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PROFESSOR RONALD GEORGE BALLINGER

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Massachusetts Institute of Technology
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TITLE Professor, Departments of Nuclear Science and Engineering
Engineering and Materials Science and Engineering, Massachusetts
Institute of Technology (Promoted from Associate Professor effective
6/1/2005).

EDUCATION MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Sc.D. degree in Nuclear Materials Engineering titled "Corrosion
Fatigue of Nickel Base Alloys for Nuclear Applications," February
1982.

S.M. degree in Materials Science, February, 1978.

S.M. degree in Nuclear Engineering, September 1977. Thesis title:
"The Anisotropic Mechanical Behavior of Zircaloy-2." (Both degrees).

WORCESTER POLYTECHNIC INSTITUTE

S.B. degree in Mechanical Engineering, with high distinction,
February, 1975. Emphasis on Materials Science.

**ORGANIZATION
AND SOCIETY
MEMBERSHIPS** President, MIT Student Section, American Nuclear Society, 1977-78

Vice President, MIT Student Section American Nuclear Society, 1976-
77

Member, Tau Beta Pi
Associate Member, Sigma XI
Member, Pi Tau Sigma
Member, American Nuclear Society
Member, American Society for Metals
Member, National Association of Corrosion Engineers
Member, American Society for Testing and Materials

**AWARDS AND
PRIZES**

1971-72 CRC Engineering Science Achievement Award,
Worcester
Polytechnic Institute

Metallurgy and Materials Science Prize, 1973, Sponsored by the
Boston Section of the AIME and given in honor of Professor Morris
Cohen

1975 George Eastman Award for Outstanding Graduate Class of 1975,
Worcester Polytechnic Institute

1985 MIT American Nuclear Society Outstanding Professor Award

1985 MIT Graduate Student Council Teaching Award

1988 Carl Richard Soderberg Professorship in Power Engineering

2003 MIT Joel & Ruth Spira Award for Outstanding Teaching

PATENTS

Patent Number 4785142, Issued 11/15/88.
European Patent Number 0285952, Issued 3/1/92

Title: "Superconductor Cable".

Patent is for a new high strength, Low Coefficient Expansion (COE)
alloy for use as a structural material for Nb_3Sn superconducting cables.
The use of this new alloy will allow higher current carrying capability
by the superconductor and, thus, higher fields and/or smaller
hardware. The new alloy also has use in high temperature gas turbine
engine applications.

RESEARCH

Mechanical behavior of structural materials and environmental
degradation of materials with emphasis on corrosion, corrosion
fatigue and stress corrosion cracking behavior in high temperature
aqueous systems including:(1) irradiation assisted stress corrosion
cracking in Water Reactor Systems, (2) stress corrosion cracking in
Pressurized Water Reactor steam generator materials, (3) high
temperature materials for advanced reactor systems. Environmental
degradation, processing, conditioning, and storage of metallic uranium
nuclear fuel. The modeling of high temperature aqueous chemistry in
cracks and crevices including the effect of radiolysis on irradiation
assisted stress corrosion cracking. High temperature aqueous
electrochemical analytical and measurement techniques including in-
core aqueous chemistry. Environmental degradation of aircraft
structural materials.

Advanced fatigue and fracture mechanics techniques and analysis. Relationships between structure, properties and performance. Failure analysis, life prediction and extension of engineering components.

Material performance at low temperatures for superconducting and structural applications.

Development of advanced reactor systems including gas cooled, liquid metal cooled, and alternative fueled light water reactors. Specialized materials development for advanced reactor systems. Fuel performance modeling. Reactor engineering for advanced concept systems, Turbo-machinery development for direct and indirect cycle Brayton systems.

PROFESSIONAL EXPERIENCE

Professor, Departments of Nuclear Science and Engineering and Materials Science and Engineering, MIT Effective June 1, 2005.

Associate Professor, Departments of Nuclear Engineering and Materials Science and Engineering, MIT. 1987-June, 2005.

Assistant Professor, Department of Nuclear Engineering and Materials Science and Engineering, MIT. 1982 - 1987.

Member, International Cyclic Crack Growth Review Group 1982-1985

Member, International Cooperative Working Group on Irradiation Assisted Stress Corrosion Cracking. 1985-1992

Entropy Ltd., South Great Road, Lincoln, MA. Consultant on Nuclear Fuel Performance Modeling. 1978 -1985

Chairman, SPEAR Fuel Rod Reliability Code Workshop, Lincoln, MA, September 25 and 26, 1980.

Session co-chairman, International Conference on Environmental Cracking of metals, Kohler, WI, Oct. 2-7, 1988.

Workshop Host, International Working Group on Irradiation Assisted Stress Corrosion Cracking, Cambridge, MA, April 10-13, 1989.

U. S. Department of Energy, Independent Technical Assessment Team for Dry Storage of N-Reactor Fuel. Jan. 1994-Sept. 1994

U. S. Department of Energy Technical Assistance Group (TAG) for Disposition of N-Reactor Fuel, Jan.1995-2001

U. S. Department of State Technical Advisory Committee on Conditioning of North Korean Reactor (DPRK) Fuel , Jan. 1995-2003

U. S. Department of Energy Technical Advisory Committee on Disposition of Savannah River Reactor Site Metallic Fuel. Jan.-Aug. 1996

U. S. Department of Energy Technical Advisory Committee on Disposition of metallic fuel stored at INEL. June 1996-2002

Member, Executive Committee-Materials Science and Technology Division, American Nuclear Society, 1999-Present

Advisory Committee on Reactor Safeguards: Member, *Ad Hoc* Subcommittee on a Differing Professional Opinion: Voltage-Based Repair Criteria, September-December 2000.

Secretary/Treasurer, Materials Science and Technology Division, American Nuclear Society, 2003-2004

Vice Chair/Chair Elect, Materials Science and Technology Division, American Nuclear Society, 2004-2005

Chair, Materials Science and Technology Division, American Nuclear Society, 2005-2006

Member, Department of Energy Independent Technology Review Group (ITRG) for the Design Features and Technology Uncertainties for the Next Generation Nuclear Plant, 2003-2004.

Member, Department of Energy Technical Review Group for Power Conversion Technology Assessment for the Next Generation Nuclear Plant, 2004.

Member, Idaho National Laboratory Materials Review Board, 2003-2006

Member, International Cooperative Group on Environmentally Assisted Cracking of Light Water Reactor Materials, 2003-Present

MILITARY

U.S. Naval Nuclear Power Program: Most Advanced rating, E-6.

SERVICE Served as Engineering Watch Supervisor on an operating nuclear submarine. Three years as instructor and Leading Petty Officer, M-Division at the SIC Naval Reactor Prototype.

BACKGROUND Born and raised in West Hartford, Connecticut.

REFERENCES Furnished upon request.

PUBLICATIONS

R. G. Ballinger, W. G. Dobson, R. R. Biederman, "Oxidation Reaction Kinetics of Zircaloy-2 in an Unlimited Steam Environment," *J. Nuc. Materials*, 62, 2, 3, November 1976.

W. G. Dobson, R. R. Biederman, R. G. Ballinger, "Zircaloy-4 Oxidation in Steam under Transient Oxidizing Conditions," ASTM, STP 663, 1977.

R. G. Ballinger, and R. M. N. Pelloux, "The Anisotropic Mechanical Behavior of Zircaloy-2," Third International Conference on Mechanical Behavior of Materials, Cambridge UK, August 1979, Vol. 2, pp 685-695.

G. S. Was, H. H. Tischner, E. L. Hall, R. M. Latanision, R. G. Ballinger, and R. M. N. Pelloux, "Effects of Heat Treatment on Segregation and Precipitation of Trace Elements in Inconel 600," presented by Environmental Fracture Session 1, Fall Meeting of TMS-AIME, Milwaukee, September 1979.

R. G. Ballinger and R. M. N. Pelloux, "The Effect of Anisotropy on the Mechanical Behavior of Zircaloy-2," *J. Nucl. Materials*, 97, No. 3, April 1981.

R. G. Ballinger, R. Christensen, R. Eilbert, S. Oldberg, E. Rumble, and G. S. Was, "Clad Failure Modeling Progress," Fifth International Conference on Zirconium in the Nuclear Industry, August 1980.

R. G. Ballinger, R. M. Latanision, W. C. Moshier, and R. M. N. Pelloux, "The Role of Uncertainty in the Measurement of Crack Length by Compliance Techniques," International Conference on Subcritical Crack Growth, Freiberg (W. Ger.), May 13-15, 1981, pp 261-285.

R. G. Ballinger et al., "Fission Gas Release and Fuel Reliability at Extended Burnup" Topical Meeting on LWR Extended Burnup, Fuel Performance and Utilization, Williamsburg, VA, April 4-8, 1982, pp 4-35.

C. K. Sheeks, W. C. Moshier, R. G. Ballinger, R. M. Latanision, and R. M. Pelloux, "Fatigue Crack Growth of Alloys X-750 and 600 in Simulated PWR and BWR Environment," International Symposium on Environmental Degradation of Materials in Nuclear Power Systems, Myrtle Beach, S.C., August 22-25, 1983.

R. G. Ballinger, W. C. Moshier, K. N. Siebein, and R. M. Latanision, "A Study of the Thermal Aging Behavior in Alloy 600 Tubing," 9th International Congress on Metallic Corrosion, Toronto, Canada, June 3-7, 1984, pp 265-273

C. K. Sheeks, R. G. Ballinger, R. M. Latanision, "Fatigue Crack Growth of Inconel Alloy X-750 in Simulated PWR and BWR Environments," 9th International Congress on Metallic Corrosion, Toronto, Canada, June 3-7, 1984, pp 310-316.

R. G. Ballinger, G. E. Lucas, and R. M. Pelloux, "The Effect of Plastic Strain on the Evolution of Crystallographic Texture in Zircaloy-2," *J. Nucl. Materials*, 126 (1984), pp 53-69

R. G. Ballinger, J. W. Prybylowski, and C. K. Elliott, "Effect of Processing History and Chemistry on the Structure of Nickel Base Superalloys," Second International Symposium on Environmental Degradation of Materials in Nuclear Power Systems - Water Reactors, Monterey, CA, Sept. 9-12, 1985.

R.G. Ballinger, and J. W. Prybylowski, "An Overview of Advanced High Strength Nickel Base Alloys for LWR Applications," EPRI Workshop on Advanced High Strength Materials for LWR Internal Applications, Clearwater Beach, FL, March 12-13, 1986.

J. W. Prybylowski, R. G. Ballinger, "The Influence of Microstructures on Environmentally Assisted Cracking of Alloy 718," Corrosion '86, Houston, TX, March 17-21, 1986.

R. G. Ballinger, et. al. "Low Coefficient of Expansion Structural Materials Development for Conductor Applications," 9th Annual Cryogenic Structural Materials Workshop, Reno, NV, October 6-8, 1986.

J. W. Prybylowski, R. G. Ballinger, "The Influence of Microstructure on Environmentally Assisted Cracking of Alloy 718", *Corrosion*, 43, No.2 (1987), pp 111-117.

J. L. Martin, R. G. Ballinger, et al., "Tensile, Fatigue and Fracture Toughness Properties of a New Low Coefficient of Expansion Cryogenic Structural Alloy, Incoloy 9XA," Int'l Conf. on Cryogenic Materials and Cryogenic Engineering, St. Charles, IL, June 14-18, 1987.

M. Morra, R. G. Ballinger, et al., "Incoloy 9XA, A New Low Coefficient of Thermal Expansion Sheathing Alloy of Use in ICCS Magnets," Int'l Conf. on Cryogenic Materials and Cryogenic Engineering, St. Charles, IL, June 14-15, 1987.

M. M. Steeves, et. al., "The US-DPC. A Poloidal Coil Test Insert for the Japanese Demonstration Poloidal Coil Test Facility," Tenth Int'l Conf. on Magnet Technology, September 21-25, 1987, Boston, MA.

I. S. Hwang, R. G. Ballinger, K. Hosoya, "High Temperature Electrochemistry of Precipitation Hardened Nickel Base Alloys in Aqueous Systems," 172nd Mtg. of the Electrochemical Society, Honolulu, HI, October 18-23, 1987.

J. W. Prybylowski, R. G. Ballinger, and C. Elliott, "Quantitative Analytical Electron Microscopy of Multiphase Alloys," *J. Electron Microscopy Technique*, 11, 1988.

K. Hosoya, R. Ballinger, J. Prybylowski, I.S. Hwang, "The Role of Microstructure in Environmentally Assisted Cracking of Nickel-Base Alloys," *Corrosion*, 44, 1988, pp 838-853.

M. J. Driscoll, et. al., "The MIT In-Pile Loops for Coolant Chemistry and Corrosion Studies," 1988 JAIF Int'l. Conf. on Water Chemistry in Nuclear Power Plants, April 19-22, 1988, Tokyo, Japan.

R. G. Ballinger, C. S. Elliott, and I. S. Hwang, "Corrosion Fatigue of Alloy X-750 in Aqueous Environments," Int'l. Conf. on Environment Induced Cracking of Metals, October 2-7, 1988, Kohler, WI

H. Becker, and R. G. Ballinger, "316LN Forgings for Alcator C-Mod; Metallurgical and Design Considerations," 11th Cryogenic Structural Materials Workshop, Colorado Springs, CO, October 18-19, 1988.

I. S. Hwang, R. G. Ballinger, and K. Hosoya, Electrochemistry of Multiphase Nickel-Base Alloys-in Aqueous Systems," *J. Electrochemical Society*, Vol. 136, No. 7, 1989

Morra, M, R.G. Ballinger, and I.S. Hwang, "The Relationship Between Processing, Structure, and Properties of a New High Strength, Low Coefficient of Expansion Alloy for Cryogenic Service," 1989 TMS Annual Meeting, Las Vegas, NV, February 27 - March 2, 1989.

S. C. Luckhardt, et al. "Measurements of Neutron and Gamma Ray Emission Rates and Calorimetry in Electrochemical Cells Having Palladium Cathodes," APS Meeting Baltimore, MD, June 1, 1989.

O. K. Harling, et al. "Engineering Activities at the MIT Research Reactor in Support of Power Reactor Technology." 1989 ANS Reactor Operations Topical Meeting, Charlotte, NC, August 6-9, 1989.

M. Steeves, et. al., "Progress in the Manufacture of the U.S. DPC Test Coil." *IEEE Transactions on Magnetics*, Vol. 25, No. 2(1989)

D. Albagli et. al., "Measurement of Neutron and Gamma Ray Emission Rates, Other Fusion Products, and Power in Electrochemical Cells Having Palladium Cathodes," *J. of Fusion Energy*, Vol. 9, No. 2(1990), pp. 133-148.

K Kumar, I.S. Hwang, R.G. Ballinger, C.R. Dauwalter, A. Stecyk, "Analysis of Palladium Cathodes Used for Heavy Water Electrolysis," *Fusion Technology*, Vol. 19, No. 1(1991), pp. 178-187.

R.L. Tobler, R.P. Reed, I.S. Hwang, M.M. Morra, R.G. Ballinger, H. Nakajima, S. Shimamoto, "Charpy Impact Tests Near Absolute Zero", *Journal of Testing & Evaluation*, Vol. 19, No. 1(1991), pp 34-40.

I.S. Hwang and R.G. Ballinger, "A Multi-frequency A.C. Potential Drop Technique for the Detection of Small Cracks", *J. Meas. Science and Technology*, 3 (1992), pp 62-74.

I.S. Hwang, M.M. Morra, R.G. Ballinger, H. Nakajima, S. Shimamoto, and R.L. Tobler, "Charpy Absorbed Energy and JIC As Measures of Cryogenic Fracture Toughness", *Journal of Testing and Evaluation*, JTEVA, Vol. 20, No. 4, July 1992, pp. 248-258.

A. Turnbull, R. Ballinger, I. Hwang, M. Morra, M. Psaila-Dombrowski. "Hydrogen Transport in Nickel Base Alloys". *Metallurgical Transactions*, Metallurgical Transactions, Vol. 23A, Dec. 1992., pp 3231-3244..

M. Morra, R. Ballinger, I Hwang, "Incoloy 908, A New Low Coefficient of Expansion Alloy For High Strength Cryogenic Applications-Physical Metallurgy". *Metallurgical Transactions*, Vol. 23A, Dec. 1992, pp 3177-3192.

M.M. Morra, I.S. Hwang, R.G. Ballinger, M.M. Steeves and M.O. Hoenig, "Effect of Cold Work and Heat Treatment on the 4°K Tensile, Fatigue and Fracture Toughness Properties of Incoloy 908", 11th International Conference on Magnet technology (MT-11), Tsukuba, Japan, Aug. 28-Sept. 1, 1989.

A. Turnbull, R.G. Ballinger, I.S. Hwang, and R.M. Gates, "The Influence of Microstructure on Hydrogen Transport in Nickel-Base Alloys", *Proceedings of the Fourth International Conference on The Effect of Hydrogen on The Behavior of Materials*, Jackson Lake Lodge, Moran, Wyoming, September 12-15, 1989, pp 121-132.

M. Psaila-Dombrowski, A. Turnbull, R. Ballinger, "Implications of Crevice Chemistry for Cracking of BWR Recirculating Inlet Safe-Ends", *UK Corrosion 90*, Surrey, October 29-31, 1990.

O.K. Harling, G.E. Kohse, M.J. Driscoll, and R.G. Ballinger, "In-Pile Facilities for LWR Materials and Chemistry Studies at the MIT Research Reactor", to be presented at the JAIF Intl. Conf. on Water Chemistry in Nuclear Power Plants, Fukui City, Japan, April 22-25, 1991.

T. Oka, R. Ballinger, I Hwang, "Modelling of Hydrogen Assisted Cracking of Ni-Base Alloy X-750 in Water". *International Symposium on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors*, Monterey, CA, 8/25-8/31/91.

P. Lidar, R. Ballinger, I Hwang, " The Use of Potential Drop Techniques for the Evaluation of Environmentally Assisted Cracking of Austenitic Alloys". *International Symposium on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors*, Monterey, CA, 8/25-8/31/91.

T. Shoji, K. Yamaki, R. Ballinger, I. Hwang, "Grain Boundary Segregation and Intergranular Stress Corrosion Cracking Susceptibility of Austenitic Stainless Steels in High Temperature Water". *International Symposium on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors*, Monterey, CA, 8/25-8/31/91.

J. Murphy, R. Ballinger, H. Becker, D. Gwinn, S. Methew, "Turbogenerator Flywheel For Alcator C-Mod", 14th Symposium on Fusion Engineering, San Diego, CA, 10/1-10/3/91.

I. Hwang, R. Ballinger, M. Morra, M. Steeves, "Mechanical Properties of Incoloy 908-An Update", ICMC/CEC 91, Huntsville AL, 4/1-4/5/91.

I. S. Hwang, R.G. Ballinger, M.M. Morra, B. Tao, and S. Mathew, "Improved Mechanical Properties of Alloy 718 by Anneal and Direct Aging Process for Nuclear Fusion Applications". International Symposium on the Metallurgy and Applications of Superalloys 718, 625 and Various Derivatives, ASM/NACE, June 23-26, 1991, Pittsburgh, PA, pp 621-634.

M. Psaila-Dombrowski, A. Turnbull, and R.G. Ballinger, "Modelling the Electrochemistry in Cracks and Crevices in Boiling Water Reactor Environments", Conference on Life Prediction of Corrodible Structures, Cambridge, U.K., September 23-26, 1991.

R.L. Tobler, R.P. Reed, I.S. Hwang, M.M. Morra, R.G. Ballinger, H. Nakajima, S. Shimamoto, "Charpy Impact Tests Near Absolute Zero", Journal of Testing & Evaluation, Vol. 19, No. 1(1991), pp 34-40.

I.S. Hwang and R.G. Ballinger, "A Multi-frequency A.C. Potential Drop Technique for the Detection of Small Cracks", J. Meas. Science and Technology, 3 (1992), pp 62-74.

I.S. Hwang, M.M. Morra, R.G. Ballinger, H. Nakajima, S. Shimamoto, and R.L. Tobler, "Charpy Absorbed Energy and J_{IC} As Measures of Cryogenic Fracture Toughness", Journal of Testing and Evaluation, JTEVA, Vol. 20, No. 4, July 1992, pp. 248-258.

A. Turnbull, R. Ballinger, I. Hwang, M. Morra, M. Psaila-Dombrowski. "Hydrogen Transport in Nickel Base Alloys". Metallurgical Transactions, Vol. 23A, Dec. 1992., pp 3231-3244.

M. Morra, R. Ballinger, I Hwang, "Incoloy 908, A New Low Coefficient of Expansion Alloy For High Strength Cryogenic Applications-Physical Metallurgy". Metallurgical Transactions, Vol. 23A, Dec. 1992, pp 3177-3192.

Y. Watanabe, R. Ballinger, O. K. Harling, G.E. Kohse, "Effects of Neutron Irradiation on Transpassive Corrosion Behavior of Austenitic Stainless Steels", *Corrosion* 51 (9), (1995): 651-659

C. H. Jang, I. S. Hwang, R. G. Ballinger, M. M. Steeves, "Development of High Toughness Weld for Incoloy 908", Adv. in Cryogenic Eng., Vol. 340B, 1323-1330.

M. M. Morra, S. Nicol, L. Toma, I. S. Hwang, M. M. Steeves, R. G. Ballinger, "Stress Accelerated Grain Boundary Oxidation of Incoloy Alloy 908 in High Temperature Oxygenous Atmospheres", Adv. in Cryogenic Eng., Vol. 40B, 1994, 1291-1298.

R. G. Ballinger, A. B. Johnson, Jr., K. A. Simpson, "Kinetic and Thermodynamic Bases to resolve Issues Regarding Conditioning of Uranium Metal Fuels", DOE Spent Nuclear Fuel Chalanges & Initiatives, Salt Lake City, UT, 12/13-12/16/94.

T. Shoji, S. Suzuki, R. Ballinger, "Theoretical Prediction of SCC Growth Behavior-Threshold and Plateau Growth Rate". Seventh International Symposium on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors, Breckenridge, CO, 8/7-8/10/95, 881-892.

C. H. Jang, D. C. Grundy, R. G. Ballinger, M. M. Steeves, " Characterization of Simulated Production Welds in Alloy 908", Adv. in Cryogenic Eng., Adv. in Cryogenic Eng., Vol. 42, 1997, 391-398.

M. M. Morra, M. M. Steeves, R. G. Ballinger, "The Effects of Oxygen Concentration, Stress, Temperature and Cold Work on the Constant-Load Stress-Rupture Behavior of Incoloy Alloy 908", Adv. in Cryogenic Eng., Vol. 42, 1997, 399-406.

B. W. Brisson, R. G. Ballinger, A. R. McIlree, "IGSCC Crack Initiation and Growth in Mill Annealed Alloy 600 Tubing in High Temperature Caustic", *Corrosion*, 54 (7), 1998, pp 504-514.

.B. W. Brisson, R. G. Ballinger, A. R. McIlree, "IGSCC Crack Initiation in Mill Annealed Alloy 600 Tubing in High Temperature Caustic", Eighth International Symposium on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors, Amelia Island, FL, 8/10-8/14/97.

A. Chatelain, B. Anderson, R. G. Ballinger, G. Wikmark, "Enhanced Corrosion of Zirconium-Base Alloys in Proximity to Other Metals: The Shadow Effect", International Topical Meeting on Light Water Reactor Fuel Performance, Park City, UT, 4/10-4/13/2000.

Y. Long, Y. Yuan, R. G. Ballinger, E.E. Pilat, and M. S. Kazimi,, "A Fission Gas Release Model for High Burnup PWR Thoria Fuel," Nuclear Technology, June, 2002

J. Lim, R. Ballinger, "Development of a Facility for Liquid Metal-Structural Material Interaction", ANS Winter Meeting, Washington, DC, November 10-12, 2000.

J. Wang. and R. G. Ballinger, "An Integrated Fuel Performance Model for the Modular Pebble Bed Reactor", ANS Winter Meeting, Reno, NV, November 2001.

J. Wang. and R. G. Ballinger, "A Fracture Mechanics Based Failure Model for TRISO Fuel Particles", ANS Winter Meeting, Reno, NV, November 2001.

J. Lim, P. W. Stahle, R. G. Ballinger, "A Test System for Experimental Studies of Liquid Metal Structural Material Interaction", ANS Winter Meeting, Reno, NV, November 2001.

C. Y. Wang, R. G. Ballinger, P. W. Stahle, E. Demetri, and M. Koronowski, "Turbo Machinery for an Indirect, Closed, Intercooled, Helium Cycle Pebble Bed Reactor System", ANS Winter Meeting, Reno, NV, November 2001.

A. Kadak, et. Al. "The MIT Pebble Bed Reactor", ANS Winter Meeting, Reno, NV, Nov. 12-15, 2001.

Y. Long, Y. Yuan, M. S. Kazimi, and R. G. Ballinger, "A Fission Gas Release Model for High Burnup Thoria Fuel," Trans. ANS, Reno, NV, Nov. 2001.

M. Takayasu, R. G. Ballinger, R. B. Goldfarb, A. A. Squitieri, P. J. Lee, and D. C. Larbalestier "Multifilamentary Nb₃Sn Wires Reacted in Hydrogen Gas Environment", , Presented at CEC-ICMC 2001, I-09A-04, submitted to Advances in Cryogenic Engineering

C. Y. Wang, R. G. Ballinger, P. W. Stahle, E. Demetri, and M. Koronowski, "Design of a Power Conversion System for an Indirect Cycle, Helium Cooled, Pebble Bed Reactor System, HTR-2002, Petten, Netherlands, April 22-24, 2002, pp 164-174.

Y. Long, R. G. Ballinger, J. E. Meyer and M. S. Kazimi, "RIA Investigation for High Burnup ThO₂-UO₂ Fuel," ANS Annual Meeting, Hollywood, FL, June 2002

Y. Long, Y. Yuan, R. G. Ballinger, E.E. Pilat, and M. S. Kazimi,, "A Fission Gas Release Model for High Burnup PWR Thoria Fuel," Nuclear Technology, Vol. 138, No. 3, June, 2002

B. Andersson, M. Limback, G. Wikmark, E. Hauso, T. Johnsen, R. G. Ballinger, and A. C. Nystrand, " Test Reactor Studies of the Shadow Corrosion Phenomena", Zirconium in the Nuclear Industry: Thirteenth International Symposium, ASTM STP 1423, G. D. Moan and P. Rudling, Eds., ASTM International, West Conshohocken, PA 2002, pp. 583-615. **NOTE: This paper was the awarded the John Schemel best paper award.**

J. Lim, R. G. Ballinger, and P. W. Stahle, "Experimental Study of the Corrosion of Fe-Si Alloys in Liquid Pb," ANS Annual Winter Meeting, Washington, DC, November 2002

H. J. Maclean, and R. G. Ballinger, "Silver Migration and Release in Thin Silicon Carbide," ANS Annual Winter Meeting, Washington, DC, November 2002.

C. Wang, R. G. Ballinger, H. C. No, "Dynamic Modeling of Modular Pebble Bed Reactor System," ANS Annual Winter Meeting, Washington, DC, November 2002.

J. Lim, R. G. Ballinger, E. Loewen, "The Effect of Silicon on the Corrosion of Iron in Lead-Bismuth Eutectic", Invited paper for Eleventh International Conference on Nuclear Engineering", ICONE-11, Tokyo, Japan, April 20-23, 2003.

J. Wang, R. G. Ballinger, "The Effect of Design and Uncertainty on Coated Particle Fuel Reliability", ANS Annual Summer Meeting, San Diego, CA June 1-5, 2003

J. Lim, R. G. Ballinger, P. W. Stahle, "Experimental Studies on the Corrosion of Fe-Si, Fe-Cr, and Fe₀Cr-Si Alloys in Pb-Bi Eutectic", ANS Annual Summer Meeting, San Diego, CA June 1-5, 2003.

J. Lim, R. G. Ballinger, P. W. Stahle, "Fe-Cr-Si Alloy Development for Pb-Bi Eutectic Service", Global 2003, New Orleans, LA, November 16-20, 2003.

H. J. Maclean, and R. G. Ballinger, "Silver Migration in SiC: A New Perspective", Global 2003, New Orleans, LA, November 16-20, 2003.

J. Wang, R. G. Ballinger, "An Improved Coated Particle Fuel Failure Model", Global 2003, New Orleans, LA, November 16-20, 2003.

Wang, J., MacLean, H., Ballinger, R. G., "An Integrated Fuel Performance Model for the Modular Pebble Bed Reactor", Nuclear Technology, Vol. 147, No 4, October 2004

Ballinger, R. G, and Lim, J. "An Overview of Corrosion Issues for the Design and Operation of lead and Lead-Bismuth Cooled Reactor Systems", Nuclear Technology, Vol. 147, No. 3, September, 2004, pp. 418-435.

Loewen, E. P., Ballinger, R. G., and Lim, J. "Corrosion Studies in Support of a Medium Power Lead Cooled Reactor", Nuclear Technology, Vol. 147, No. 3, September 2004, pp. 436-457.

J. Wang, R. G. Ballinger, J. T. Diecker, "Design Optimization and Analysis of Coated Particle Fuel Using Advanced Fuel Performance Modeling Techniques", Second Topical Meeting on High Temperature Reactors 2004 (HTR-2004), Beijing, China, September 22-24, 2004.

J. Wang, R. G. Ballinger, "Fracture Mechanics Based Coated Particle Fuel Failure Models", Second Topical Meeting on High Temperature Reactors 2004 (HTR-2004), Beijing, China, September 22-24, 2004.

J. Wang, R. G. Ballinger, H. J. MacLean, J. T. Diecker, "TIMCOAT: An Integrated Fuel Performance Model for Coated Particle Fuel", Second Topical Meeting on High Temperature Reactors 2004 (HTR-2004), Beijing, China, September 22-24, 2004.

H. J. MacLean, R. G. Ballinger, "Silver Ion Implantation and Annealing in CVD Silicon Carbide: The Effect of Temperature on Silver Migration", Second Topical Meeting on High Temperature Reactors 2004 (HTR-2004), Beijing, China, September 22-24, 2004.

C. Wang, R. G. Ballinger, P. W. Stahle, E. Dimetri, M. Koronowski, "Power Conversion System Design for an Indirect Cycle, Helium Cooled Pebble Bed Reactor System", ANS Annual Winter Meeting, Washington, DC November 15-18, 2004.

J. Lim, R. G. Ballinger, P. W. Stahle, "Corrosion Resistant Alloy Development for Pb-Bi Eutectic Service", ANS Annual Summer Meeting, San Diego, CA, June 5-9, 2005.

J. Lim, N. Li, R. G. Ballinger, "Materials Testing in Supercritical CO₂", ANS Annual Summer Meeting, Reno, NV, June 4-8, 2006.

J. Lim, R. G. Ballinger, P. W. Stahle, N. Li, "Effects of Chromium and Silicon on Iron-Alloy Corrosion in Pb-Bi Eutectic", ANS Annual Summer Meeting, Reno, NV, June 4-8, 2006.

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Professor R.G. Ballinger

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S.B. Mechanical Engineering, Worcester Polytechnic Institute, 1975

S.M. Nuclear Engineering, Massachusetts Institute of Technology, 1977

S.M. Materials Science, Massachusetts Institute of Technology, 1978

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Ronald G. Ballinger is a Professor of Nuclear Science and Engineering and Materials Science and Engineering (Promotion effective June 1, 2005). Professor Ballinger is also Head of the H.H. Uhlig Corrosion Laboratory in the Department of Materials Science and Engineering at MIT. Professor Ballinger is active in the teaching of graduate and undergraduate subjects in reactor design, corrosion engineering, chemistry, mechanical behavior and physical metallurgy.

Professor Ballinger served for 8 years in the nuclear navy before attending college. After receiving his B.S. in Mechanical Engineering from Worcester Polytechnic Institute in 1975 he did his graduate work at MIT. He received his S.M. in Nuclear Engineering in 1977 and in Materials Science in 1978. He received his Sc.D. in Nuclear Materials Engineering in 1982 with a thesis entitled "Corrosion Fatigue of Nickel Base Alloys for Nuclear Applications." After receiving his Sc.D. he joined the faculty with a joint appointment as an Assistant Professor in the Nuclear Engineering and Materials Science and Engineering Departments. He was promoted to Associate Professor in 1987 and received tenure in 1989. He has been promoted to Full Professor, effective June 1, 2005.

Professor Ballinger's areas of specialization are materials selection and engineering of nuclear engineering systems and environmental degradation and life assessment of these systems. Specific areas of active research are as follows: (1) environmental effects on material behavior, (2) physical metallurgical and electrochemical aspects of environmentally assisted cracking in aqueous systems, (3) stress corrosion cracking and hydrogen embrittlement in Light Water Reactor systems, (4) failure analysis of engineering structures, (5) the effect of radiation on aqueous chemistry, (6) experimental fatigue and fracture mechanics, (7) degradation of materials properties and their effects on component life, (8) nuclear fuel performance including, gas reactor coated particle fuel and environmental degradation, processing, and storage of metallic uranium fuel, and (9) materials development for advanced reactor and fusion systems including, supercritical water, supercritical CO₂, liquid metal, high temperature gas reactor and cryogenic structural applications.

Professor Ballinger has taught the MIT Nuclear Science and Engineering Department's courses related to fuel development and performance since his joining the faculty. He currently teaches these courses as well as corrosion and chemistry courses in the Department of Materials Science and Engineering.

Professor Ballinger spent his sabbatical leave at the EPRI where he participated in the organization and implementation of a new program to improve steam generator reliability. In this capacity he organized and conducted one of the first workshops that brought together the world experts in the area of stress corrosion cracking in alloy 600 to discuss the state of our current knowledge in this area and to make recommendations for future research.

Professor Ballinger has authored or co-authored more than 100 scientific publications and is a member of several professional societies including the National Association of Corrosion Engineers, The American Society for Metals, The Electrochemical Society, The American Nuclear Society, and the American Society for Testing and Materials. Professor is currently Vice Chair/Chair-Elect of the Materials Science and Technology Division of the American Nuclear Society.

Professor Ballinger is a member of the International Cooperative Group on Environmentally Assisted Cracking of Light Water Reactor Materials (ICG-EAC). The ICG-EAC is charged with the development of methodology for understanding of Light Water Reactor (LWR) materials.

Professor Ballinger has served or is serving on several DOE committees dealing with the stabilization, processing and disposition of metallic uranium fuel from the production reactors as well as from research reactors including teams to evaluate options for the Hanford, Savannah River, and INEL sites. He also is, or has been, a member of several DOE committees to evaluate advanced reactor options and materials for these options. These committees include: (1) the DOE Independent Technical Review Group (ITRG): Design Features and Technology Uncertainties for the Next Generation Nuclear Plant. The ITRG was tasked with evaluating options for the Next Generation Nuclear Plant (NGNP), (2) The DOE Power Conversion Unit Study Committee tasked with evaluation options for the NGNP power conversion unit, and (3) the Idaho National Laboratory Materials Review Board.

Professor Ballinger has consults in the nuclear industry in the areas of environmental degradation of materials and failure root cause and analysis. In recent years his focus has been in the steam generator reliability area. Professor Ballinger has been active in the analysis on steam generator tubing failures throughout the industry and has represented the utility as a consultant at the NRC. R&D efforts in his research laboratory have included the development of stress corrosion crack initiation and growth data for actual steam generator tubing under prototypic environmental conditions.

In the regulatory area Professor Ballinger has participated as a voting member of the Advisory Committee on Reactor Safeguards in the area of environmental degradation of steam generator materials and the safety implications of this degradation as a member of the *Ad Hoc* Subcommittee on a Differing Professional Opinion: Voltage-Based Repair Criteria during the September-December 2000 time period. In this capacity Professor Ballinger provided expert input in the steam generator degradation area and gained valuable working experience with the ACRS members and staff.

On a personal level, Professor Ballinger is married and lives with his wife Sheila in Andover, MA. Professor Ballinger and his wife are active in their local church. He was involved in youth ministry for over 15 years and has been involved in approximately 15 short term youth and adult mission trips. He is currently actively involved in missions and serves as a member of the

International Missions Advisory Committee at his church. He and his wife Sheila spend time working among the Yanomamo Indians in the border region between Venezuela and Brazil. He currently chairman of the governing board for Mission Padamo, an evangelical mission operating in the border region between Venezuela and Brazil at the head-waters of the Orinoco River.