Science Foundation revealed that 21 of the top 50 institutions for educating African-American graduates who go on to receive their doctorates in science and engineering, are HBCUs.

- *Among Black STEM PhD recipients who earned their degrees between 2005 and 2010:*
  - *More than one third earned their undergraduate degrees at an HBCU.*
  - *Twelve percent earned their doctorates at an HBCU.*
  - *A few HBCUs stand out as top producers of Black STEM PhD recipients, though there is variation among the top-producing HBCUs by discipline of study.*

- Although most Black STEM PhD recipients took PWI institutional pathways to the doctorate, earning at least an undergraduate degree, if not both undergraduate and doctoral degrees, from an HBCU was most common among Black STEM PhD recipients who were U.S. citizens, females, and first-generation college students; all groups of individuals who are presently among the most underrepresented in the STEM academic and broader workforce.

Sources: U.S. Department of Education, 2016
R, Upton, C. Tanenbaum, "The Role of Historically Black Colleges and Universities as Pathway Providers" Broadening Participation in STEM Graduate Education, **Am. Inst. Research**, (2014)

“Tangible and relevant action can be achieved through workplace efforts OR personal strategy”

- *Lynette Madsen* -

Program Director, National Science Foundation

Recipient of the 2016 TMS Ellen Swallow Richards Diversity Award

DIVERSITY (DMMM3)
IN THE MINERALS, METALS, AND MATERIALS PROFESSIONS

Sandia National Laboratories

Logistics

WHEN
- **July 23–24, 2018**

WHERE
- **University of California, Santa Barbara**
- **Santa Barbara, California, USA**

CHAIR
- **Jonathan Madison,** Sandia National Labs

CO-CHAIRS
- **Jennifer Andrew**, University of Florida
- **Megan Brewster**, Applied Materials
- **Amy Clarke**, Colorado School of Mines
- **Kristen Constant**, Iowa State University
- **Oscar Dubón**, University of California, Berkeley
- **Emily Kinser**, IBM
- **Matthew Korey**, Purdue University
- **Natalie Larson**, University of California, Santa Barbara
- **Xavier Ochoa**, McEwen Mining Inc.
- **Michael Rawlings**, National Science Foundation
- **Rosa Maria Rojas**, University of Arizona

DIVERSITY (DMMM3)
IN THE MINERALS, METALS, AND MATERIALS PROFESSIONS

Sandia National Laboratories

What's on Deck

FOCI
- Race & Ethnicity
- LGBT
- Means & Measures

CROSS-CUTTING LENSES
- Early, Mid & Executive Level Breakouts
- Personalized Spheres of Influence Breakouts
- Industry, Academia & Government Tracks

RETURNING ITEMS
- Professional Development Sessions
- High-Level Plenaries from Current Thought Leaders
- (2) Hosted Luncheons
- Presentation of TMS Diversity Awards
  (Frank L. Crossley & Ellen Swallow Richards)

NEW EFFORTS
- Input from Current & Relevant Social Science on D&I
- Personalized Toolbox Creation for D&I Advocacy
- Individual Commitments

DIVERSITY (DMMM3)

IN THE MINERALS, METALS, AND MATERIALS PROFESSIONS

Plan now to attend the 3rd Summit on Diversity in the Minerals, Metals, and Materials Professions, sponsored by TMS.

ENGAGE | MEASURE | TRANSFORM

DMMM3 will focus on three key elements for initiating change:

- **Engaging** participants on the most recent social-science findings in the areas of diversity and inclusion while exploring current issues and potential solutions.
- **Measuring** progress and ensuring positive outcomes for all through the establishment of well informed and proactive measures and metrics.
- **Transforming** the professional community by implementing changes in workplace cultures and policies.

REGISTRATION FOR DMMM3 OPENS SOON.

Want opportunities for immediate engagement? Visit the meeting website at **www.tms.org/Diversity2018/SaveTheDate** to review diversity and inclusion resources or to sign up for e-mail updates on DMMM3 programming and registration announcements.

SEE WHAT ATTENDEES OF DMMM2 HAD TO SAY:

"Tremendously engaging, interesting, and useful."

"High quality presentations, with excellent examples and recommendations for effective diversity approaches."

"A progressive and necessary approach to increasing minority participation in the STEM fields."

SAVE THE DATE

JULY 23 – 24, 2018

University of California, Santa Barbara
Santa Barbara, California

ORGANIZERS

Jonathan Madison, Sandia National Laboratories (Chair)
Jennifer Andrew, University of Florida
Megan Brewster, Applied Materials
Amy Clarke, Colorado School of Mines
Kristen Constant, Iowa State University
Oscar Dubón, University of California, Berkeley
Emily Kinser, IBM
Matthew Korey, Purdue University
Natalie Larson, University of California, Santa Barbara
Xavier Ochoa, McEwen Mining Inc.
Michael Rawlings, National Science Foundation
Rosa Maria Rojas, Freeport-McMoRan Inc.

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www.tms.org/Diversity2018/SaveTheDate

TMS Diversity Committee

Sandia National Laboratories

- **Rectifying diversity & inclusion shortfalls are a challenging dilemma to be sure, but useful measures can provide valuable insight to effective solutions**
- **Solutions which develop an eco-system surrounding diversity and inclusion that receive buy-in from all levels is an commonality among successful efforts**
- **Cognitive and non-cognitive factors in tandem are better indicators of STEM researcher success than most commonly utilized estimators**
- **HBCUs are a quantifiably precious and impactful resources in the production of URMs professionals from among a group which has seen little to no progress in under-representation in STEM**

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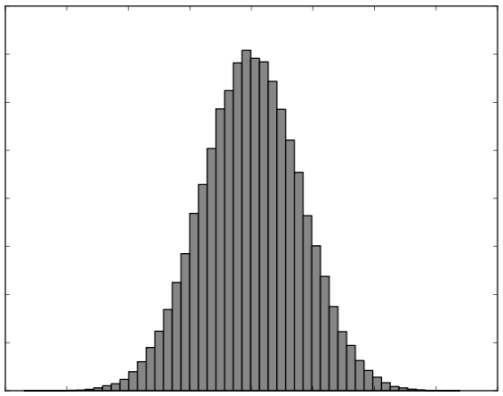
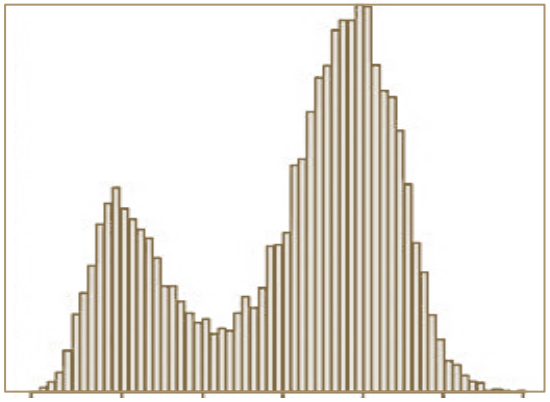
www.tms.org/diversity2018

A Word on Distributions



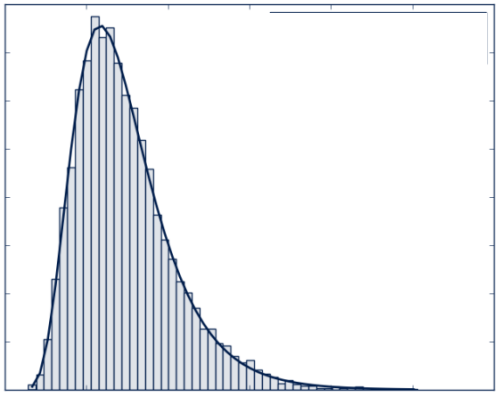
Properties of a normal distribution:

- the mean, median and mode are all equal
- bell-shaped and symmetric about the mean
- total area under the curve is equal to one
- the normal curve approaches but never touches the x-axis as it extends farther away from the mean



Properties of a bimodal distribution:

- Has two distinct and identifiable modes
- Individual peaks do not have to exhibit an equivalent magnitude or population



Properties of a log-normal distribution:

- the mean and median and are by definition different and both typically differ from the mode
- the lognormal distribution is asymmetric about the mean

Contents lists available at SciVerse ScienceDirect

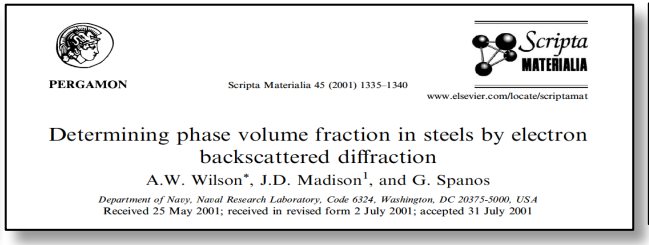
International Journal of Fatigue

journal homepage: www.elsevier.com/locate/ijfatigue

Demonstration of an *in situ* microscale fatigue testing technique on a titanium alloy

C.J. Szczepanski[a,*], S.K. Jha[b], P.A. Shade[a], R. Wheeler[c], J.M. Larsen[a]

[a] US Air Force Research Laboratory, AFRL/RX, Wright–Patterson AFB, OH 45433, United States
[b] Universal Technology Corporation, Dayton, OH 45432, United States
[c] UES, Inc., Dayton, OH, United States



PERGAMON

Scripta Materialia 45 (2001) 1335–1340

Scripta MATERIALIA

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Determining phase volume fraction in steels by electron backscattered diffraction

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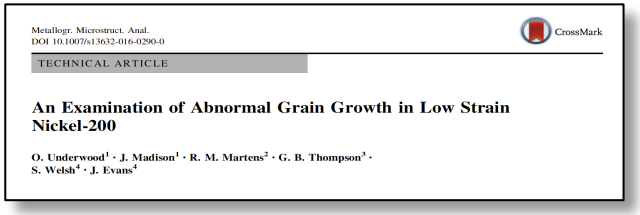
How Grain Growth Stops: A Mechanism for Grain-Growth Stagnation in Pure Materials

Elizabeth A. Holm* and Stephen M. Foiles



Metallogr. Microstruct. Anal.
DOI 10.1007/s13632-016-0290-0

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TECHNICAL ARTICLE

An Examination of Abnormal Grain Growth in Low Strain Nickel-200

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ADVANCED ENGINEERING MATERIALS

FULL PAPER

DOI: 10.1002/adem.201700102

Extreme-Value Statistics Reveal Rare Failure-Critical Defects in Additive Manufacturing**

By Brad L. Boyce,* Bradley C. Salzbrenner, Jeffrey M. Rodelas, Laura P. Swiler, Jonathan D. Madison, Bradley H. Jared and Yu-Lin Shen

Means and modes of distributions are cool, but the really interesting and insightful things occur at the tails …

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Sources: *U.S. News & World Report*
Economics & Statistics Administration, U.S. Department of Commerce
U.S. Department of Education, National Assessment of Educational Progress in Math & Science, 2003 - 2013

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Research Scientist

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