Dan J. Thoma

Work Address
University of Wisconsin - Madison
1550 Engineering Drive
Madison, WI 53706
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Education

University of Wisconsin-Madison, Madison, Wisconsin.
Ph.D. in Metallurgical Engineering, Minor in Chemistry (May of 1992).
Master of Science in Metallurgical Engineering (August of 1988).
University of Cincinnati, Cincinnati, Ohio.
Bachelor of Science in Metallurgical Engineering, summa cum laude (June of 1986).

Professional Experience

2015-present: University of Wisconsin-Madison

2015-present**:** Grainger Professor in the Department of Materials Science and Engineering.
Inaugural Director, Grainger Institute for Engineering, College of Engineering.
Affiliate Professor, Department of Engineering Physics.
Affiliate Professor, Department of Mechanical Engineering.

1992-2015: Los Alamos National Laboratory, Los Alamos, New Mexico.

2013-2015: Deputy Division Leader – Materials Science and Technology
250 person division with an annual operating budget of $90M. Oversee facilities, operations, budgets, and programs.

2005-2013: Director and Adjunct Professor – Materials Design Institute
a collaborative educational research program with the University of California, Davis, College of Engineering.

2003-2005: Associate Directorate for Weapons Engineering and Manufacturing (ADWEM) Science Advisor
assisted Associate Director on materials/manufacturing programs, LANL Chair of the Materials Science and Engineering Council.

1997-2003: MST-6 Project Leader and Team Leader: Alloy Design and Development
originated, grew, and led a twelve person team with an annual budget of $4M-$5M.

1994-1997: MST-6 Technical Staff Member
physical metallurgy of uranium and beryllium

1992-1993: Postdoctoral Fellow
metastable equilibria synthesis and characterization

1986-1992: University of Wisconsin-Madison,

Graduate Student - Ph.D. Thesis: "Microstructural Development in $NbCr_2$-Based Alloys"
Master's Thesis: "Structural Evolutions in the Drop Tube Processing of Fe-Ni Alloys"

1983-1985: NASA Lewis Research Center, Cleveland, Ohio

Undergraduate Co-op Student: rapid solidification processing, microgravity processing sciences, mechanical/thermal fatigue.

Honors and Awards

TMS Fellow (2019)
Chaired Professor – Director of Grainger Institute for Engineering, University of Wisconsin-Madison (2015-present)
AIME Distinguished Service Award (2011)
University of Wisconsin-Madison College of Engineering Distinguished Achievement Award (2010)
Fellow of ASM International (2008)
Adjunct Faculty, Department of Chemical Engineering and Materials Science, University of California, Davis (2008)
Los Alamos National Laboratory's Fellows Prize for Leadership (2007)
The Minerals, Metals, Materials Society (TMS) Distinguished Service Award (2007)
NRC Committee Member on New Materials Synthesis and Crystal Growth (2007-2008)
US Chair for a Joint Working Group (JOWOG 22 -Nuclear Materials) with the United Kingdom (2003-2007)
University of California, Davis National Laboratory Advisory Board (2005-current)
Founding Editor of *TMS Letters* (2004-2006) – an electronic journal
Editorial Board for the Science Journal *Intermetallics* (2000 - 2006)
Defense Programs Award for Excellence (2000, 2003)
Distinguished Performance Award (1997) – Target Fabrication and Development Team
Los Alamos National Laboratory Outstanding Performance Award (1996)
A Best Poster in the MRS '94 Fall Meeting (1994)
Los Alamos National Laboratory Director's Funded Postdoctoral Fellowship [50%] (1992)
Alpha Sigma Mu (1986)
NASA Special Achievement Award for Outstanding Service (1984)

Elected Representations in Professional/Technical Societies

Trustee, United Engineering Foundation (UEF) Board of Trustees (2008-2011)
President, American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) (2007-2008), includes Executive Committee Member of Board (2005-2009)
President of the Federation of Materials Society (FMS) (2009-2010)
Federation of Materials Society (FMS) Revitalization Task Force Leader (2006-2007)
President of The Minerals, Metals, and Materials Society (TMS) (2003), includes Executive Committee Member of Board (2002-2005)
AIME Board of Trustees (2003-2005)
TMS Public and Government Affairs Committee (2005-2007)
TMS Structural Materials Division Council {Information Technology Committee Representative} (2005-2008)
TMS Materials Processing and Manufacturing Division Council {Education Committee Rep.} (2005-2007)
Programming Director for TMS (served on Board of Directors 1997-2002)
Chair and Vice-Chair of the Solidification Committee of TMS (1997-2002)
Programming Representative - Materials Design and Manufacturing Division of TMS (1994-1997)
Education Committee Representative - Materials Design and Manufacturing Division of TMS (1993-1994)

Solidification Committee Representative for Subcommittee on Education in the Materials Design and Manufacturing Division of TMS (1994)
TMS/ASM Student Design Competition Organizer (1993)
Executive Board Member (Secretary), Los Alamos Chapter of ASM (1993)

Membership in National Technical/Functional Committees

Additive Manufacturing Committee (2016-present)
Information Technology Committee (2005-2007)
Public and Government Affairs Committee (2002-2009)
Phase Transformation Committee (1998-present)
Nuclear Materials Committee (1999-present)
Thermodynamics and Phase Equilibria Committee of ASM (1995-2000)
Powder Materials Committee (1995-2000)
Programming Committee (1994-2007)
Education Committee (1993-1994, 2005-2007)
Solidification Committee (1987-present)

Advisory Boards

NASA University Leadership Initiative External Advisory Board (2019-present)
eXtremeMAT Technical Advisory Board (2019-present)
AIME Council of Excellence (2017-present) Chair (2018-present)
Argonne National Laboratory Manufacturing Sciences Initiative Review (2018-present)
HC Starck Strategic Advisory Council (2009-present)
University of California, Irvine Institute for Design and Manufacturing Innovation Advisory Board (2016-present)
University of California, Davis National Laboratory Advisory Board (2005-2010)
California Polytechnic University, Department of Materials Engineering External Advisory Board (2006-2010)
TMS Materials for Nuclear Power Advisory Group (2006)
Multiple Member and Student Awards Committees for TMS and ASM (2002-present)

Meetings/Conferences Organized

International Organizing Committee for PRICM-10 (2019)
Organizer for International Conference on Plasticity, Damage & Fracture (2019)
Organizer for UEF Infrastructure Resiliency (1 workshop in 2018, conference in 2019)
Organizer for UW-Madison Additive Manufacturing Workshop (2019)
Organizer for Advanced Die-casting Initiative Workshop (2018)
Organizer for Forum for Manufacturers in Neenah, WI (2018)
Los Alamos Workshop On Additive Manufacturing (2015)
5th Pacific Rim International Conference on Advanced Materials (2004)
Organized all Fall and Annual TMS Meetings between 1997 and 2002 (Over 4000 attendees annually)
Programming Coordinator for TMS/ASM Materials Week '96 in Cincinnati, OH (October, 1996)
3rd International Symposium on Structural Intermetallics (2001)
4th Pacific Rim International Conference on Advanced Materials (2000)

Materials Processing & Manufacturing: Educating for the Future, TMS/ASM Materials

Week '95

Programming Coordinator for TMS/ASM Materials Week '94 in Rosemont, IL (1994)

Publications and Presentations

133 Technical Publications (1788 citations, h-index: 20+ as of August, 2014)

65 Invited National/International Presentations

163 Contributed Technical Presentations

Students

Los Alamos National Laboratory

Post-docs	Graduate Students	Undergraduate students
Elliot Schwartz	Matthew Willard	Daniel Bender
David Teter	Thomas Slankard	Elizabeth Perepezko
Robert Hanrahan, Jr	Scott Dillard	Michelle Crown
Katherine Chen	Daniel Worthington	Kevin Nibur
Robert Hackenberg	Christine Tower	Alyssa Maich
Fuming Chu	Daniel Walker	Day Frostensen
Paul Kotula	Phillip Van Stockum	
Michael Steinzig		
Michael Manley		

University of Wisconsin-Madison

Post-docs	Graduate Students	Undergraduate students
William Aquite	Janine Erickson	Bailey Kuehl
David Gross	Michael Niezgoda	Max Roth
Kaila Bertsch	Michael Moorehead	Manthra Venkatakrishnan
Gabriel Meric de Bellefon	Buzz Rankouhi	Baily Syring
		Tory Wendlandt

Publications

133 Technical Publications (1788 citations, h-index: 20+ as of August, 2014)

Select publications

1. "Proton Radiography Peers into Metal Solidification" A.J. Clarke, S.D. Imhoff, J.C. Cooley, B.M. Patterson, W.-K. Lee, K. Fezzaa, A. Deriy, T.J. Tucker, M.R. Barker, K.D. Clarke, R.D. Field, D.J. Thoma, D.F. Teter *Scientific Reports*, 3, 2020 (2013).
2. "Crystallographic and Kinetic Origins of Acicular and Banded Microstructures in U-Nb Alloys" R. D. Field and D.J. Thoma *J. of Nuclear Materials*, **436**, 105-117 (2013)
3. "EBSD and FIB/TEM Examination of Shape Memory Effect Deformation Structures in U-14 at.% Nb" A.J. Clarke, R.D. Field, R.J. McCabe, C.M. Cady, R.E. Hackenberg, D.J. Thoma *Acta Materialia*, **35**, 2638-2648 (2008).
4. "Free-Energy Density of the Shape-Memory Alloy AuZn" J.C. Lashley, H. Ledbetter, T.W. Darling, A. Saxena, A. Malinowski, M.F. Hundley, J.L. Smith and D.J. Thoma *Materials Transactions*, **47**, 587-593 (2006).
5. "Martensite Structures and Deformation Twinning in the U-Nb Shape Memory Alloys" R.D. Field, D.J. Thoma, P.S. Dunn, D.W. Brown, and C.M. Cady *Philosophical Magazine A*, **81**, 1691-1724, (2001).
6. "Intermetallics: Laves Phases" D.J. Thoma in *Encyclopedia of Materials*: *Science and Technology* (Elsevier Science Ltd., London) 4205-4213 (2001).
7. "The Prediction of the Hydriding Thermodynamics of Pd-Rh-Co Ternary Alloys" D.F. Teter and D.J. Thoma *Metallurgical and Materials Transactions B*, **30,** 667-673, (2000).
8. "Mo_5Si_3 Single Crystals: Physical Properties and Mechanical Behavior" F. Chu, D.J. Thoma, K. McClellan, P. Peralta, *Materials Science and Engineering A* **261,** 44-52, (1999).
9. "Structure and Magnetic Properties of $(Fe_{.5}Co_{.5})_{88}Zr_7B_4Cu_1$ Nanocrystalline Alloys" M.A. Willard, D.E. Laughlin, M.E. McHenry, D.J. Thoma, K. Sickafus, J.O. Cross, V.G. Harris *J. of Applied Physics* **84**, 6773-6777, (1998).
10. "Directed Light Fabrication of a Solid Metal Hemisphere Using 5-Axis Powder Deposition" J.O. Milewski, G.K. Lewis, D.J. Thoma, G.I. Keel, R.B. Nemec, and R.A. Reinert. *Journal of Materials Processing Technology*, **75**, 165-172, (1998).
11. "Phase Stability and Defect Structure of the C15 Laves Phase $Nb(Cr,V)_2$ " F. Chu, D. J. Thoma, P. G. Kotula, S. Gerstl, T. E. Mitchell, I. M. Anderson, and J. Bentley *Acta Mater.*, **46 #5**, 1759-1769, (1998).
12. "In-Situ Hydrogen Charging of Pd and Pd-Rh in the TEM" R.D. Field and D.J. Thoma *Scripta Materialia*, **37 #3**, 347-353, (1997).
13. "Solidification Behavior during Directed Light Fabrication" D.J. Thoma, G.K. Lewis, and R.B. Nemec in Beam Processing of Advanced Materials, J. Singh, ed. (ASM, Materials Park, OH), 247-253, (1996).
14. "A Geometric Analysis of Solubility Ranges in Laves Phases" D.J. Thoma and J.H. Perepezko *J. of Alloys and Compounds*, **224**, 330-341, (1995).
15. "An Experimental Evaluation of the Phase Relationships and Solubilities in the Nb-Cr System" D.J. Thoma and J.H. Perepezko, *Mater. Sci. & Eng. A*, **156**, 97-108, (1992).

Presentations

Most presentations from 2007 - 2017 were either administrative or in proprietary settings and not counted in the 74 Invited National/International Presentations and 160 contributed technical presentations given.

Select Presentations

1. D.J. Thoma, "Advanced Manufacturing: Processing and Testing of Radioactive Materials", Keynote Address at CIRMS 2014 Council on Ionizing Radiation Measurements and Standards, Gaithersburg, MD, March, 2014.
2. D.J. Thoma, W. King, R. Seals, "Additive Manufacturing of Actinides within the NNSA Nuclear Weapons Complex (U)", Additive Manufacturing Summit, Oak Ridge, TN, May 15, 2014.
3. D.J. Thoma, "Advanced Manufacturing: Requirements for Material Specification, Qualification, and Certification", Invited Seminar, University of Wisconsin, Madison, WI, December 4, 2014.
4. D.J. Thoma, "Additive Manufacturing: A Perspective on Advanced Manufacturing and Engineering Grand Challenges", National Academy of Engineering, Section 9, Washington, DC, October 5, 2105.
5. D.J. Thoma, "Panel: Transforming the Diversity Landscape", TMS Annual Meeting, Nashville, TN, February, 2016.
6. D.J. Thoma, "Metal Additive Manufacturing: Challenges and Opportunities for Component Fabrication", PRICM9, Kyoto, Japan, August, 2016.
7. D.J. Thoma, "Challenges and Opportunities in Advanced Manufacturing: Where is Metal Processing Going?", Advanced Photon Source at Argonne National Laboratory, Chicago, IL, August, 2016.
8. D.J. Thoma, "Directed Light Fabrication: A Near-Net Shape Process using Laser Assisted Metal Deposition", TMS Annual Meeting, San Diego, CA, February, 2017.
9. D.J. Thoma, "Challenges and Opportunities for Metal Additive Manufacturing", TMS Annual Meeting, San Diego, CA, February, 2017.
10. D.J. Thoma, "Structure-Property Relationships in Metal Additive Manufacturing", Keynote, Plasticity 2018, San Juan, Puerto Rico, January, 2018.

Patents

1. "Production of High Strength, High Conductance Materials" M.A. Hill, J.F. Bingert, S.A. Bingert, and D.J. Thoma Disclosure 84912, Nov. 30, 1995.
2. "Hydrostatic Extrusion of Cu-Ag Melt-Spun Ribbon" M.A. Hill, D.J. Thoma, S.A. Bingert, and J.F. Bingert Patent No. US 5,802,708/A/; Priority No.: US Patent Application 8-657-860; Assignee: Univ. of California, Oakland, CA : Date Filed: 30 May1996.
3. "Nickel-Aluminum-Beryllium Alloys" R.J. Hanrahan, D.J. Thoma, and L.A. Jacobson Disclosure 87240, Feb. 26, 1997.
4. "Super-Flexible Steel" J. C. Lashley and D. J. Thoma (S-133,290 ; 8472-95159-01) Date Filed: 15 September, 2015.

Dan Thoma, Professor and Director, Grainger Institute for Engineering

Dr. Thoma is the Director of the Grainger Institute for Engineering (GIE) at the University of Wisconsin-Madison (UW) and a Professor in Materials Science and Engineering. The GIE initial thrust areas were Advanced Manufacturing and Accelerated Materials Discovery and has expanded to many other societal impact areas.. Prior to UW, he was the Deputy Division Leader for the Materials Science and Technology (MST) Division at Los Alamos National Laboratory (LANL). This division focused on manufacturing and novel materials research. His technical efforts have been devoted to new manufacturing methods and materials by design, with a particular focus on property response as a function of microstructural evolution during phase transformations. Dr. Thoma has been active within materials professional societies, where he was the president of The Minerals, Metals, Materials Society (TMS) in 2003, the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) in 2008, and the Federation of Materials Societies (FMS) in 2009-2010. His expertise in materials and manufacturing was recognized in 2008 by being elected as a Fellow of ASM International. In 2018, he was elected Fellow of TMS

Dan Thoma External Activity 2018

AIME – American Institute of Mineral, Metallurgical, and Petroleum Engineers
AIME Council of Excellence (2017-present)
AIME Board of Trustees (2003-2009)
TMS Representative to Board of Trustees (2003-2005)
Presidential Cycle (2005-2009)
(President 2007-2008)
Representative to Founder Societies ad hoc committee on Engineering Grand Challenges (2007-2009)

UEF – United Engineering Foundation
Board Member of United Engineering Foundation representing AIME (2008-2011)

TMS – The Minerals, Metals, and Materials Society
TMS Technical Committees
Additive Manufacturing Committee (2016-present)
Solidification Committee (1987-present)
Chalmers Award Committee Chair (2006-2007) Phase
Transformation Committee (1998-present) Nuclear Materials
Committee (1999-present)
Powder Materials Committee (1995-2000)

TMS Functional/Administrative Activities Education
Committee (1993-1994, 2005-2007)
Programming Committee (1994-2007) Information
Technology Committee (2005-2007)
Public and Government Affairs Committee (2002-2009)
MPMD Council (1993-2002, 2005-2007)
Education Committee Representative (1993-1994) Program
Committee Representative (1994-1997) Solidification
Committee Chair/Vice Chair (1997-2002) Education
Committee Representative (2005-2007)
SMD Council (2005-2007)
Information Technology Committee (2005-2007)
Distinguished Service Award Committee (2006-2007)
Distinguished Scientist Award Committee (2006-2007) SMD
Undergraduate Award Committee (2005-2007)
TMS Board of Directors (1997-2005)
Programming Director (1997-2002)
Presidential Cycle/Executive Committee (2002-2005)
President (2003)

FMS – Federation of Materials Societies
FMS Board of Trustees (2007- current) Revitalization Task Force Leader (2006-2008) **President (2009-2010)**

NRC - National Research Council (part of the National Academies)
New Materials Synthesis and Crystal Growth Committee (2007-2009)

Advisory Boards

DOE-FE eXtreme environment MATerials (XMAT) National Laboratory Consortium Technical Adviory Board (2019-present)
Argonne National Laboratory Manufacturing Sciences Initiative Review (2018-present)
HC Starck Strategic Advisory Council (2009-present)
University of California, Irvine Institute for Design and Manufacturing Innovation
Advisory Board (2016-present)
University of California, Davis National Laboratory Advisory Board (2005-2010) California Polytechnic University, Department of Materials Engineering External
Advisory Board (2006-2010)
TMS Materials for Nuclear Power Advisory Group (2006)

Editorial

Founding Editor of *TMS Letters* (2004-2006) – an electronic journal
Editorial Board for the Science Journal *Intermetallics* (2000 - 2006)

Publications and Conference Presentations

Publications

1. "Interaction of High-Cycle and Low-Cycle Fatigue of Haynes 188 Alloy at 1400°F"
P.T. Bizon, D.J. Thoma, and G.R. Halford
in Structural Integrity and Durability of Reusable Space Propulsion Systems, NASA Conference Proceedings Publication 2381, Cleveland, OH, 129-138, (1985).

2. "Effects of Process Parameters on Melt-Spun Ag-Cu"
D.J. Thoma, T.K. Glasgow, S.N. Tewari, J.H. Perepezko, and N. Jayaraman
Mater. Sci. & Eng. A, **98,** 89-93, (1988).

3. "Solidification Processing of $NbCr_2$ Alloys"
D.J. Thoma and J.H. Perepezko
Mat. Res. Soc. Symp. Proc., **194,** 105-112, (1990).

4. "Microstructural Transitions During Containerless Processing of Undercooled Fe-Ni Alloys"
D.J. Thoma and J.H. Perepezko
Metall. Trans. A, **24 #4,** 1347-1362, (1992).

5. "An Experimental Evaluation of the Phase Relationships and Solubilities in the Nb-Cr System"
D.J. Thoma and J.H. Perepezko
Mater. Sci. & Eng. A, **156**, 97-108, (1992).

6. "A Tri-Junction Diffusion Couple Analysis of the Nb-Cr-Ti System at 950°C"
D.J. Thoma and J.H. Perepezko
in Experimental Methods of Phase Diagram Determination, J.E. Morral, R.S. Schiffman, and S.M. Merchant, eds., (TMS, Warrendale, PA), 43-54, (1993).

7. "Supersaturation of the Al_2Y Laves Phase by Rapid Solidification"
J.C. Foley, D.J. Thoma, and J.H. Perepezko
Metall. Trans. A, **25**, 230-234, (1994).

8. "Directed Light Fabrication"
G.K. Lewis, R.B. Nemec, J. Milewski, D.J. Thoma, M. Barbe, and D. Cremers
in ICALEO '94 Conference Proceedings, (LIA, Orlando, FL), 17-26, (1994).

9. "Metastable BCC Phase Formation in the Nb-Cr System"
D.J. Thoma, J.H. Perepezko, D.H. Plantz, and R.B. Schwarz
Mater. Sci. & Eng. A, **179**, 176-180, (1994).

10. “Metastable BCC Phase Formation in the Nb-Cr-Ti System” D.J. Thoma and J.H. Perepezko
Materials Science Forum, **179-181**, 769-774, (1995).

11. “Stacking Fault Energy of the Laves Phase Compound $NbCr_2$”
F. Chu, A.H. Ormeci, T.E. Mitchell, J.M. Wills, D.J. Thoma, R.C. Albers, and S.P. Chen
Phil. Mag. Letters, **72 #3,** 77-84, (1995).

12. “Theoretical and Experimental Studies on the C15 Intermetallic Compound $NbCr_2$”
F. Chu, D.J. Thoma, Y. He, T.E. Mitchell, S.P. Chen, and J.H. Perepezko
Mat. Res. Soc. Symp. Proc., **364**, 1089-1094, (1995).

13. "A Geometric Analysis of Solubility Ranges in Laves Phases"
D.J. Thoma and J.H. Perepezko
J. of Alloys and Compounds, **224**, 330-341, (1995).

14. “Elastic Constants of the C15 Laves Phase $NbCr_2$”
F. Chu, Y. He, D.J. Thoma and T.E. Mitchell
Scripta Metall. et Mater, **33 #8**, 1295-1300, (1995).

15. “Solidification Behavior during Directed Light Fabrication”
D.J. Thoma, G.K. Lewis, and R.B. Nemec
in Beam Processing of Advanced Materials, J. Singh, ed. (ASM, Materials Park, OH), 247-253, (1996).

16. “Directed Light Fabrication of Iron-Based Materials”
D.J. Thoma, C. Charbon, G.K. Lewis, and R.B. Nemec
Mat. Res. Soc. Symp. Proc., **397,** 341-346, (1996).

17. “Microsegregation during Melt-Spinning of Dilute Palladium Alloys”
D.J. Thoma, E.M. Schwartz, S.R. Bingert, D.R. Korzekwa, R.D. Field, and L.A. Jacobson
in Melt-Spinning, Strip Casting and Slab Casting, E. Matthys, ed., (TMS, Warrendale, PA), 173-184, (1996).

18. “High Temperature Oxidation of $Ni_{50}(Al,Be)_{50}$”
R.J. Hanrahan, D.P. Butt, K.C. Chen, T.N. Taylor C.J. Maggiore, and D.J. Thoma
in Elevated Temperature Coatings: Science and Technology III, (TMS, Warrendale, PA) 305-315 (1996).

19. “Current Progress in NIF Target Concepts”
P.L. Gobby, L.R. Foreman, D.J. Thoma, L.A. Jacobson, R.V. Hollis, J. Barrera, M.A. Mitchell, M.A. Salazar, L.J. Salzer,
Proc. of the American Nuclear Society, (1996).

20. “Surrogate Studies of the Pu-Be Reaction”
R.J. Hanrahan, T.G. Zocco, D.J. Thoma, L.A. Jacobson, and J.L. Lowery
in 20^{st} Compatibility, Aging, and Stockpile Stewardship Conference, (Kansas City, MO) (1996).

21. "Directed Light Fabrication of Near-Net Shape Metal Components"
G.K. Lewis, D.J. Thoma, R.B. Nemec, J.O. Milewski
in Advances in Powder Metallurgy & Particulate Materials - 1996, (Metal Powder Industries Federation, Princeton, NJ) 15-65 to 15-76, (1996).

22. "A Total-Energy Study of Electronic Structure and Mechanical Behavior of C15 Laves Phase Compounds: $NbCr_2$ and HfV_2"
A.H. Ormeci, F. Chu, J.M. Wills, T.E. Mitchell, R.C. Albers, D.J. Thoma, and S.P. Chen
Physical Review B, **54 #18**, 12753 (1996).

23. "Current Progress in NIF Target Concepts"
P.L. Gobby, L.J. Salzer, M.A. Salazer, M.A. Mitchell, J. Barrera, R.V. Hollis, L.A. Jacobson, D.J. Thoma, L.R. Foreman
Fusion Technology **30 #3,** 534-538, (1996).

24. "In-Situ Hydrogen Charging of Pd and Pd-Rh in the TEM"
R.D. Field and D.J. Thoma
Scripta Materialia, **37 #3**, 347-353, (1997).

25. P. G. Kotula, K. C. Chen, D. J. Thoma, F. Chu, and T. E. Mitchell, "Orientation Relationships in Nb-$NbCr_2$", in *Proc. of Microscopy and Microanalysis 1997*, (Springer Press, San Francisco, CA), 707-708, (1997).

26. "Hydrogen-Induced Phase Separation of Palladium-Rhodium Alloys Using an Environmental Cell TEM"
D.F. Teter, D.J. Thoma, and R.D. Field
in *Proc. of Microscopy and Microanalysis 1997*, (Springer Press, San Francisco, CA), (1997).

27. "Directed Light Fabrication of Rhenium Components"
J.O. Milewski, D.J. Thoma, and G.K. Lewis
in Rhenium and Rhenium Alloys, ed. by B.D. Bryskin, (TMS, Warrendale, PA) 283-290 (1997).

28. "Phase Stability in Processing of High-Temperature Intermetallic Alloys"
J.H. Perepezko, C.A. Nunes. S-H. Yi, and D.J. Thoma
in High Temperature Ordered Intermetallic Alloys-VII, ed. by C. C. Koch, N. S. Stoloff, C. T. Liu, and A. Wanner, *Mat. Res. Soc. Symp. Proc.* **460,** 3-14, (1997).

29. "Comparison of $NbCr_2$ and HfV_2 Laves Phases"
D. J. Thoma, F. Chu, J. M. Wills, and T. E. Mitchell
in High Temperature Ordered Intermetallic Alloys-VII, ed. by C. C. Koch, N. S. Stoloff, C. T. Liu, and A. Wanner, *Mat. Res. Soc. Symp. Proc.* **460,** 689-694, (1997).

30. "Site Occupancies of Alloying Additions in C15-Structured Laves Phase Materials"
P. G. Kotula, I. M. Anderson, F. Chu, D. J. Thoma, J. Bentley, and T. E. Mitchell
in High Temperature Ordered Intermetallic Alloys-VII, ed. by C. C. Koch, N. S. Stoloff, C. T. Liu, and A. Wanner, *Mat. Res. Soc. Symp. Proc.* **460,** 617-622, (1997).

31. "Elastic Constants of a Laves Phase Compound: C15 $NbCr_2$"
A.H. Ormeci, F. Chu, J. M. Wills, S. P. Chen, R. C. Albers, D. J. Thoma, and T. E. Mitchell
in High Temperature Ordered Intermetallic Alloys-VII, ed. by C. C. Koch, N. S. Stoloff, C. T. Liu, and A. Wanner, *Mat. Res. Soc. Symp. Proc.* **460,** 623-628, (1997).

32. "Rapid Fabrication of Materials Using Directed Light Fabrication"
D.J. Thoma, G.K. Lewis, J.O. Milewski, K.C. Chen and R.B. Nemec
in *Proc. of THERMEC '97*, T. Chandra and T. Saki, eds. (TMS, Warrendale, PA) 2295-2301, (1997).

33. "Free-From Processing of Near-Net Shapes Using Directed Light Fabrication"
D.J. Thoma, G.K. Lewis, J.O. Milewski, R.B. Nemec
in Proc. of the 15th International Thermal Spray Conference (ASM International, Materials Park, OH) vol. 2, 1205-1210, (1997).

34. "Free Form Fabrication of Metallic Components Using the Directed Light Fabrication Process"
G.K. Lewis, J.O. Milewski, R.B. Nemec, and D.J. Thoma
in Proc. of the 15th International Thermal Spray Conference (ASM International, Materials Park, OH) vol. 2, 1357-1362, (1997).

35. "Environmental Cell Optical Microscopy of Hydrogen Reactions on the Surface of Alpha Uranium"
R.J. Hanrahan and D.J. Thoma
in 21st Compatibility, Aging, and Stockpile Stewardship Conference, (Sandia National Laboratory, Albuquerque, NM) VB-5 (1997).

36. "Surrogate Studies of the Pu-Be Reaction II"
R.J. Hanrahan, T.G. Zocco, D.J. Thoma, L.A. Jacobson, J.L. Lowery, R. Pereyra,
in 21st Compatibility, Aging, and Stockpile Stewardship Conference, (Sandia National Laboratory, Albuquerque, NM) VB-6 (1997).

37. "Directed Light Fabrication of Refractory Metals"
G.K. Lewis, D.J. Thoma, R.B. Nemec, J.O. Milewski
in 1997 International Conference on Powder Metallurgy and Particulate Materials, (1997).

38. "Properties of Near-Net Shape Metallic Components Made by the Directed Light Fabrication Process"
G.K. Lewis, J.O. Milewski, and D.J. Thoma
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2. "Hydrostatic Extrusion of Cu-Ag Melt-Spun Ribbon" M.A. Hill, D.J. Thoma, S.A. Bingert, and J.F. Bingert Patent No. US 5,802,708/A/; Priority No.: US Patent Application 8-657- 860; Assignee: Univ. of California, Oakland, CA : Date Filed: 30 May1996.
3. "Nickel-Aluminum-Beryllium Alloys" R.J. Hanrahan, D.J. Thoma, and L.A. Jacobson Disclosure 87240, Feb. 26, 1997.
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Presentations

Invited

D.J. Thoma, "Controlling Microstructural Development During Powder Processing Using Heat Flow Analysis," Workshop on Modeling of the Formation and Evolution of Microstructures, Los Alamos, NM, August, 1993.

S.P. Chen, F. Chu, A.H. Ormeci, D.J. Thoma, T.E. Mitchell, R.C. Albers, and J.Wills, "Theoretical and Experimental Studies of Laves Phase Compounds", TMS/ASM Materials Week, Cleveland, OH, 1995.

D.J. Thoma, "Near Net Shape Processing of Metal Powders Using Directed Light Fabrication" Seminar at the University of Cincinnati, Cincinnati, OH, January, 1996.

D.J. Thoma and F. Chu, "Experimental and Theoretical Evaluations of Laves Phases" Workshop on High Temperature Materials Based on Laves Phases (in conjunction with DOE Tenth Annual Conference on Fossil Energy Materials), Knoxville, TN, May, 1996.

D.J. Thoma, F. Chu, J.D. Livingston, C.T. Liu, D.P. Pope, and K.S. Kumar, "Laves Phase Superalloys?", DOE Workshop on Intermetallic Alloys, Atlanta, GA, June, 1996.

G.K. Lewis, D.J. Thoma, R.B. Nemec, J.O. Milewski, "Directed Light Fabrication of Near-Net Shape Metal Components", 1996 World Congress on Powder Metallurgy and Particulate Materials, Washington, D.C., June, 1996.

D.J. Thoma, R.D. Field, and G.K. Lewis, "Solidification Processes at High Rates", Workshop on Solidification", Los Alamos, NM, July, 1996.

J.H. Perepezko, C.A. Nunes. S-H. Yi, and D.J. Thoma, "Phase Stability in Processing of High-Temperature Intermetallic Alloys" High Temperature Ordered Intermetallic Alloys-VII, MRS Meeting, Boston, MA, November, 1996.

D.J. Thoma and G.K. Lewis, "Near Net Shape Processing of Metal Powders Using Directed Light Fabrication", TMS Annual Meeting, Orlando, FL, February, 1997.

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T. E. Mitchell, D. J. Thoma and F. Chu, "Structure and Mechanical Properties of Laves Phase Alloys", Annual Meeting of Japan Institute of Metals, Tokyo, Japan, March, 1997.

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D.J. Thoma, F. Chu, K.C. Chen, P.G. Kotula, C.M. Cady, G.T. (Rusty) Gray III, P.S. Dunn and D.R. Korzekwa, "Alloy Design of Monolithic and Dual-Phase Laves Phase Alloys" Seminar at Oak Ridge National Laboratory, Oak Ridge, TN, October, 1997.

S.R. Goldman, S.E. Caldwell, P.L. Gobby, W.W. Hsing, D.J. Thoma, R. P. Weaver, M.D. Wilke, D.C. Wilson, "Using Laser Drive to Explore the Physics of Structuring due to Target Defects" 11^{th} Biennial Nuclear Explosives Design Physics, Livermore, CA, October, 1997.

D.C. Wilson, P.A. Bradley, N.M. Hoffman, R.J. Swenson, D.P. Smitherman, R.E. Chrien, R.W. Margevicius, D.J. Thoma, L.R. Foreman, J.K. Hoffer, S.R. Goldman, S.E. Caldwell, T.R. Dittrich, S.W. Haan, M.M. Marinak, S.M. Pollaine, J.J. Sanchez, "The Development and Advantages of Beryllium Capsules for the National Ignition Facility", American Physical Society Meeting, Pittsburg, PA, November, 1997.

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M. Cray, D.C. Wilson, L.R. Foreman, J.C. Fernandez, C. Adams, C.W. Barnes, S.E. Caldwell, N.D. Delamater, S.R. Goldman, J.K. Hoffer, R.W. Margevicius, D.S. Montgomery, H.A. Rose, D.J. Thoma, and D.L. Tubbs, "Los Alamos Progress Toward Achieving DT Burn on the National Ignition Facility", American Nuclear Society Meeting, Nashville, TN, June, 1998.

J.O. Milewski, G.K. Lewis, D.J. Thoma, G.I. Keel, R.B. Nemec, J.C. Fonseca, and R. Reinert, "Direct Laser Fabrication of Solid Metal Objects Using 5-Axis Powder Deposition", Welding, Hamburg, Germany, September, 1998.

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R.G. Castro, D.J. Thoma, R.V. Vaidya, R.D. Field, "Characterization of Plasma Sprayed Aluminum-Beryllium for Aerospace and Space Applications", Thermal Spray Conference, Montreal, Canada, May, 1999.

R.J. Hanrahan, D.J. Thoma, C.M. Cady, D.A. Korzekwa, J.A. Lillard, M.T. Paffett, W.L. Manner, R.L. Bridges, "Corrosion and Aging of Uranium-Niobium Alloys", Oxford, England, July, 1999.

R.J. Hanrahan, D.J. Thoma, M.E. Hawley, G.W. Brown, J.F. Bingert, D.F. Teter, and R.L. Bridges, "Investigations of the Hydride Initiation Mechanism", JOWOG 28, Aldermaston, England, July, 1999.

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A. Nobile, J.C. Cooley, D.J. Thoma, R.W. Margevicius, T.J. Asaki, T.C. Hale, M.A. Salazer, G. Rivera, B.J. James, R.L. Nolen, M.M. Hoppe, R.B. Stephens, and W. Baugh, "Status and Long Term Plans for Fabrication and Fielding of Indirect Drive Beryllium Alloy Ignition Targets on the National Ignition Facility", Target Fabrication Specialist's Meeting, West Point, NY, July, 2001.

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J.L. Smith, J.C. Cooley, R.J. Hanrahan, W.L. Hults, A.M. Kelly, M.E. Manley, D.J. Thoma, E.J. Peterson, D. Dlguerova, J. Quan, G.M. Schmeideshoff, R.E. Lang, D.F. Woodfield, E.C. Gay, and C.C. McPheeters, " Magnetic-Field Studies of the CDW's in Single-Crystal Uranium", American Physical Society Meeting, Indianapoli, IN, March, 2002.

R.E. Hackenberg, D.C. Swift, K.C. Chen, J.C. Cooley, D.L. Paisley, D.J. Thoma and A. Hauer, " Phase Changes in NiTi Under Shock Loading, NMHSWPCM, Edinburgh, Enlgand, May, 2002.

E.J. Peterson, W.L. Hults, D.F. Teter, J.C. Cooley, A.M. Kelly, L.B. Dauelsberg, and D.J. Thoma, "Rietveld Refinements of U-Nb Alloys", X-ray Conference, Colorado Springs, CO, July, 2002.

D.J. Thoma, "Professionals Without Borders", IOMMS Meeting, Chicago, IL, November, 2003.

D. Brown, M. Bourke, W. Blumenthal, D.J. Thoma, D.F. Teter, R. Varma, "Engineering Neutron Diffraction Measurements Applied to Stockpile Stewardship Issues", University of Virginia, April, 2004.

D.W. Brown, D.F. Teter, D.J. Thoma, M.A. Bourke, R.D. Field, and W.L. Hults, "Beyond Slip: Using Neutron Diffraction and Polycrystallinc Plasticity Models to Understand Plastic Deformation in Anisotropic Materials", Northwestern University Seminar, Evanston, April, 2004.

D.J. Thoma, "Networking", Inaugural Material Advantage Student Workshop, New Orleans, LA, September, 2004.

D.J. Thoma, “Processing and Properties of U-Nb Shape Memory Alloys” Colorado School of Mines Seminar, October, 2004

D.J. Thoma, “Networking”, Material Advantage Student Workshop, Pittsburgh, PA, September, 2005. (encore of 2004 presentation)

C.P. Opeil, R.C. Albers, K.B. Blagoev, M. Gulacsi, J.C. Lashley, P.B. Littelwood, M.E. Manley, B. Mihaila, P.S. Riseborough, R.K. Schulze, D.J. Thoma, H.M. Volz, and J.L. Smith, “Photoelectric Effect in Uranium”, Advances in Physics and Chemistry of Actinide Compounds, Tokai, Japan, Sept., 2005.

D.J. Thoma, “Processing and Properties of U-Nb Shape Memory Alloys”, Iowa State University Seminar Series, April, 2006.

J.C. Lashley, P. and L. Mañosa, T. R. Finlayson, S. M. Shapiro, R. A. Fisher, M. E. Manley, P. Riseborough, A. Saxena, D.J. Thoma, W. Hults, J. L. Smith, and H. Ledbetter, “Electronic Restructuring in Shape Memory Alloys”, TMS Annual Meeting, Orlando, FL, February, 2007.

D.J. Thoma, “Thermoelastic Martensite Behavior in AuZn”, University of Illinois, Seminar, May, 2007.

Most presentations from 2007 - 2015 were either administrative or in classified settings and not counted in these sections or overall metrics.

D.J. Thoma, “Materials Design Institute Overview”, Materials Design Institute Seminar, April, 2012.

D.J. Thoma, “Advanced Manufacturing: Processing and Testing of Radioactive Materials”, Keynote Address at CIRMS 2014 Council on Ionizing Radiation Measurements and Standards, Gaithersberg, MD, March, 2014.

D.J. Thoma, W. King, R. Seals, “Additive Manufacturing of Actinides within the NNSA Nuclear Weapons Complex (U)”, Additive Manufacturing Summit, Oak Ridge, TN, May 15, 2014.

D.J. Thoma, “Advanced Manufacturing: Requirements for Material Specification, Qualification, and Certification”, Invited Seminar, University of Wisconsin, Madison, WI, December 4, 2014.

D.J. Thoma, “Additive Manufacturing: A Perspective on Advanced Manufacturing and Engineering Grand Challenges”, National Academy of Engineering, Washington D.C, October, 2015.

D.J. Thoma, “How to Implement Smart Manufacturing in Your Organization”, Engineering Professional Development Smart Manufacturing Webinar, Madison, WI, April, 2016.

D.J. Thoma, “Metal Additive Manufacturing: Challenges and Opportunities for Component Fabrication”, 9th Pacific Rim International Conference on Advanced Materials and Processing, Kyoto, Japan, August, 2016.

D.J. Thoma, “Keynote address: Challenges and Opportunities in Advanced Manufacturing: Where is Metal Processing Going?”, Advanced Photon Source at Argonne National Laboratory, Chicago, IL, August, 2016.

D.J. Thoma, “Grainger Institute for Engineering: Opportunities for Collaboration”, Midwest Energy Research Consortium Member Meeting, Milwaukee, WI, September, 2016.

D.J. Thoma, “Overview: Grainger Institute for Engineering”, ASM Milwaukee Chapter Meeting, Milwaukee, WI, January, 2017.

D.J. Thoma, “Directed Light Fabrication: A Near-Net Shape Process using Laser Assisted Metal Deposition”, TMS Annual Meeting, San Diego, CA, February, 2017.

D.J. Thoma, “Challenges and Opportunities for Metal Additive Manufacturing”, TMS Annual Meeting, San Diego, CA, February, 2017.

D.J. Thoma, “How Cross-cutting Technologies are Drivers for Growth”, MWERC Keynote, Milwaukee, WI, April, 2017.

D.J. Thoma, “Overview: Grainger Institute for Engineering”, Legislative Dinner, Madison, WI, April, 2017.

D.J. Thoma, “Industrial Outreach in Advanced Manufacturing”, Milwaukee Engineering Research Conference, Milwaukee, WI, May, 2017.

D.J. Thoma, "Metal Additive Manufacturing: Challenges and Opportunities for Component Fabrication", Conformal Cooling Conference, Minneapolis, MN, May 2017.

D.J. Thoma, “Structure-Property Relationships in Metal Additive Manufacturing”, Arizona State University Materials Seminar, Tempe, Arizona, September 2017.

D.J. Thoma, “Keynote address: Advanced Manufacturing: Smart Technologies and Digital Design”, Affiliated Construction Services, Engine and Vehicle Test Facility Forum, Madison, WI, June, 2017.

D.J. Thoma, “Refractory Alloys with Metal Additive Manufacturing”, H.C. Starck, Boston, MA December, 2017.

D.J. Thoma, “Keynote address: Structure-Property Relationships in Metal Additive Manufacturing”, International Conference on Plasticity, San Juan, Puerto Rico, January, 2018.

D.J. Thoma, *Advanced Manufacturing Opportunities*, Argonne-Wisconsin Workshop on Manufacturing Opportunities, Chicago, IL, January 2018.

D.J. Thoma, “Advanced Manufacturing Capabilities”, Forum for Manufacturers, Neenah, WI, June 2018.

D.J. Thoma, “Strengths and Opportunities with Metal Additive Manufacturing”, Thermo Fisher Scientific Virtual Materials Science Conference, May, 2018.

D.J. Thoma, *Keynote address*: “Design Innovations with Metal Additive Manufacturing”, University of Alberta Workshop, Materials Seminar, Edmonton, Canada, October, 2018.

D.J. Thoma et al., *Keynote:* “Design Innovation with Metal Additive Manufacturing”, International Conference on Plasticity, Damage, & Fracture, Panama City, Panama, January 2019.

K. Bertsch, D.J. Thoma, “Multiscale Analysis of the Effect of Processing Parameters on Microstructure in Additive Manufactured Components with Reduced Dimensionality”, International Conference on Plasticity, Damage, & Fracture, Panama City, Panama, January 2019.

B. Rankouhi, K.M Bertsch, D.J. Thoma, and K. Suresh, “Challenges and Opportunities at the Cross-Roads of Topology Optimization and Metal Additive Manufacturing” International Conference on Plasticity, Damage, & Fracture, Panama City, Panama, January 2019.

D.J. Thoma, “The Evolution and Impact of Additive Manufacturing (3D Printing)”, Vail Symposium, Vail, CO, June 2019.

D.J. Thoma, et al, “Design Innovations with Metal Additive Manufacturing”, PRICM-10 Conference, Xian, China, August 2019.

D.J. Thoma, M. Moorehead, M. Niezgoda, P. Nelaturu, A. Couet, “High-Throughput Experimental Synthesis of Refractory High-Entropy Alloys”, 1st World Congress on High Entropy Alloys, Seattle, WA, November 2019.

M. Moorehead, M. Elbakhshwan, C. Parkin, K. Sridharan, C. Zhang, A. Savan, A. Ludwig, D.J. Thoma, A. Couet, “High-Throughput Aging Investigation of High-Entropy Alloys for Advanced Nuclear Applications”, 1st World Congress on High Entropy Alloys, Seattle, WA, November 2019.

Contributed

P.T. Bizon, D.J. Thoma, and G.R. Halford, "Interaction of High-Cycle and Low-Cycle Fatigue of Haynes 188 Alloy at 1400° F", NASA Conference on Structural Integrity and Durability of Reusable Space Propulsion Systems, NASA Lewis Research Center, Cleveland, OH, June, 1985.

D.J. Thoma, T.K. Glasgow, S.N. Tewari, J.H. Perepezko, and N. Jayaraman, "Process Parameter Effects on Melt-Spun Ag-Cu", TMS-AIME Annual Meeting, Denver, CO, February, 1987.

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D.J. Thoma and J.H. Perepezko, "Solidification Processing of $NbCr_2$ Alloys", MRS Symposium: Intermetallic Matrix Composites, San Francisco, CA, April, 1990.

D.J. Thoma and J.H. Perepezko, "Phase Relationships and Stabilities in the Nb-Cr and the Nb-Cr-Ti Systems", TMS-AIME Fall Meeting, Cincinnati, OH, October, 1991.

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D.J. Thoma and J.H. Perepezko, “A Tri-Junction Diffusion Couple Analysis of the Nb-Cr-Ti System at 950°C,” TMS/ASM Materials Week ‘93, Pittsburgh, PA, October, 1993.

D.J. Thoma, “Hydrogen Storage Materials,” Workshop of the Hydrogen Working Group, Los Alamos, NM, March, 1994.

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Abstracts of Past Research

Microstructural Development in $NbCr_2$-Based Alloys

Ph.D. Thesis, Univ. of Wisconsin-Madison
9/88-5/92
Advisor: J.H. Perepezko

The microstructural development and phase stability of monolithic and composite structures based on the $NbCr_2$ Laves phase have been evaluated with various solidification processing techniques and thermal treatments. For equilibrium phase relationships in the Nb-Cr system, the results from a series of microstructural investigations, heat treatments, x-ray diffraction, and compositional analyses provide a basis to modify previously reported solubility limits and phase boundaries. In the Nb-Cr-Ti system, the phase formation and solubility limits were evaluated at 950°C through the study of a tri-junction ternary diffusion couple consisting of pure component elements. The established phase equilibria permits a detailed analysis of the microstructural evolutions during conventional solidification processing and thermal treatments. In addition, the defined equilibrium phase stabilities and relationships delineate a thermodynamic and structural gauge in predicting and defining the metastable phase development. For example, thermodynamic and kinetic methodologies to optimize a precursor metastable disordered phase have been developed, and additions of bcc stabilizing elements such as Nb, Cr, and Ti to the $NbCr_2$ intermetallic compound have demonstrated different extents of primary metastable bcc phase development in rapidly solidified samples which result from increased thermodynamic driving forces for the disordered metastable bcc phase and the kinetic nucleation and growth limitation of the ordered equilibrium Laves phase. Moreover, from the precursor microstructures, the definition and optimization of the microstructural features for enhanced mechanical properties in equilibrium Laves/bcc phase intermetallic matrix composites have been identified.

Structural Evolutions in the Drop Tube Processing of Fe-Ni Alloys

M.S. Thesis, Univ. of Wisconsin-Madison
7/86 - 8/88
Advisor: J.H. Perepezko

The microstructural development associated with solidification in undercooled Fe-Ni alloys has been reported to follow various pathways, with apparent dissimilarities existing as a function of sample size and processing environment. In order to identify the possible microstructural transitions and pathways, a systematic evaluation on the microstructural evolution in undercooled Fe-Ni alloys was performed on samples covering seven orders of magnitude in volume. Drop tube processing is a containerless solidification technique which promotes liquid undercooling through the elimination of potent, heterogeneous, nucleation sites associated with crucible walls. At appropriate undercooling levels, alternate solidification pathways become thermodynamically feasible and metastable product structures can result from the operation of competitive solidification kinetics. For thermal history evaluation, a heat flow analysis was applied to Fe-15wt% Ni and Fe-20wt% Ni large particles (1-3 mm) to predict undercooling potential. Alloy powders (10-100 μm), with large liquid undercoolings, were then studied under various compositions (10, 15, 20, 25, and 30 wt.% Ni) and processing conditions which affect the solidification kinetics and microstructural evolution, including fcc/bcc phase selection and the solid state stability of the retained metastable bcc phase. The identification of microstructural transitions with controlled variations in sample size and composition during containerless solidification processing was used to develop a microstructure map which delineates regimes of structural evolutions.

<u>Process Parameter Effects on Melt Spun Ag-Cu</u>

NASA-Lewis Research Center in Cleveland, OH and Univ. of Cincinnati in Cincinnati, OH
1/85 - 6/86
Advisors: H. Gray, T.K. Glasgow, and S. Tewari at NASA; and N. Jayaraman at U.C.

Process parameters in Chill Block Melt Spinning (CBMS) play an important role in product formation during rapid solidification. Wheel speed and melt superheat variations were examined in terms of ribbon dimensions and microstructures of Ag-19 wt.% Cu melt spun under high vacuum conditions. The ribbon thickness varied linearly with $(\text{solidification time})^{0.5}$, and the solidification rate increased with increasing wheel speed. The solidification microstructures initiated with a fine, equiaxed, two phase morphology on the wheel side that developed into a directional growth. Examination of serial sections parallel to the wheel side revealed a helical two-phase growth pattern in the mid-thickness of the ribbon which subsequently adopted a mixed cellular/dendritic solidification mode. The helical morphology appears to be related to the morphological instability associated with a banded microstructure. Near the free surface an equiaxed microstructure again developed due to dendritic fragmentation induced by melt shear flow. Wheel speed and melt superheat affected the extent of the different microstructures. Through control of processing parameters under high vacuum conditions in CBMS, a degree of control on ribbon dimensions and structural development has been achieved.

<u>Gravity Effects on Pb-Sn Dendrite Morphology</u>

NASA-Lewis Research Center
6/84 - 9/84
Advisors: H. Gray, E. Winsa, and V. Laxmanan

Ground-based, preliminary studies are required to establish a framework with which to compare microgravity experiments to be performed on the Space Shuttle. A gradient furnace was constructed to "quench-in" dendrite/liquid interfaces of Pb-15wt.% Sn for dendrite morphology analysis. Fraction solid calculations were compared with metallographic and microprobe investigations on solidification processed samples to establish an experimental correlation with theoretical predictions. With the terrestrial baseline of data, a Space Shuttle experiment was supervised by Dr. V. Laxmanan.

<u>Interaction of High-Cycle and Low-Cycle Fatigue of Haynes 188 Alloy at 1400°F</u>

NASA-Lewis Research Center
6/83 - 9/83 and 1/84 - 3/84
Advisors: P. Bizon, M. Hirschberg, and G. Halford

The interaction of low-cycle fatigue (LCF) and high-cycle fatigue (HCF) was evaluated on Haynes 188 alloy at 1400°F. Completely reversed, axial-load, strain-controlled fatigue tests were performed to determine the baseline data for this study. Additional specimens for interaction tests were cycled first at a high strain range for various small portions of expected LCF life followed by a step change to a low strain range to failure in HCF. Failure was defined as complete specimen separation. The resultant lives varied between 10 and 5000 cycles for the low-cycle fatigue tests and between 4500 and 3 million for the high-cycle fatigue tests. For the interaction tests the low-cycle life portion ranged from 30 and 100 applied cycles while the high-frequency life ranged from 300 and 300,000 cycles to failure. The step change results showed a significant nonlinear interaction in expected life. Application of a small part of the LCF life drastically decreased the available HCF life as compared with what would have been expected by classical linear damage rule (LDR).

The nonlinear cumulative damage rule proposed by Manson and Halford in 1981 and referred to as the "damage curve approach (DCA)" predicted the trends of the results. However, the presently observed interactions were more severe than anticipated, implying that the single universalized constant in the DCA has a different value than found for previous materials tested. A fractographic study of failed specimens showed that the fracture surfaces from interaction tests appeared to be essentially the same as surfaces from specimens tested in HCF only: the LCF portion of the cycling was not distinguishable on the interaction fracture surfaces.

Thermal Fatigue of TAZ-8A Alloy and Sixteen Alloy Variations

NASA-Lewis Research Center
6/83 - 9/83 and 1/84 - 3/84
Advisor: P. Bizon

A microstructural and statistical investigation was performed on the thermal fatigue behavior of a NASA developed alloy, TAZ-8A, and sixteen alloy variations. The systems investigated included alloy TAZ-8A and alloy variations consisting of a unique composition with an alteration in the percentage of carbon, molybdenum, tungsten, niobium, tantalum or boron. Double-edge wedge specimens of these alloys were cycled between fluidized beds maintained at 1088°C and 316°C with a 180 s immersion in each bed. Only carbon alloy variations survived 3500 cycles without cracking in the small radius, although substantial cracks were present, emanating from the end notches which were used for holding the specimens. Refined microstructural features resulting from the presence of carbides were defined as the dominant influencing variable in extending the thermal fatigue life in the TAZ-8A alloy variation.

Metallurgical Investigation of a TF-34 Engine Compressor Failure

NASA-Lewis Research Center
6/83 - 9/83
Co-worker: P. Bizon

Failure of the compressor section of a TF-34 aircraft gas turbine engine occurred during an evaluation of non-recoverable stall characteristics. The results of the metallurgical investigation revealed that the cause of the failure was ingestion of a foreign object and that this object was #8 cadmium plated screw. This conclusion was based on the analysis of one piece of debris, found in the exhaust ducting, that was identified as the head of a #8 cadmium plated screw. Energy dispersive analysis of x-rays showed that the #8 screw head had been exposed to impact from a titanium material object (compressor blades and vanes) and high temperatures. Furthermore, several areas of impact damage to compressor stage 6 blades and vanes were of a form that fit both the shape of a #8 screw head and screw thread. (NASA Special Achievement Award for outstanding service: D. Thoma & P. Bizon)

Los Alamos National Laboratory Projects

Beryllium Target Fabrication for Inertial Confinement Fusion (ICF)
P.I. - Dan J. Thoma
FY95-FY97, $350K per year

The objective of the program was to field a beryllium-base inertial confinement fusion (ICF) capsule for the National Ignition Facility (NIF). This capsule must have dimensions on the order of 2 mm in diameter with a 100 μm wall thickness, and the target must have a deuterium/tritium (DT) mix totaling approximately 300 atm. Beryllium was chosen because of its low atomic number, high strength, and good thermal conductivity. These features are important because of the implosion physics, the fidelity of gas retention at room temperature, and smooth layering of DT ice for uniform implosion, respectively. Alloying elements were explored for slight modifications of the atomic number.

Bulk Amorphous Alloys
P.I.'s - Dan J. Thoma, Loren A. Jacobson, and Richard Rhorer
FY95, $120K

A five component amorphous alloy incorporating beryllium has been developed by Prof. W.A. Johnson at CalTech. The critical cooling rate of this alloy for bypassing the crystallization kinetics is on the order of 2 K/s. The goal of this project was to evaluate the processing capabilities of this alloy. For example, we were the first to arc-cast 200 gram amorphous ingots, and the ability to form and machine this alloy was investigated. The ability to cast such large amorphous ingots in 1995 was the major thrust behind this growing topical area. The beryllium arc-melter that I developed was the sole reason for the initial success of this program.

Solidification Behavior and Alloy Development in Directed Light Fabrication
P.I.'s - Gary K. Lewis and Dan J. Thoma
FY95-FY97, $100K per year

Directed light fabrication (DLF) (developed by G.K. Lewis) is a rapid prototyping process that fuses gas delivered metal powders within a focal zone of a laser beam to produce 3-dimensional metal components. The focal zone of the laser beam is programmed to move along or across a part cross- section, and coupled with a multi-axis sample stage, complex metal geometries can be produced. The DLF technique offers unique advantages over conventional thermomechanical processes in that many labor and equipment intensive steps can be avoided. For example, typical processing of metals into desired shapes and assemblies involves casting and metal forming (rolling, stamping, forging extrusion) followed by machining and joining operations. The DLF process yields a final geometry from a single piece of equipment and the appropriate software control.

Since DLF processing offers unique capabilities and advantages for rapid prototyping of complex metal components, an examination of the microstructural development is required to define and optimize the process. The intent of this study was to address the solidification behavior during DLF processing to characterize the technique. In addition, the capability to produce advanced materials through alloy design was evaluated. Solidification modeling and multi-component phase equilibria calculations were used to achieve these goals.

Theory and Design of Monolithic and Dual Phase Alloys Based on Laves Phases

P.I. - Dan J. Thoma

FY96-FY02, $550K per year

Laves phases are the most abundant yet least utilized intermetallic phase. Because of some unique properties, including superconductivity, magnetic properties, hydrogen storage characteristics, high melting temperatures, high strength, reasonable oxidation resistance, and excellent creep properties, they have unusually high potential for a wide variety of applications that are directly related to energy sciences. Unfortunately, this potential has not been exploited, largely because of their tendency for low temperature brittleness. However, continued advances are being made in improving Laves phase toughness and ductility through the following three approaches: (1) understanding the defect structure and deformation mechanisms in Laves phases; (2) electronic and geometric contributions to phase stability and alloying behavior; and (3) dual phase (Laves/bcc) structures. Based upon our advances, we pursued a scientific focus on experimental and theoretical alloy design methodologies in order to elucidate and optimize deformation mechanisms as a function of defect structure. Our results provided a fundamental methodology—from the atomic to bulk scale—that improved the low temperature ductility and toughness of Laves phases.

Alloy Synthesis and Characterization of Dilute Palladium Alloys for Hydrogen Storage

P.I. - Dan J. Thoma

FY95-FY00, $450K per year

Palladium serves as an optimum basis for hydrogen storage because it displays fast hydrogen interchange kinetics near ambient temperatures, does not structurally degrade with time, and can be processed with low interstitial impurity content. The goal of the research was to tailor the hydrogen response (e.g., plateau pressure, hydrogen to metal ratio, and interchange kinetics) of Pd with dilute alloying additions. To synthesize the alloy, melt-spinning was used to produce compositionally uniform product with a high surface area to volume ratio. Process optimization studies were performed using fluid/heat flow simulations and solidification modeling. Alloy characterization included metallographic studies, *in situ* hydrogen cycling in a TEM, and gas/solid thermodynamics and kinetics studies. The latter was performed with the construction and use of a Sievert’s apparatus that measured gas overpressure as a function of time/temperature.

Solid-State Phase Transformations in Dilute Uranium Alloys

P.I. - Dan J. Thoma

FY95-FY99, $350K per year

The goal of the project was to determine the effects of composition and thermal history (heat-treatment, temperature phase file, and cooling rate) on the transformation temperatures and the resulting microstructures (i.e., grain size and phase distribution) in dilute uranium alloys. An alloy matrix consisted of elemental additions to uranium that were potential carbide formers. The phase transformation analyses were evaluated with continuous cooling experiments in a quench dilatometer. Samples were cooled from the gamma phase field (~950°C), and cooling rates varied from 0.1 to 1000°C/s. Kinetic evaluations, microstructural evaluations, continuous cooling transformation (CCT) curve construction, and microstructure map determinations were performed and optimized with thermodynamic phase diagram calculations. As a result of defining the microstructural evolution as a function of thermal history, performance and aging responses of the alloys were evaluated.

Uranium Corrosion and Aging

P.I.'s - Dan J. Thoma and Robert J. Hanrahan
FY96-FY99, $400K per year

Over time, hydrogen and hydrocarbons affect the physical properties of uranium. In this program, three undefined aspects of the aging response were evaluated: (1) surface reaction kinetics as a function of texture, (2) hydrogen effect on microstructure and bulk swelling, and (3) bulk dynamic mechanical properties. The specific tasks associated with these efforts were:

1. Measure rates of general corrosion, selective attack, and hydrogen permeation as a function of texture and environment.
2. Dilatometry studies on swelling and quenching kinetics.
3. High/low strain-rate testing of select dilatometer specimens.

By exploring these efforts in a combined evaluation, a kinetic reaction timeline coupled with the material property was investigated.

Beryllide Reaction Kinetics

P.I.'s - Dan J. Thoma, Robert J. Hanrahan and Loren A. Jacobson
FY95-FY98, $150K per year

Many molten actinide metals react with Be to form a high melting temperature beryllide (MBe_{13}, M=actinide). The reaction kinetics (under various surface area to volume ratios), structural integrity, and phase equilibria of these systems were defined. Characterization techniques included diffusion studies, phase diagram determinations, and single crystal beryllide synthesis and characterization.

Evaluation of Microstructural Development in Beryllium Weldments

P.I. - Dan J. Thoma
FY97-FY01, $150K per year

The goal of the study was to evaluate microstructural evolutions in weld material. Specifically, with liquid undercoolings during the weld process, alternate solidification pathways are possible that affect the strength, corrosion, and aging characteristics of a weld. Therefore, the phase relationships, stability, metastable equilibria, and morphologies were evaluated in Al-Be-Si. As an initial test case (for experimental safety reasons), Al-Si eutectic samples were evaluated. With the establishment of Al-Si baselines, Be additions were evaluated in both laboratory and production samples. Microstructural consistency was achieved in the laboratory samples as compared to the manufactured product. As a result, thermophysical and mechanical properties were defined to simulate the manufacturing and constitutive response of the alloy. Wide ranges of temperature response and static vs. dynamic properties were characterized.

Shock Loading of Beryllium Single Crystals Using the TRIDENT Laser

P.I.'s - Dan J. Thoma, Allen Hauer

FY98-FY00, $150K per year

The objective of this facet of the Inertial Confinement Fusion Program is to develop alloy samples for Equation of State studies. Recent efforts have focused on static properties of Be single crystals as a function of pressure and temperature using a variety of tools including diamond anvil cells and resonant ultrasound spectroscopy. Future dynamic experiments will center upon pulse-shock tests performed on the TRIDENT laser. The dynamic tests will be characterized with transient diffraction techniques coupled with optical *in situ* diagnostics. Transmission electron microscopy was used for post mordem evaluations.

Microstructural Control of High-Temperature *in situ* Composites Using Directed Light Fabrication (DLF)

P.I. Dan J. Thoma

FY98, $180K per year

The goal of the proposed research is two-fold in that there is a scientific benefit as well as a technological impact. The scientific thrust is to fundamentally define eutectic solidification at rates never before achieved in bulk components. Although eutectic solidification is the topic of many research programs, no studies have been able to study the bulk microstructural development at the growth velocities defined in DLF processing. The technological impact of this effort resides in the refinement of the microstructural evolution in refractory materials. Composite structures can be tailored so that enhanced properties can be realized in systems typically dictated by the heat flow constraints associated with containment of high-melting temperature alloys. In fact, the ultimate goal is to achieve a three decade old endeavor to capitalize on the novel properties associated with rapid solidification. Only with DLF can this effort be realized in bulk forms for refractory alloys.

Bulk Rapid Solidification

P.I. Dan J. Thoma

FY99-FY01, $200K per year

Directed light fabrication is a fabrication process that fuses gas delivered metal powders within a focal zone of a laser beam to produce fully dense, near-net shape, 3-dimensional metal components from a computer generated solid model. Moreover, owing to the flexibility in power distributions of lasers, a variety of materials were processed, ranging from aluminum alloys to tungsten, and including intermetallics such as Mo_5Si_3 and NiAl. Upon examination of the microstructures generated with DLF processing, the microstructural features were significantly refined over any other conventional solidification process. Using secondary dendrite arm spacing in the processed material, we have demonstrated that the cooling rates are in the regime classified as rapid solidification. This study (1) experimentally and theoretically determined the solidification behavior, and (2) realized the unique advantages associated in rapidly solidified bulk product. In short, we achieved the "holy grail" of a 30 year international research effort.

<u>Hydrogen Storage in Intermetallics</u>

P.I. Dan J. Thoma
FY99-FY01, $200K per year

Methodologies for designing complex intermetallic alloys useful in hydrogen storage applications had not existed. As a result, trial-and-error approaches were typically used, severely limiting the goal to achieve light-weight materials with large hydrogen to metal atom ratios. We developed a methodology using (1) geometric models (for hydrogen site accommodation) and (2) electronic structure calculations (for available electronic state occupancy) on a class of intermetallic phases to develop new strategies in optimizing the capacity for hydrogen storage. The addressed a fundamental and unresolved question in a variety of Engineering Sciences: what are *a priori* methods for predicting hydrogen capacities in an engineering product? The development of new models (known in simpler forms to have an influence on hydrogen storage capability) provided an enabling strategy for design of chemical species without numerous experimental evaluations.

<u>Time Resolved Study of Martensitic Phase Transformations</u>

P.I. Dan J. Thoma
FY00-FY02, $200K per year

We applied a new experimental method - laser based materials measurements (such as transient x-ray diffraction) - to a problem of fundamental scientific interest: martensitic transformations in solids. Martensite reactions are a type of solid-state phase transformation that occur via a shear distortion of a crystal lattice. The research addressed a fundamental and unresolved question in Materials Science: what are the nucleation mechanisms and kinetics in the martensitic (displacive) transformation? The production of ultra-fast tensile pulses with laser generated shocks (on the Los Alamos Trident laser) enabled probing of the material on a time and stress scale not heretofore accessible by other experimental methods. A variety of martensitic structures were investigated, but focused on shape-memory alloys such as NiTi, AuZn, and U-6wt.%Nb. Novel features of dynamic pressure effects were defined in these systems, including charge density wave transitions, pressure/temperature critical points, and first order phase transitions with second order characteristics.

<u>Pu Dilatometry and Phase Stability</u>

P.I. – Dan J. Thoma
FY00-FY01, $300K per year

This program studied the relevant aging mechanisms affecting phase stability in Pu alloys. To accomplish this task, dilatometry was used as a sensitive guide to microstructural evolutions as a function of time. The initial boundary conditions were explored by analyzing Continuous Cooling Transformation (CCT) curves and comparing the experimental results to thermodynamic/kinetic models. In addition, Isothermal Transformation (IT) curves were used to determine phase stability at constant temperatures. Both studies required the fabrication of a highly sensitive dilatometer (with nm resolution). With "virgin" material baselines, the aging changes were explored to evaluate lifetime predictions of the material. The aged material showed distinct changes in thermodynamic and kinetic phase stability, allowing models to be formulated.

Evaluation of Beryllium Brazing Cycles

P.I. – Dan J. Thoma
FY00-FY02, $150K per year

Braze cycles that bond Be to Monel have been investigated using *in situ* dilatometry and microstructural characterization. Commercial brazing environments can yield temperature and time deviations, resulting in uncertainty boundaries of the interfacial reaction product. Controlled experiments monitored length changes as a function of the process parameters. Brazing reactions could be kinetically evaluated and characterized in *post mordem* investigations. This effort led to tighter controls of the industrial practice.

Characterization of Uranium and U-Nb

P.I. - Dan J. Thoma
FY00-FY03, $1M per year

The goal of this program fundamentally explores the microstructural evolution during processing and how these microstructures affect performance. This has required a detailed understanding of the thermodynamic boundary conditions and the kinetic constraints affecting the performance variable. Our basic methodology is simple: the thermomechanical processing history dictates the starting microstructure, and the starting microstructure is the baseline from which aging and performance can be evaluated.

In the past, we have focused our progress in uranium on the role of impurities (i.e., carbon and hydrogen). We now have clear evidence of how carbon evolves in a microstructure. We have also extended our knowledge in quantifying the role of carbon, and we have defined certain aspects of hydrogen evolution and hydride formation. Quantification under different conditions is a required goal. The role of other impurities has been initiated.

In addition to "pure" uranium, we have explored the stability of uranium-niobium alloys. We have quantified segregation, how it thermodynamically evolves, and how niobium content influences phase stability. We have also noted that the coupling of impurities STRONGLY affects the phase stability, but as of yet, this effect has not been quantified.

Finally, this program has evolved into an effort to determine how uranium and uranium alloys change as a function of time, temperature, composition, and environment (e.g., how the material ages). This task provides data and understanding used in decision-making processes associated with stockpile material utilization. Specifically, we address aging phase stability and the corresponding change in design property requirements, and offer models for predictive capability.

ICF Be Capsule Development

P.I. - Dan J. Thoma
FY01-FY03, $1.2 M per year

The goal of this program is to fabricate beryllium capsules for ignition at NIF. In order to achieve this long term task within Campaign 10, our specific efforts revolve around beryllium capsules because Be has the best ablator characteristics in simulations, Be has the potential to hold DT fill pressure and be transported warm, and DT ice layering is facilitated by the high thermal conductivity of Be. Our fabrication focus for the Be capsule is basically four-fold: develop the alloy with appropriated mictrostructures, join and fill the capsule, define machining and polishing procedures, and perform ablator work. Specifically, these four activities include….

Binary Be alloy development:

1) Processing of Be-Cu
2) Fundamental properties of Be-Cu alloys
3) Grain refinement techniques
4) Grain growth kinetics

This task involved the development and control of mictrostructures within NIF specifications. The majority of the work consisted of arc-casting, ECAE processing for grain refinement, recrystallization, and grain growth. Processing and characterization techniques were used to develop activation energy maps to establish production windows that yield optimum material for NIF.

Beryllium alloy joining and filling:

1) Bonding/brazing studies
2) Characterization of bonds
3) Burst tests of bonds

This task involves the ability to bond alloys together for desired strengths in a NIF capsule. The bonding procedures hinge upon the previous task in that thermal cycles will be required to achieve bonding, and microstructural control is needed. The majority of the focus will center upon the utilization of sputter-deposited brazes.

Beryllium alloy machining and polishing:

1) Polishing specifications
2) Mode Roughness

This task was a finalization and reporting of past studies on surface roughness attainable in polishing procedures. The final achieved goal was a nanometer finish for performance optimization.

Ablator Work:

1) Sample Production
2) Sample Characterization

This task involved the first task and careful characterization of samples to be used in evaluating the role of microstructural variations in shock propagation during ablation.

<u>Hydro Materials Characterization</u>

P.I. – David F. Teter and Dan J. Thoma
FY02-FY03, $300K per year

The goal of this activity is to characterize the processing of wrought depleted uranium. Ultimately, we aim to bracket the materials properties that might be achievable for material processed for the Hydro program. This includes characterization of as rolled plates, recrystallized plates and final as- formed parts. This program is motivated by the anisotropy of the material that gives rise to location dependent properties. In particular, the three dimensional constitutive response defines a confidence range from which product performance can be reliably predicted. Moreover, the anisotropy developed during manufacturing imparts distortion in final assembly. The physical mechanisms that yield the uncertainties are being characterized and defined.

Materials Design Institute

P.I. – Dan J. Thoma, Director
FY05-FY13, $2M per year

The Materials Design Institute at Los Alamos National Laboratory is the primary source for educating, recruiting, and retaining the essential skills that are critical for materials design and development needs. The Institute, as part of an ensemble of Integrated Institutes, will evaluate a streamlined process for rapidly maturing materials requirements with state-of-the-art technology and practices. The Institute will also provide a focal point of materials expertise, knowledge, and information dissemination to foster integration and collaboration among the materials science and engineering community. Materials issues are interwoven in programmatic activities at LANL, and the ability to develop the essential skills in the implementation of material requirements will connect the generation of materials data with performance objectives. The Institute will create educational programs at various levels: summer sessions, degree programs at the Masters and Ph.D. levels, professional short courses for current staff, and an active seminar/workshop series that will disseminate capabilities, practices, and understandings of materials to capitalize on the multi-disciplinary materials workforce requirements. Also, individual projects (as defined by Associate Directors and LANL's Executive Board) on fostering materials futures (such as characterization, integrated performance, responsive infrastructure, etc.) will be performed. Initially, three competency areas are being developed: 3D microscopy, functional materials (active sensors), and crystal synthesis. Activities will be coordinated through laboratory councils and external reviews.

University of Wisconsin-Madison Projects

CURRENT PROJECTS
Title: High-Throughput Design of Metallic Glasses with Physically Motivated Descriptors
Sponsor: NSF-DMREF Award 1728933 - $1,200,000
PI: Dane Morgan (UW, PI), Dan Thoma (UW, co-PI), Paul Voyles (UW, co-PI), John Perepezko (UW, co-PI), Izabela Szulfarska (UW, co-PI),
Level of Support – D. Thoma, 0 mo/yr
Duration: 10/01/2017 - 9/31/2020

Title: Accelerated Materials Design for Molten Salt Technologies Using Innovative High-Throughput Methods
Sponsor: ARPA-E Award No. DE-AR0001858 - $1,861,820
PI: Adrien Couet (UW, PI), Dan Thoma (UW, co-PI), Kumar Sridharan (UW, co-PI), Dimitris Papailiopoulos (UW, co-PI), Santanu Chaudhuri (ANL, co-PI), Jason Hattrick-Simpers (NIST, co-PI)
Level of support - D. Thoma, 0.3 mo/yr
Duration: 2/01/2019-1/31/2022

Title: Consortium for Enabling Technologies and Innovations
Sponsor: DOE-NNSA for DE-FOA-001875j - $25,000,000
PI: Anna Erickson, (GTI, PI) many co-PI's
Level of Support to Co-PI – Dan Thoma, 0.5 mo/yr
Duration: 6/2019 to 5/2024

PENDING PROJECTS

Title: Grain Boundary Design to Enhance Damage Resistance of polycrystalline Metallic Materials
Sponsor: NSF DMREF- $1,700,000
PI: Curt Bronkhorst (UW, PI), Dan Thoma (UW, co-PI), Marko Knezevic (UNH, co-PI), Sid Pathak (UNR, co-PI)
Level of Support – D. Thoma, 0.5 mo/yr
Duration: 10/2019 to 9/2023