CURRICULUM VITAE

Peng-Sheng Wei

PRESENT POSITION

Professor
Department of Mechanical and Electro-Mechanical Engineering
National Sun Yat-Sen University
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PLACE OF BIRTH: Tokyo, Japan

DATE OF BIRTH: September 29, 1953

EDUCATION

University of California, Davis, California, 1980-1984, Ph.D. in Mechanical Engineering
Thesis title: Analysis of Velocity and Temperature Distributions in the Liquid Flowing around the Front of an Electron Beam Cavity
Advisor: Professor W. H. Giedt

National Tsing Hua University, HsinChu, Taiwan, 1976-1978, M.S. in Power Mechanical Engineering
Thesis title: Radiative Heat Transfer in Black Liquid Layer in a Flat-Plate Solar Collector
Advisor: Professor G. J. Hwang

PROFESSIONAL CAREER

National Sun Yat-Sen University (NYSYU)

1984-1989	Associate Professor of Mechanical Engineering
1989-2001	Professor of Mechanical Engineering
2001-present	Professor of Mechanical and Electro-Mechanical Engineering

Chinese Marine Corps

1978-1980	Ensign, Reserve Officer

SOCIETY MEMBERSHIPS

American Society of Mechanical Engineers (ASME)
American Welding Society (AWS)
The Institute of Electrical and Electronics Engineers (IEEE)
Japan Welding Society (JWS)
Taiwan Welding Society (TWS)

INVITED OR KEYNOTE LECTURES

2013 — "Some Defects Induced by Laser Beam," Optics-2013, International Conference and Exhibition on Lasers, Optics and Photonics, San Antonio, Oct-7-9, 2013

"Surface Roughness and Porosity Formation during High Power Density Beam Welding," Department of Metallurgical & Materials Engineering, Colorado School of Mines, Oct. 9, 2013

2012 — "Controlling Fusion Zone Shape and Peak Temperature Produced by Laser or Electron Beam," the 14th International Conference on Electronic Materials and Packaging, EMAP2012, IEEE, Dec. 13-16, 2012, Hong Kong

"Simulation of Resistance Spot Welding," The 2nd International Symposium on Computer-Aided Welding Engineering, Jinan, China, Aug. 23-26, 2012

2010-12 — "Green House Effects," National Sun Yat-Sen University

2011 — "Unified Prediction of Fusion Zone Shape Produced by Laser or Electron Beam," Keynote Speaker, Keynote Lecture 3-2, (IWHT'2011), Xi'an, Shaanxi, China, Oct. 17-20, 2011

"Physical Phenomena during Resistance Spot Welding," University of Kentucky, Dept. Electrical and Computer Engineering, Nov. 18, 2011

2010 — "Mechanisms of Weld Beads," Department of Materials Science and Engineering, the Pennsylvania State University, University Park, Nov. 5

"A Review of Surface Science in Weld Beads," Department of Materials Science and Engineering, University of Wisconsin, Madison, Nov. 11

1999 — "Factors Affecting Pore Formation in Metals Processing," In memory of Prof.G. J. Hwang, Proceedings of the 16^{th} National Conference on Mechanical Engineering, Vol. 1, CSME, National Tsing Hua University, HsinChu, 3-4^{th} Dec., pp. H110-124

1998 — "Heat Transfer Analysis of Rippling, Porosity, Spiking and Missed Joint in Metals Processing," the 17^{th} anniversary of NSYSU, Nov. 5

1984-present — National Tsing Hua University, National Chiao Tung University, National Cheng Kung University, National Central University, National Kaohsiung University of Applied Sciences, National Chung Cheng University, NSYSU, etc.

PROFESSIONAL AND ADMINISTRATIVE APPOINTMENTS AND ACTIVITIES (International)

2013 — Chair, International Program Committee (Taiwan), the 2nd International Conference on Industrial Design and Mechanics Power (ICIDMP2013), Nanjing, China, August 24-25, 2013

2012 — Session Chair, Session I-a: Materials and Processing, the 14th International Conference on Electronic Materials and Packaging, EMAP2012, Dec. 13-16, 2012, Hong Kong

Member, International Advisory Committee, The 2nd International Symposium on Computer-Aided Welding Engineering, Jinan, China, 23-26th August, 2012

Session Chair, the 2nd International Symposium on Computer-Aided Welding Engineering, Session C1: Welding metallurgy, Jinan, China, 23-26th August, 2012

2011 Member, International Scientific and Advisory Committee, 2011 International Workshop on Heat Transfer Advances for Energy Conservation and Pollution Control (IWHT'2011), Xi'an, Shaanxi, China, Oct. 17-20, 2011

2009 Session Chair (10-2 Laser Welding, Symp 10, Laser Based Manufacturing), ASME International Manufacturing Science and Engineering Conference (MSEC2009), Purdue University, Oct. 4-7, 2009, West Lafayette, IN.

2008 Session Chair, the 7th International Symposium on Heat Transfer, University of Science and Technology Beijing, Oct. 26-29, Beijing, China

Member, International Organizing Committee, the 8th International Conference on Trends in Welding Research, ASM, Pine Mountain, Georgia, USA, 2-6 June

Session Chair, the 8th International Conference on Trends in Welding Research, ASM, Pine Mountain, Georgia, USA, 2-6 June

2006 Session Chair, the 5th Asian-Pacific Conference on Aerospace Technology and Science, APCATS'2006, 10/30-11/3, Guilin, China

2002-present Member, Advisory Committee, the 1st- 10th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics, Chairman: J. P. Meyer, South Africa

1985-present Members, ASME (1990-), AWS (1989-), IEEE (2000-), JWS (1985-)

HONORS AND AWARDS

2013 **Invited Editor**, Physics of Laser Processing, (in preparing) Nova Publisher, New York, USA

Downloads by more than 2000 times within the first 5 months, May 14, for Invited Chapter "Chapter 16: The Physics of Weld Bead Defects" published in the book "Welding Processes," Editor: R. Kovacevic, InTech, Croatia, 2012

Editorial Board Member, Journal of Heat and Mass Transfer

2012 **The Warren F. Savage Memorial Award,** American Welding Society, for recognizing the paper that best represents " *original and innovative research resulting in a better understanding of the metallurgical principles related to welding*" published during the previous calendar year in the Welding Journal

2011-12 **The University Distinguished Superior Scholar Awardee (US$ 20,000 per year)**, National Science Council

2010- **Editorial Board Member**, the international journal, Science and Technology of Welding and Joining (Impact factor: 1.735, 6/75, Metall.Metall.Eng., 2011), 2010-

2009-11,2012-14	**Xi-Wan Chair Professorship**, National Sun Yat-Sen University, for *"Outstanding contributions to academic research"*
2009	**Faculty Encouragement Reward for Teaching and Research (US$ 4000 one year),** National Sun Yat-Sen University
	The Outstanding Scholar, National Sun Yat-Sen University, for "*winning the Outstanding Scholar Research Project, National Science Council, 2008*"
2008	**The Adams Memorial Membership Award**, American Welding Society, for *"In recognition of outstanding teaching activities which are advancing the knowledge of welding technology of students in educational institutions"*
2008-10	**The Outstanding Scholar Research Project Winner,** National Science Council, the Republic of China, for "*In recognition of an outstanding researcher, who is the Outstanding Research Awardee of the National Science Council, to propose sustainable and innovative research projects to promote and enhance the energetic power and competition of science and technology of our country*"
2007-present	**Fellow**, American Welding Society, for "*In recognition of outstanding and distinguished contributions that have enhanced the advancement of the science, technology and application of welding"*
2007-10	**The NSYSU Distinguished Research Professor**, for "*the honorable position to recognize the distinguished research achievements*"
2007	**Newsmaker**, The Liberty Times, July 9
2004	**The Outstanding Research Award**, National Science Council, the Republic of China, for "*sustaining academic research to promote the research level and international academic stature, and strengthen science and technology of the Republic of China*"
2001	**ASME Fellow Achievement Award**, National Sun Yat-Sen University
2000-present	**Fellow**, American Society of Mechanical Engineers, for *"recognizes significant engineering achievements and contributions to the engineering profession"*
1998	**The Notable Research Faculty in the Hall of the Fame**, National Sun Yat-Sen University
1995	**Ten-Times Achievement Award from National Science Council**, National Sun Yat-Sen University
1991,2000,2004	**The Outstanding Research Achievement Award**, National Sun Yat-Sen University, for "*enhancing the advancement of the research stature and image of National Sun Yat-Sen University"*
1990-	Listed in Who's Who in the World (Marquis), Who's Who in Science and Engineering (Marquis), Who's Who in Finance and Industry (Marquis), Who's Who in Asia (Marquis), the New York Academy of Sciences, International Biographical Centre, American Biographical Institute, International Who's Who of Professionals, Who's Who in Thermal-Fluids, etc.

1989,1992-94 **A-Grade Research Awards**, National Science Council

1986 **The First Best Paper Award**, the Chinese Society of Mechanical Engineers, for paper "Analysis of Weld Pool Development for Stationary Arc Welding Processes," presented at the 50th year's meeting of CSME, Taipei, Nov. 2

1985-88,1990-91 1995-99 **The Research Achievement Award**, National Science Council

CONSULTING

2003-present Hotway Technology Corp. in manufacturing PC peripheral devices, Shijr city, Taipei

2000-01 Sino-Japan Electric Heater Co., Ltd., Hsiao Kang, Kaohsiung

2000-01 The Internet Technology Databank, TechnologyMall, www.technologymall.com, including more than 40 European and USA research institutions and organizations

1997-02 Gongin Precision Ind. Co., Ltd., Ren Wuu Industry District, Kaohsiung

INTERNATIONAL JOURNALS REVIEWER

Welding Journal, AWS
Science and Technology of Welding and Joining
Metallurgical and Materials Transactions B, TMS
International Journal of Heat and Mass Transfer
International Journal of Heat and Fluid Flow
Journal of Applied Physics
Journal of Laser Applications
Journal of Heat Transfer, ASME
Journal of Fluids Engineering, ASME
Journal of Manufacturing Science and Engineering, ASME
Journal of Manufacturing Processes
Journal of Thermophysics and Heat Transfer, AIAA
Applied Physics Letters
Japanese Journal of Applied Physics
IEEE Transactions on Magnetics
Physica B
Experimental Thermal and Fluid Sciences
Numerical Heat Transfer
International Journal of Thermal Sciences
International Journal of Numerical Methods for Heat and Fluid Flow
Heat Transfer Engineering
Manufacturing Letters
Precision Engineering
Heat and Mass Transfer
Optics & Laser Technology
Applied Thermal Engineering
Surface and Coatings Technology
Proceedings of the Institution of Mechanical Engineers,Part C-Journal of Mechanical Engineering Science
Journal of Materials Engineering and Performance

Advances in Materials Science and Engineering
Materials Chemistry and Physics
Journal of Composite Materials
Journal of the Electrochemical Society
Journal of Marine Science and Technology
Journal of the Chinese Society of Mechanical Engineers
Journal of the Chinese Institute of Engineers
Transactions of the Aeronautical and Astronautical Society of ROC
Proceedings of National Science Council, ROC

PUBLICATIONS: Journal Papers

1985 1. Wei, P. S., and Giedt, W. H., 1985, "Surface Tension Gradient- Driven Flow Around an Electron Beam Welding Cavity," AWS Welding Journal, Vol.64, pp.251-s to 259-s.

1986 2. Ku, C. H., Wei, P. S., and Chung, F. K., 1986, "Analysis of Weld Pool Development for Stationary Arc Welding Processes," Journal of the Chinese Society of Mechanical Engineers, Vol. 7, pp. 259-266 (in Chinese).

1988 3. Wei, P. S., and Chiou, L. R., 1988, "Molten Metal Flow Around the Base of a Cavity During a High-Energy Beam Penetrating Process," ASME Journal of Heat Transfer, Vol. 110, pp. 918-923.

1990 4. Wei, P. S., Wu, T. H., and Chow, Y. T., 1990, "Investigation of High-Intensity Beam Characteristics on Welding Cavity Shape and Temperature Distribution," ASME Journal of Heat Transfer, Vol. 112, pp. 163-169.

5. Wei, P. S., and Ho, C. Y., 1990, "Axisymmetric Nugget Growth During Resistance Spot Welding," ASME Journal of Heat Transfer, Vol. 112, pp. 309-316.

6. Wei, P. S., and Lii, T. W., 1990, "Electron Beam Deflection When Welding Dissimilar Metals," ASME Journal of Heat Transfer, Vol. 112, pp. 714-720.

7. Wei, P. S., and Ho, J. Y.,1990, "Energy Considerations in High-Energy Beam Drilling," International Journal of Heat and Mass Transfer, Vol. 33, pp. 2207-2217.

1991 8. Wei, P. S., and Yeh, F. B., 1991, "Factors Affecting Nugget Growth with Mushy-Zone Phase Change during Resistance Spot Welding," ASME Journal of Heat Transfer, Vol. 113, pp. 643- 649.

1992 9. Wei, P. S., and Chow, Y. T., 1992, "Beam Focusing Characteristics and Alloying Element Effects on High-Intensity Electron Beam Welding," Metallurgical Transactions B, Vol. 23B, pp. 81-90.

10. Wang, S. C., and Wei, P. S., 1992, "Energy-Beam Redistribution and Absorption in a Drilling or Welding Cavity," Metallurgical Transactions B, Vol. 23B, pp. 505-511.

1993 11. Wei, P. S., and Shian, M. D., 1993,"Three-Dimensional Analytical Temperature Field Around the Welding Cavity Produced by a Moving Distributed High-Intensity Beam," ASME Journal of Heat Transfer, Vol. 115, pp. 848-856.

1994 12. Fomin, S. A., Wei, P. S., and Chugunov, V. A., 1994, "Melting Solid Plug Between Two Co-Axial Pipes by a Moving Heat Source in the Inner Pipe," ASME Journal of Heat Transfer, Vol. 116, pp. 1028 -1033.

1995 13. Fomin, S. A., Wei, P. S., and Chugunov, V. A., 1995, "Contact Melting by a Non-Isothermal Heating Surface of Arbitrary Shape," International Journal of Heat and Mass Transfer, Vol. 38, pp. 3275-3284.

1996 14. Wei, P. S., Wang, S. C., and Lin, M. S., 1996, "Transport Phenomena during Resistance Spot Welding," ASME Journal of Heat Transfer, Vol. 118, pp. 762-773.

15. Wei, P. S., Chang, C. Y., and Chen, C. T., 1996, "Surface Ripple in Electron-Beam Welding Solidification," ASME Journal of Heat Transfer, Vol. 118, pp. 960-969.

1997 16. Wei, P. S., and Chung, F. K., 1997,"Three-Dimensional Electron-Beam Deflection and Missed Joint in Welding Dissimilar Metals," ASME Journal of Heat Transfer, Vol. 119, pp. 832- 839.

17. Ho, C. Y. and Wei, P. S., 1997, "Energy Absorption in a Conical Cavity Truncated by Spherical Cap Subject to a Focused High-Intensity Beam," International Journal of Heat and Mass Transfer, Vol. 40, pp. 1895-1905.

18. Wei, P. S., Ho, C. Y., Shian, M. D., and Hu, C. L., 1997, "Three-Dimensional Analytical Temperature Field and Its Application to Solidification Characteristics in High- or Low-Power- Density-Beam Welding," International Journal of Heat and Mass Transfer, Vol. 40, pp. 2283- 2292.

1998 19. Wei, P. S., and Ho, C. Y., 1998, "Beam Focusing Characteristics Effect on Energy Reflection and Absorption in a Drilling or Welding Cavity of Paraboloid of Revolution," International Journal of Heat and Mass Transfer,Vol.41,pp.3299-3308.

1999 20. Chung, F. K., and Wei, P. S., 1999, "Mass, Momentum, and Energy Transport in aMolten Pool When Welding Dissimilar Metals, " ASME Journal of Heat Transfer ,Vol. 121, pp. 451-461.

21. Wei, P. S., 1999, "Pore Formation in Metals Processing- Research Trends," An invited review paper in Trends in Heat, Mass & Momentum Transfer, Research Trends, Poojapura, Trivandrum, India, 1999, Vol. 5, pp. 101-125.

2000 22. Wei, P. S., Kuo, Y. K., Chiu, S. H., and Ho, C. Y., 2000, "Shape of a Pore Trapped in Solid during Solidification." International Journal of Heat and Mass Transfer, Vol. 43, pp. 263-280.

23. Wei, P. S., Kuo, Y. K., and Ku, J. S., 2000, "Fusion Zone Shapes in Electron- Beam Welding Dissimilar Metals," ASME Journal of Heat Transfer,Vol.122, pp.626-631.

24. Wei, P. S., Yeh, F. B., and Ho, C. Y., 2000, "Distribution Functions of Positive Ions and Electrons in a Plasma near a Surface," IEEE Transactions on Plasma Science , Vol. 28, pp. 1244-1253.

25. Wei, P. S., and Yeh, F. B., 2000, "Fluid-like Transport Variables in a Kinetic,Collisionless Plasma near a Surface with Ion and Electron Reflection," IEEE Transactions on Plasma Science , Vol. 28, pp. 1233-1243.

26. Wei, P. S., and Yeh, F. B., 2000, "Heat Transfer Coefficient in Rapid Solidification of a Liquid Layer on a Substrate," ASME Journal of Heat Transfer, Vol.122, pp.792-800.

27. Wei, P. S., and Chung, F. K., 2000, "Unsteady Marangoni Flow in a Molten Pool When Welding Dissimilar Metals," Metallurgical and Materials Transactions B, Vol. 31, pp. 1387-1403.

2001 28. Wang, S. C., and Wei, P. S., 2001, "Modeling Dynamic Electrical Resistance during Resistance Spot Welding," ASME Journal of Heat Transfer, Vol. 123, pp. 576-585.

29. Ho, C. Y., and Wei, P. S., 2001,"Absorption in a Paraboloid of Revolution-Shaped Welding or Drilling Cavity Irradiated by a Polarized Laser Beam," Metallurgical and Materials Transactions B , Vol. 32, pp. 603-614.

2002 30. Wei, P. S. and Ho, C. Y., 2002, "An Analytical Self-Consistent Determination of a Bubble with a Deformed Cap Trapped in Solid during Solidification," Metallurgical and Materials Transactions B, Vol. 33, pp. 91-100.

31. Wei, P. S., and Wen, C. W., 2002, "Missed Joint Induced by Thermoelectric Magnetic Field in Electron-Beam Welding Dissimilar Metals-Experiment and Scale Analysis," Metallurgical and Materials Transactions B, Vol. 33, pp. 765-773.

2003 32. Yeh, F. B., Wei, P. S., and Chiu, S. H., 2003, "Distinct Property Effects on Rapid Solidification of a Thin Liquid Layer on a Substrate Subject to Self-Consistent Melting," Journal of Crystal Growth, Vol. 247, pp. 563-575.

33. Wei, P. S., Huang, C. C., and Lee, K. W., 2003, "Nucleation of Bubbles on a Solidification Front-Experiment and Analysis," Metallurgical and Materials Transactions B , Vol. 34, pp. 321-332.

34. Wei, P. S., Chen, Y. H., Ku, J. S., and Ho, C. Y., 2003, "Active Solute Effects on Surface Ripples in Electron-Beam Welding Solidification," Metallurgical and Materials Transactions B , Vol. 34, pp. 421-432.

2004 35. Yeh, F. B., and Wei, P. S., 2004, "Plasma Energy Transport to an Electrically Biased Surface," International Journal of Heat and Mass Transfer, Vol. 47, pp. 4019-4029.

36. Wei, P.S., Huang, C. C., Wang, Z. P., Chen, K. Y., and Lin, C. H., 2004,"Growths of Bubble/Pore Sizes in Solid during Solidification -An In Situ Measurement and Analysis," Journal of Crystal Growth, Vol. 270, pp. 662-673.

2005 37. Yeh, F. B., and Wei, P. S., 2005, "Effects of Plasma Parameters on the Temperature Field in a Workpiece Experiencing Solid-Liquid Phase Transition," ASME Journal of Heat Transfer, Vol. 127, pp. 987-994.

38. Yeh, F. B. and Wei, P. S., 2005,"The Effect of Sheath on Plasma Momentum Transport to an Electrically Biased Surface," International Journal of Heat and Mass Transfer, Vol. 48, pp. 2198-2208.

39. Chen, K. Y., Lin, C. H., Lin, K. R., Huang, C. C., Wang, Z. P., and Wei, P. S., 2005, "An In-Situ Measurement and Analysis of Bubble/Pore Sizes in Solid during Solidification," Journal of the Chinese Society of Mechanical Engineers, in Commemoration of Prof. C. K. Chen's 70th Birthday, Vol. 26, pp. 81-85.

2006 40. Hsiao, S. Y., Wei, P. S., and Wang, Z. P., 2006, "Three-Dimensional Temperature Field in a Line-Heater Embedded by a Spiral Electric Resistor," Applied Thermal Engineering, Vol. 26, pp. 916-926.

41. Wei, P. S., and Ho, C. Y., 2006, "Analytical Solution of a Creeping Flow Impinging on a Spherical Cap-Shaped Bubble on a Flat Solid Surface," ASME Journal of Applied Mechanics, Vol. 73, pp. 516-523.

2008 42. Wei, P. S., Hsiao, C. C., and Chen, K. Y., 2008, "Universal Phase and Force Diagrams for a Microbubble or Pendant Drop in Static Fluid on a Surface," Journal of Applied Physics, Vol. 103, pp. 023515-1 to -10 (also selected in Virtual Journal of Nanoscale Science & Technology, February 4, 2008)

2009 43. Lin, K. R., Wei, P. S., and Hsiao, S. Y., 2009, "Unsteady Heat Conduction Involving Phase Changes for an Irregular Bubble/Particle Entrapped in a Solid during Freezing- An Extension of the Heat- Balance Integral Method," International Journal of Heat and Mass Transfer, Vol. 52, pp. 996-1004.

44. Wei, P. S., and Hsiao, C. C., 2009,"Microbubble or Pendant Drop Control Described by a General Phase Diagram," International Journal of Heat and Mass Transfer, Vol. 52, pp. 1304-1312.

45. Wei, P. S., Ting, C. N., Yeh, J. S., DebRoy, T., Chung, F. K., and Yan, G. H., 2009, "Origin of Wavy Weld Boundary," Journal of Applied Physics, Vol. 105, pp. 053508-1 to 8.

46. Wei, P. S., Yeh, J. S., Ting, C. N., DebRoy, T., Chung, F. K., and Lin, C. L., 2009, "The Effects of Prandtl Number on Wavy Weld Boundary," International Journal of Heat and Mass Transfer, Vol. 52, pp. 3790-3798.

47. Wei, P. S., and Kuo, S. C., 2009, "Chapter 6 Annular Flow Effects on Pore Formation in High-Intensity Beam Welding or Drilling," Advances in Multiphase Flow and Heat Transfer, Vol. 1, pp. 213-232.

2010 48. Wei, P. S., and Wu, T. H., 2010, "Effects of Electrical Current on Transport Processes in Resistance Spot Welding," Science and Technology of Welding and Joining, Vol. 15, pp. 448-456.

49. Wu, T. H., Wei, P. S., and Ku, J. S., 2010, "Dynamic Electrical Resistance Effects on Transport Processes in Resistance Spot Welding,"Welding and Cutting,Vol.20,pp. 57-69.

2011 50. Wei, P. S., 2011, "Thermal Science of Weld Bead Defects: A Review," in Special Issue on Advanced Thermal Processing, ASME Journal of Heat Transfer, Vol. 133, pp. 031005-1-22.

51. Wei, P. S., Wu, T. H., and Hsieh, S. S., 2011,"Phase Change Effects on Transport Processes in Resistance Spot Welding," Journal of Mechanics, Vol.27, pp. 19-26.

52. Wei, P. S., Chuang, K. C., DebRoy, T., and Ku, J. S., 2011,"Scaling of Spiking and Humping in Keyhole Welding," Journal of Physics D: Applied Physics, Vol. 44, 245501 (11 pages).

53. Wei, P. S., and Wu, T. H., 2011,"Magnetic Property Effect on Transport Processes in Resistance Spot Welding," Journal of Physics D: Applied Physics, Vol. 44, 325501.

54. Kou, S., Limmaneevichitr, C., and Wei, P. S., 2011,"Oscillatory Marangoni Flow: A Fundamental Study by Conduction-Mode Laser Spot Welding", Welding Journal, Vol. 90, pp. 229-s to 240-s.

2012 55. Wei, P. S., Lin, C. L., Liu, H. J., and DebRoy, T., 2012, “Scaling Weld or Melt Pool Shape Affected by Thermocapillary Convection with High Prandtl numbers,” ASME Journal of Heat Transfer, Vol. 134, 042101.

56. Wei, P. S., Lin, C. L., Liu, H. J., and Ting, C. N., 2012, “Transient Thermocapillary Convection in a Molten or Weld Pool,” ASME Journal of Manufacturing Science and Engineering, Vol. 134, 011001.

57. Wei, P. S., Chuang, K.C., Ku, J. S., and DebRoy, T., 2012, “Mechanisms of Spiking and Humping in Keyhole Welding,” IEEE Transactions on Components, Packaging and Manufacturing Technology, Vol. 2, pp. 383-394.

58. Wei, P. S., Hsiao, S. Y., and Hsieh, S. S., 2012, “Pore Formation in Solid,” Journal of Mechanics, Vol. 28, pp. 1-6.

59. Wei, P. S., and Wu, T. H., 2012, “Electrical Contact Resistance Effect on Resistance Spot Welding,” International Journal of Heat and Mass Transfer, Vol. 55, pp. 3316-3324.

60. Ho, J. E., Wei, P. S., and Wu, T. H., 2012, “Workpiece Property Effect on Resistance Spot Welding,” IEEE Transactions on Components, Packaging and Manufacturing Technology, Vol. 2, pp. 925-934.

61. Wei, P. S., and Liu, H. J., 2012, “Scaling Thermocapillary Weld Pool Shape and Transport Variables in Metals, “ Welding Journal, Vol. 91, pp. 187-s-194-s.

62. Wei, P. S., Liu, H. J., and Lin, C. L., 2012, “Scaling Weld or Melt Pool Shape Induced by Thermocapillary Convection,” International Journal of Heat and Mass Transfer, Vol. 55, pp. 2328-2337.

63. Wei, P. S., 2012, “Chapter 16. The Physics of Weld Bead Defects,” in Welding Processes, edited by R. Kovacevic, InTech Co., Rijeka, Croatia, pp. 395-414.

64. Wei, P. S., and Hsiao, S. Y., 2012, “Pore Shape Development from a Bubble Captured by a Solidification Front,” International Journal of Heat and Mass Transfer, Vol. 55, pp. 8129-8138.

2013 65. Wei, P. S., and Ku, J. S., 2013, “A General Expression to Predict Fusion Zone Shape and Peak Temperature during Welding or Melting with a Low Power Density Beam “ Welding and Cutting, Vol. 23, pp. 27-30.

66. Wei, P. S., and Wu, T. H., 2013, “Numerical Study of Electrode Geometry Effects on Resistance Spot Welding,” Science and Technology of Welding and Joining,” (in print)

PUBLICATIONS: Conference Papers

1982 1. Giedt, W. H., and Wei, P. S., "Temperature and Velocity Distributions in the Liquid Flowing Around the Front of an Electron Beam Welding Cavity," Proceedings of the 7th International Heat Transfer Conference , München, Germany, editors: Grigull, U. et al., Hemisphere Publishing Corp., Washington, DC, Vol. 6, pp. 403-407.

1984 2. Giedt, W. H., and Wei, P. S.,"Fluid Flow in the Liquid Layer around an Electron Beam Welding Cavity," Modeling of Casting and Welding Processes, 1983 Engineering Foundation Conferences, (edited by Dantzig, J. A., and Berry, J. T.), New England College, Henniker, New Hampshire, July 31-August 5, 1983, AIME, New York, Vol.2, pp.342-348.

1988 3. Wei, P. S., and Chiou, L. R.,"Recoil Pressure and Thermocapillary Force- Driven Flow during High Energy Beam Penetrating Process," Proceedings, 69th AWS Annual Welding Conference , American Welding Society, New Orleans, pp.22-24.

1989 4. Wei, P. S., and Lee (or Lii), T. W., "Missed Joint for Welding Dissimilar Metals with an Electron Beam," Proceedings, 70th AWS Annual Welding Conference, American Welding Society, Washington, D. C., pp.178-180.

1994 5. Fomin, S. A., and Wei, P. S., "The Shape Factor and Thermal Resistance in Contact Melting Problem," Proceedings of the 10th International Heat Transfer Conference, Brighton, U. K, editor: Hewitt, G. F., 14-18, Aug., Institution of Chemical Engineers, Warwickshire, U.K., Vol.4, pp. 25-30.

1999 6. Wei, P. S.,"Factors Affecting Pore Formation in Metals Processing," the invited paper in memory of Professor Hwang, G. J., Proceedings of the 16th National Conference on Mechanical Engineering, Vol. 1, the Chinese Society of Mechanical Engineers, National Tsing Hua University, Hsinchu, Dec. 3-4, pp. H110-H124.

2000 7. Chiu, S. H., Kuo, Y. K., and Wei, P. S.,"A Pore Trapped in Solid during Solidification," ASME-ZSITS International Thermal Science Seminar, 11-14, June, Bled, Slovenia, pp. 167-174.

2001 8. Wei, P. S., Chiu, S. H., and Ho, C. Y., "Thermal and Solutal Marangoni Convection in a Droplet Solidifying on a Cold Substrate," Proceedings of NHTC'0135th National Heat Transfer Conference, June 10-12, Anaheim, California,NHTC2001-20074.

2002 9. Wei, P. S., and Kuo, Y. K., "An Observation of the Growth of a Pore Trapped in Solid during Solidification," The 1st International Conference on Heat Transfer,Fluid Mechanics, and Thermodynamics, editor, J. P. Meyer, 8-10 April, Kruger National Park, South Africa, pp. 642-646.

10. Wei, P. S., and Wang, S. C.,"The Variations of Dynamic Electrical Resistance during Resistance Spot Welding," The 1st International Conference on Heat Transfer, Fluid Mechanics, and Thermodynamics, editor, J. P. Meyer, 8-10 April, Kruger National Park, South Africa, pp. 1025-1030.

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QUALIFICATIONS

Professor Wei has led his student groups to conduct pioneering heat transfer analyses and measurements of the fundamental but critical processes of manufacturing. Professor Wei together with students analyzed and measured a micro-pore in different shapes in solid from a general entrapment of a micro-bubble experiencing rupture, growth, decay, or necking on a solidification front. They found universal phase diagrams to interpret and control micro-bubble behavior on a surface. They also did in-situ measurements of bubble nucleation process, and subsequent micro-pore formation which can be divided into distinct stages for different cooling rates, solute contents of dissolved gases. Professor Wei initiated a model based on a vertical annular two phase flow to study pore formation in high-intensity beam welding (also applicable to incapability of high-intensity beam drilling). His detailed studies of micro-pore formation have laid the foundation of our present high-quality micropore-free materials, which are of permanent importance for the advanced manufacturing technology of all electronic and photonic devices, semiconductor and microelectronic systems to improve processing-related precision, reliability, and cost-reduction. Professor Wei also innovatively scaled surface defects of rippling and humping, and root spiking after solidification, which is crucial issues for the manufacturing industry. These defects usually company with segregation, undercut, porosity, cold shuts, etc. The rippling mechanism and thermocapillary instability in the corner region were for the first time scaled and confirmed by good quantitative agreement between the scaled and measured roughness in alloy Al 1100 and SS 304, and most steels containing surface active solutes, such as O, S, Se, affected by thermocapillary force. Professor Wei's universal scaling law also agreed quite well with the pitches of humps and spikes. His technical papers also included the first successful scaling of the molten pool shapes and the missed-joint problem due to thermoelectric magnesium in high-intensity electron beam welding of dissimilar metals, as well as the first numerical prediction of the molten pool shapes affected by thermocapillary convection in melting or welding dissimilar metals. This has been accomplished through novel and original theoretical analyses coupled with basic and verification experiments. Extensive investigations of beam focusing characteristics and the effects of specular and diffuse reflections on energy absorption in the high intensity beam keyhole have been published. Resistance spot welding has widely been one of the most popular welding techniques used in automobile, aerospace, electronic, optical and medical packaging technologies. Professor Wei is the first person to rigorously find the effects of all critical working parameters related to properties of workpieces, electrodes, contact resistances and electromagnetic fields on transport variables during the entire range of heating, melting, cooling and solidification of RSW. By including a relevant model of the contact resistance composed of constriction and film resistances as a function of temperature, hardness, electrode force and surface contamination, the dynamic electrical resistance often used for controlling resistance spot welding was modified, and a new concept of time delay of electric current was introduced for determining and controlling the nugget formation. The effects of different working variables on defect of workpiece surface melting were found. Efforts also led to find the first exact closed-form solutions of mass, energy and momentum transport across a space charge region in a thin layer between plasma and a surface by using kinetic analysis. The important phenomena encountered in different plasma processing, such as ion implantation, discharges, lamps, deposition, nuclear fusion, etching et al. therefore can be predicted.

Professor Wei has been technical consultants in several manufacturing companies. In view of distinguished achievements, Professor Wei has been invited to present lectures in numerous domestic and international universities and conferences in the States and China. Professor Wei has supervised 90 M.S. and 5 Ph.D. graduate students, publishing more than 70 journal papers, 40 conference papers and 45 technical reports. His work has been recognized by receiving the prestigious Adams Memorial Membership Award from AWS in 2008, Warren F. Savage Memorial Award from AWS (2012), the Outstanding Scholar Research Project Winner from the National Science Council (NSC) of ROC, the Outstanding Research Awards from both the NSC and National Sun Yat-Sen University (NSYSU). Professor Wei is a Xi-Wan Chair Professor of NSYSU. He is also an Editorial Board Member of the journals, Science and Technology of Welding and Joining, and Journal of Heat and Mass Transfer. Professor Wei was elected as an ASME Fellow in 2000, AWS Fellow in 2007

The original and pioneering researches conducted by Professor Wei are

(1) Confirmative measurement and study of pore formation from bubble heterogeneous nucleation to entrapment in solid
(2) Modeling of pore formation due to keyhole collapse during high intensity beam welding
(3) Introduction of universal phase and force diagrams for a micro-bubble (or pendant drop) on a surface or orifice
(4) Control of a micro-bubble (or pendant drop) on a surface or orifice
(5) Prediction and control of pore shape using introduced phase diagram
(6) Scaling of measured surface rippling and humping after solidification of pure metals, and alloys containing minor or significant surface active solutes.
(7) Introduction of thermocapillary corner flow instability
(8) Scaling of measured root spiking in high intensity beam melting or welding
(9) Interpretation and scaling of measured missed joint induced by thermoelectric magnetism in high-intensity electron-beam welding of dissimilar metals
(10) Prediction of fusion zone shapes affected by Marangoni convection in melting or welding of dissimilar metals
(11) Universal scaling of weld pool shapes and transport variables affected by thermocapillary convection
(12) Realistic simulation of transient transport processes for mass, momentum, energy, species and magnetic field intensity during resistance spot welding
(13) Revised interpretation of dynamic electrical resistance, and new concept to control resistance spot welding
(14) Finding surface melting defect of workpiece for specific working parameters of resistance spot welding
(15) Correcting interpretation of drilling mechanism
(16) Exploring parameters controlling incapability of high-intensity beam drilling
(17) Prediction of energy absorption and transfer efficiency in the welding/drilling keyhole affected by specular reflection, beam focusing characteristics and polarizations of a laser beam
(18) Prediction of fusion zone shapes affected by beam focusing characteristics and volatile elements in drilling or keyhole welding
(19) Exact solutions of three-dimensional temperature distribution around a paraboloid of revolution-shaped keyhole irradiated by a moving distributed energy beam
(20) Exact closed form expressions of transport variables based on kinetic analysis near a surface in contact with plasma

They are briefly described as follows:

(1) Pore formation due to bubble entrapment in solid

Porosity is one of the most serious defects often found in products of manufacturing and packaging technology, semiconductor and microelectronic systems. To avoid or control pore formation, the transition from a generated micro-bubble to pore formation in solid must be understood. Wei et al. (2003) first quantitatively measured and analyzed the entrapment of a tiny bubble heterogeneously nucleated in water-gas solutions supersaturated ahead of the solidification front. The spherical bubble after heterogeneous nucleation was observed to have a rapid growth, elongation by the solidification front, rupture or entrapment, and the final pore (Wei et al. 2004). A systematical prediction of the pore shape in solid should account for mass, momentum, energy, species transport and physicochemical equilibrium at the top bubble surface (Wei et al. 2000), rather than conventional pure mass diffusion. Since the bubble was not strictly spherical, Wei and Ho (2002) proposed a continuous slope criterion at the solidification front between the bubble cap and pore in solid to self-consistently determine the contact angle. Pore formation in solid after bubble nucleation was confirmed by experimental data. Wei and Hsiao (2012) also found that the shape of a tiny pore in solid can be described by a nonlinear first-order ordinary differential equation, namely, the Abel's equation of the first kind.

(2) Pore formation due to keyhole collapse during high intensity beam welding or drilling

Pores in a millimeter scale often occur in high intensity electron and laser beam welding or drilling. Different from pore formation due to bubble entrapment (see item (1)), this can be attributed to collapse of the thin molten liquid layer surrounding the induced keyhole. The blockage or bridging of the two-phase annular flow is quite similar to the collapse of the keyhole. Wei and Kuo (2009) therefore proposed and numerically predicted pore formation due to keyhole collapse based on a separation model for a vertical annular two-phase flow. This model accounted for a compressible vapor in the core region, liquid layer flow around the keyhole, and deformation of the liquid-vapor interface. The keyhole shape strongly depended on Mach number, drilling speed, liquid entrainment, surface tension parameter, etc. This is the first time to find that pore formation in solid is interestingly related to the parameters of compressible vapor flow and heat transfer.

(3) Universal phase and force diagrams for a micro-bubble (or pendant drop) on a surface or orifice

Bubbles plays vital roles in mass, momentum, energy and concentration transport in contemporary micro- and nano-sciences and technologies, such as ink-jet printing, pump and valves, ultrasound diagnostics, drug delivery and gene transfection, etc. To study micro-bubble behavior, Wei et al. (2008) found there exist universal three-dimensional phase and lift force diagrams of a micro-bubble (or pendant drop) in static liquid on a solid surface or orifice, as can be obtained from singular perturbation solutions of Young-Laplace equation governing balance of normal pressures at the interface (O'Brien, 1991). The diagrams were universally specified by two dimensionless independent parameters, contact angle and base radius or Bond number. The state or bubble shape can thus be described by the phase diagram characterized by three regions, where are distinguished by the presence of an inflection point or neck on the micro-bubble surface. With the relevant bubble shape, the total lift force, including hydrostatic buoyancy, difference in gas and hydrostatic pressures at the base, capillary pressure, as well as surface tension induced by the variation of circumference shown on diagrams, can be calculated and found to be identical to surface tension induced by the variation of circumference. The latter, which had not been treated in the literature, can be an attaching or lifting force, depending on whether the state in the distinct regions and contact angle was less than or greater than a critical angle. This work had also been selected by Virtual Journal of Nanoscale Science & Technology for a focused pioneering research in the future.

(4) Controlling of a microbubble (or pendant drop) on a surface or orifice

Introducing micro-bubbles is an important method to enhance mass, momentum, energy, species and charge transport in various contemporary micro- and nano-sciences and technologies, as mentioned previously. Replacing the length scale of the universal phase diagram introduced by Wei et al. (2008) with a given or critical radius, Wei and Hsiao (2009) found that the resulting phase diagrams can be used to describe different paths of growth or decay for a microbubble or pendant drop on a surface. Clearly speaking, a desired growth or decay of a micro-bubble can be controlled by two dimensionless parameters such as base radii (or contact angle) and apex radius, determined by the imposed atmospheric, liquid, capillary pressures and gas pressure in the bubble. Given the start and end states, different paths, for example, can be selected by fixing the base radius and varying apex radius, or fixing apex radius and varying base radius. Different behaviors of a microbubble or pendant drop on a surface are therefore determined and controlled by adjusting working parameters to satisfy desired requirements from the phase diagrams.

(5) Pore shape described and controlled by phase diagram

Different path lines on the phase diagram (Wei and Hsiao, 2009), which is a function of bubble apex and base radii or contact angle, can be used to describe and control the pore in different shapes of a bubble experiencing rupture, growth, decay, or necking near a solidification front (Wei and Hsiao 2009, 2013, Wei et al. 2012). The time-dependent gas pressure used to determine the apex radius was determined by satisfying mass conservation and equation of the state in the bubble (Wei et al 2000, Wei and Ho, 2002).

(6) Surface rippling and humping after solidification of pure metals, and alloys containing minor or significant surface active solutes

Surface patterns of rippling, humping and undercut seriously deteriorate qualities of welding, drilling, and fabrications of wafers and chips in packaging and manufacturing technologies. Humping and rippling are also accompanied with porosity, segregation, and other microstructure defects. Wei (2011) extensively reviewed surface patterns affected by different working parameters. Regardless of complexity of the processes, Wei et al. (1996) and Wei et al. (2003) quantitatively scaled and disclosed mechanisms of rippling to be the variation of dynamic pressure due to thermocapillary flow. The measured ripples on alloys Al 1100 and SS 304 and steels containing surface active solutes (O, S, Se, etc.) agreed well with the scaled results. The surface active solutes induce opposite thermocapillary surface flow (Wei et al. 2003). Wei et al. (2011) also successfully scaled the measured humping pitches, which agreed quite well with the previous scaling law (Wei et al. 1996) by introducing enhanced liquid pressure governed by the depth-to-width ratio.

(7) Thermocapillary corner flow instability

Thermocapillary corner flow is responsible for surface patterns and associated defects of porosity, segregation, undercut, etc. As reviewed in the paper of Wei (2011), Kelvin-Helmholtz instability, Rayleigh-Taylor instability, Rayleigh's capillary instability, evaporative instability, etc. can be comprehensively derived by scaling Young-Laplace equation governing balance of normal pressures at the free surface. The liquid pressures were, respectively, the dynamic pressure from specified average velocity, hydrostatic pressure, radius-dependent capillary pressure, and evaporation rate, etc. With the same reason, a new instability due to thermocapillary corner flow is found by introducing a dynamic pressure induced by thermocapillary force with a loss coefficient near the corner region (Wei et al. 1996, 2003).

(8) Root spiking in high intensity beam melting or welding

Spiking is a serious defect encountered in keyhole mode welding. A spike, which represents a sudden increase in penetration beyond the average penetration line, usually has voids and cold shuts in lower portions. Interestingly, experiments showed that measured pitch of spikes was identical to that of humps in welding SS 304, carbon steel, Al 6061, and Al 5083 containing volatile element Mg for different scanning speeds and beam focusing characteristics (Wei et al. 2011; 2012). Therefore, Wei et al. (2011) successfully scaled the measured pitches of spiking by including enhanced liquid pressure and beam focusing characteristics in the scaling law of rippling (Wei et al. 1996). Measured spiking amplitude was also found to be enhanced for the focal spot below the workpiece surface, decrease of scanning speed and existence of a volatile element. Considering energy balance at the keyhole base, measured amplitude of spiking can be innovatively and successfully scaled.

(9) Missed joint induced by thermoelectric magnetism in high-intensity electron-beam welding of dissimilar metals

Electron beam welding of dissimilar metals is often found in fabrication and manufacturing fields to improve strength and reduce cost of the products. Unfortunately, misalignment of the joint can be induced by thermoelectric Seebeck effect, indicating that electrical potential occurs as temperature gradient exists in dissimilar metals. Extending the first thermoelectric model for predicting two-dimensional missed joint (Wei and Lii, 1990), Wei and Chung (1999) calculated the three-dimensional missed joint induced by Seebeck effect coupled with three-dimensional electromagnetic and heat conduction equations (Wei and Shian, 1993). It was found that misalignment was toward the metal having higher Seebeck coefficient, due to magnetic field induced from thermoelectric currents flowing from the metal having the smaller to that having the larger Seebeck coefficient. The induced magnetic lines emerged from the rear region of bulk metals into the surrounding, turned to face the incoming solid, entered the front region, and completed circulation in the lower region. The measured missed-joints can successfully be scaled in dissimilar welding of low carbon steel and SS 304, low carbon steel and Ni-Cu alloy, and SS 304 and Ni-Cu alloy (Wei and Wen, 2002), and experimental data in the literature. This work has provided quantitative answers to avoid missed joint via choosing different pairs of dissimilar metals and working parameters in advance.

(10) Fusion zone shapes affected by Marangoni convection in melting or welding of dissimilar metals

The melting or welding of dissimilar metals frequently occurs in manufacturing and materials industries. The fusion zone shapes were strongly determined by Marangoni convection due to the difference in surface tension coefficients between dissimilar molten metals, as first investigated by Chung and Wei (1999). Surface tension coefficients of opposite signs led to complicated flow patterns with surface flow in three directions: being inward and outward from sides to the joint plane and from one side to the other. Depths of dissimilar molten regions were insensitive to the variation in surface tension coefficients of opposite signs. If surface tension coefficients were both positive and Marangoni numbers of the same magnitude, an enhanced heat transfer in the downward direction near the joint plane produced the maximum depth. Unsteady deformation of interfaces between immiscible dissimilar metals, solid and liquid, and fusion zone shapes for different working parameters were presented and shown to agree with experimental results (Wei and Chung, 2000).

(11) Scaling molten pool shapes affected by thermocapillary convection

The fusion boundary in melting or welding strongly affects microstructure and properties of products in manufacturing and materials industries. The molten pool shape and surface peak temperature and velocities affected by thermocapillary force for different Prandtl numbers have been successfully scaled by Wei et al. (2011, 2012). The transport variables were functions of beam power, beam radius, scanning speed and transport and thermal properties of workpieces. Prandtl number represents the momentum-to-energy diffusivity ratio. Wei et al. (2009, 2012) first pointed out that there were two peak surface velocities for low Prandtl numbers rather than one peak surface velocity for high Prandtl numbers. The regions for scale analysis included momentum and thermal boundary layers in five regions: the hot, intermediate and cold corner regions, boundary layers along the solid-liquid interface and ahead of melting front. The scaling results coupled among distinct regions were found to agree well with unsteady two-dimensional and steady state three-dimensional numerical computations and experimental data in the literature. Given working parameters and material, the fusion zone shapes and transport variables can therefore be predicted in advance.

(12) Transport processes during resistance spot welding

Resistance spot welding has been widely used in joining thin workpieces in fabrication and manufacturing technologies. The joint between two workpieces held by two electrodes is accomplished via solidification of the molten nugget induced by heat generation from electrical resistances in workpieces and at contact surfaces (Wei and Ho, 1990; Wei and Yeh, 1991). The nugget shape, magneto-fluid flow and heat transfer, solute concentration were first extensively predicted by Wei et al. (1996) proposing a rather general model including unsteady axisymmetric transport of mass, momentum, energy, species, and electrical and magnetic field intensity with a mushy-zone phase change in workpieces subject to different geometry of electrodes. Electromagnetic force, heat generations in bulk workpieces and at the faying surface and the electrode-workpiece interfaces were also accounted for. Wang and Wei

(2001) further included realistic contact resistance composed of constriction and film resistances as functions of hardness, temperature, electrode force and surface conditions. Temperatures, nugget growth, and species concentration in workpieces and electrode for different working variables were therefore realistically and successfully found (Wei and Wu, 2012, 2013).

(13) Dynamic electrical resistance, and controlling of resistance spot welding

Dynamic electrical resistance has been known the most important factor affecting and controlling resistance spot welding. The well-accepted dynamic electric resistance was revised by Wang and Wei (2001) and Wei and Wu (2013) and confirmed to be divided into four and more stages, resulted from extensive investigation of temperature dependent and surface characteristics of constriction and film and bulk resistances. Temperature rise and nugget formation at the faying surface in the early stage, however, cannot be satisfactorily interpreted from dynamic resistance viewpoint. Wei and Wu (2011) therefore successfully introduced a new concept of the delay of response time of electric current density. It is a future trend to use time delay of electric current density to control resistance spot welding, rather than dynamic resistance.

(14) Defect of surface melting during resistance spot welding

Surface melting of the workpicee results in collapse and crack of the joint. Using the elaborate model for simulating resistance spot welding (Wang and Wei, 2001), it was found that the workpiece surface was readily melted through by reducing electrode tip radius, welding current, and increasing Curie temperature, magnetic permeability, and constriction resistance at the electrode face (Wei et al 1996; Wei and Wu, 2009, 2012, 2013).

(15) Drilling mechanism

High intensity energy beam drilling is an important technique commonly used in packaging and manufacturing industries. It had been known that the mechanism of drilling was attributed to one-dimensional evaporation. Wei and Chiou (1988), however, found that mechanism of drilling was due to incessantly upward and outward flow of the thin layer surrounding the keyhole induced by Marangoni force and recoil pressure. The one-dimensional pure evaporation model to investigate drilling process was criticized by Wei and Ho (1990) to be overestimation of evaporation rate. In reality, liquid at the keyhole base was primarily driven to the side in the radial directions. Rather than energy loss due to evaporation, energy losses for drilling were mainly radial and axial conduction of the same magnitude near the keyhole base. The analysis was confirmed by the measured keyhole temperature and molten pool shape.

(16) Incapability of drilling.

The model to interpret mechanism of pore formation during high intensity beam welding or drilling, as discussed previously, has been used for studying incapability of drilling (Wei et al. 2013).

(17) Energy absorption and transfer efficiency in the welding/drilling keyhole by accounting for specular and diffuse reflections, beam focusing characteristics and polarizations of a laser beam

Energy transfer efficiency depends on energy absorbed by the keyhole produced in high-intensity beam welding or drilling. Using a Monte Carlo and ray tracing method, Wang and Wei (1992) and Wei and Ho (1998) found that energy absorbed by the keyhole subject to collimated and over-focused energy beams exhibited distinct regions. The central region was irradiated by direct incident ray, whereas the outer region was subject to additional energy rays from the first specular reflections. The absorbed energy distribution thus exhibited a jump, in contrast to a Gaussian distribution for an under-focused energy beam. Wei and Ho (1998) also proposed that root spiking in welding or melting can be due to relative oscillations between the keyhole base and focal spot location. In order to enhance absorption, reducing the distance between the focal spot and the keyhole base, spot size and convergence angle was needed. The global absorption of p-polarization was always higher than that of s-polarization, even though energy flux absorbed for s-polarization near the radius of the central region was higher (Ho and Wei, 2001).

(18) Fusion zone shapes affected by beam focusing characteristics and volatile elements in drilling or keyhole welding

Focusing the energy beam is the key factor affecting laser beam welding or drilling. It is determined by focusing current, which is a function of the location and radius of the focal spot and convergence angle. In order to understand the beam focusing components, Wei and Chow (1992) solved the heat conduction equation around the keyhole irradiated by a focused energy beam. It was innovatively found that to obtain a reliable fusion zone shape, adjusting the focal spot on the workpiece surface was needed. The focal spot radius then determined the fusion zone shape. Besides, keyhole temperature decreased in the presence of volatile element in order to balance surface forces. The fusion zone thus becomes deep to balance beam power.

(19) Analytical three-dimensional temperature distribution and weld fusion zone shape around a paraboloid of revolution-shaped keyhole irradiated by a moving distributed energy beam

Microstructures, stresses and deformation of workpieces can be generally and effectively studied if analytical temperature field is known. The temperature predicted by the well-known Rosenthal's models in welding and cutting had shortcomings such as occurrence of infinite temperatures near the heat source modeled by a line or point source, ignorance of the distribution of incident flux, convection effects, vertical heat transfer for a line source, and balance of momentum. Removing these limitations, Wei and Shian (1993) found a new analytical solution in terms of transcendental functions for three-dimensional temperature field around a paraboloid of revolution-shaped keyhole irradiated by an incident flux of a moving Gaussian distribution. Imposing an adiabatic top surface, more relevant new analytical solutions for temperature fields, cooling rates and stability criterion responsible for microstructures at the solidification front, which agreed with experimental data and three-dimensional finite-difference predictions, were obtained (Wei et al. 1997).

(20) Transport processes from plasma to a surface

Transport processes from plasma to a surface are widely encountered in etching, lamps, discharges, ion implantation, deposition, nuclear fusion, welding, drilling, etc. In view of different mobilities between ions and electrons, a thin space charge region characterized by high electrostatic field and supersonic flow occurs on a surface. The ions and electrons are of highly non-Maxwell-Boltzmann distributions near a surface. Wei and Yeh (2000) integrated the moment equations of the abnormal distribution functions, which were obtained by solving the ion Boltzmann kinetic equation with the well-known Emmert et al.'s ion source model due to thermal ionization and collisions between neutrals and ions. The integrable equations led to exact closed form expressions of ion and electron transport variables such as fluid-like viscous stress, heat conduction, mean pressure and hydrodynamic velocity from the bulk plasma across the space charge layer to the electrically floating surface. The results agreed with available experimental data. Momentum, energy and current transport were therefore provided by Yeh and Wei (2003-2005).