Abhijit Dasgupta

1. PERSONAL INFORMATION

Department	:	Mechanical Engineering Department
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Education:

Ph.D.	Theoretical & Applied Mechanics, 1989, University of Illinois, Urbana, IL
	Thesis: Multiaxial Homogeneous Fatigue Damage in Short-Fiber Composites
M.S.	Mechanical Engineering, 1981, Villanova University, Villanova, PA
	Thesis: Nonlinear Failure Analysis of Fiber Composite Laminates
B.S.	Mechanical Engineering, 1976, Indian Institute of Technology, Madras, India

Employment:

Aug 99-present	Professor, Mechanical Engineering, University of Maryland, College Park
Aug 94-Aug 99	Associate Professor, Mechanical Engineering, University of Maryland, College Park
Aug 88-Aug 94	Assistant Professor, Mechanical Engineering, University of Maryland, College Park
Aug 81-Aug 88	Graduate Assistant, Theoretical & Applied Mechanics, University of Illinois, Urbana
Aug 80-Aug 81	Analytical Engineer, Gulf & Western, Philadelphia
Aug 79-Aug 80	Graduate Assistant, Mechanical Engineering, Villanova University, Philadelphia
Aug 76-Aug 79	Development Engineer, Tata Engineering & Locomotive Co., Poona, India

Books Authored/Edited:

- 1. Contributing Co-Editor (with M. Pecht, John Evans and Jillian Evans), <u>Quality Assurance and Qualification</u> of Electronic Packages, John Wiley, 1994.
- 2. Contributing Co-Editor (with E. Garcia and H. Cudney), <u>Adaptive Structure and Multifunctional</u> <u>Composites</u>, AD/MD Vol. 45, ASME Winter Annual Meeting, Chicago, Nov. 1994.

Books in Progress:

1. Principal Author (co-author: K. Upadhyayula), <u>Physics-of-Failure Approach for Accelerated Qualification</u> of Electronic Assemblies, Contract signed with Marcel Dekker, Inc, to appear in 2001.

Chapters in Books:

- 1. Dasgupta, A., "Thermo-Mechanical Analysis and Design," Chapter 8, pp. 477-528, in <u>Handbook of Electronic Package Design</u>, Editor M. Pecht, Marcal Dekker, 1991.
- 2. Dasgupta, A., "The Role of Finite Element Analysis in CAD for MMIC Reliability Investigations," Chapter 4, pp. 83-99, in <u>Reliability of Gallium Arsenide MMICs</u>, Editor A. Christou, John Wiley, 1992.
- 3. Christou, A., Dasgupta, A., Pecht, M., and Barker, D., "Reliability Considerations for MMIC Packages," Chapter 11, pp.411-434, in <u>Reliability of Gallium Arsenide MMICs</u>, Editor A. Christou, John Wiley, 1992.
- 4. Barker, D. and Dasgupta, A., "Thermal Stress Issues in Plated-Through-Hole Reliability," Chapter 20, pp. 648-683, in <u>Thermal Stress and Strain in Microelectronics Packaging</u>, Editor J. Lau, Van Nostrand Reinhold, 1993.

- 5. Dasgupta, A., Contributor, <u>Integrated Circuit, Hybrid, and Multichip Module Package Design Guidelines</u>, Editor M. Pecht, Wiley Interscience, 1994.
- 6. Dasgupta, A., contributor, <u>Plastic Encapsulated Microelectronics</u>, Ed. M. Pecht, L. Nguyen, E. Hakim, pub. John Wiley, 1994.
- 7. Dasgupta, A., "Hardware Reliability," Chapter 5, pp. 95-133, in <u>Product Reliability, Maintainability, and</u> <u>Supportability Handbook</u>, Editor M. Pecht, CRC Press, 1995.
- 8. Sirkis, J. and Dasgupta, A., "Optical Fiber/Composite Interaction Mechanics," Chapter 4, pp. 61-108, in <u>Fiber Optic Smart Structures</u>, Editor E. Udd, John Wiley, 1995.
- 9. Upadhyayula, K., and Dasgupta, A., "Accelerated Stress Testing of Surface-Mount Interconnects under Combined Temperature and Vibration Loading," Chapter accepted in <u>Accelerated Stress Testing Handbook</u> <u>for Quality Products in a Global Market</u>, Ed.: H. A. Chan, Pub. Addison Wesley Longman, MA, to appear in 2001.

Articles in Refereed Journals

- 1. McLaughlin, P. V. Jr., Dasgupta, A., and Chun, Y. W., "Bilinear Failure Analysis of Fiber Composite Laminates," *Journal of the Astronautical Sciences*, Vol. 32, No. 3, pp. 235-252, 1984.
- Wang, S. S. and Dasgupta, A., "Deformation and Fracture of Random Short-Fiber SMC Composite under Multiaxial Loading," <u>ASTM Transactions, Journal of Composites Technology and Research</u>, Vol. 8, No. 4, pp. 129-137, 1986.
- 3. Dasgupta, A., Barker, D., and Pecht, M., "Reliability Prediction of Electronic Packages," *Journal of the Institute of Environmental Sciences*, Vol. 33, No. 3, pp. 36-45, 1990, (won the *Maurice Simpson Technical Editor's Award* for best paper of the year).
- 4. Barker, D., Vodzak, J., Dasgupta, A., and Pecht, M., "Combined Vibrational and Thermal Solder Joint Fatigue A Generalized Strain Versus Life Approach," <u>ASME Transactions, Journal of Electronic Packaging</u>, Vol. 112, No. 2, pp. 129-134, 1990.
- 5. Whelan, S., Pecht, M., and Dasgupta, A., "Operational Temperature Cycle Values for Application Environment Categories," *International Journal for Hybrid Microelectronics*, Vol. 13, No. 1, pp. 6-11, 1990.
- Pecht, M., Dasgupta, A., Barker, D., and Leonard, C., "The Reliability Physics Approach to Failure Prediction Modeling," *International Journal of Quality and Reliability Engineering*, Vol. 6, No. 4, pp. 267-274, 1990.
- 7. Oyan, C. and Dasgupta, A., Pecht, M. and Barker, D., "Role of Strain-Partitioning Analysis in Solder Life Prediction," *International Journal for Hybrid Microelectronics*, Vol. 14, No. 2, pp. 37-47, 1991.
- 8. Agarwal, R., Dasgupta, A., Pecht, M. and Barker, D., "Prediction of PWB/PCB Thermal Conductivity," *International Journal for Hybrid Microelectronics*, Vol. 14, No. 3, pp. 83-47, 1991.
- 9. Sharif, I., Barker, D., Dasgupta, A., and Pecht, M., "Fatigue Analysis of a Planarpak Surface Mount Component," <u>ASME Transactions, Journal of Electronic Packaging</u>, Tech. Note, Vol. 113, No. 2, pp. 194-199, 1991.
- Barker, D., Pecht, M., Dasgupta, A. and Naqvi, S., "Transient Thermal Stress Analysis of a Plated Through-Hole Subjected to Wave Soldering," <u>ASME Transactions, Journal of Electronic Packaging</u>, Vol. 113, No. 2, pp. 149-155, 1991.

- Hu, J. M., Pecht, M. and Dasgupta, A., "A Probabilistic Approach for Predicting Thermal Fatigue Life of Wire Bonding in Microelectronics," <u>ASME Transactions, Journal of Electronic Packaging</u>, September, Vol. 113, No. 3, pp. 275-285, 1991.
- 12. Dasgupta, A. and Bhandarkar, S., "A Generalized Self-Consistent Mori-Tanaka Scheme for Fiber Composites with Multiple Interphases," *Mechanics of Materials*, Vol. 14, pp. 67-82, 1992.
- Dasgupta, A., Oyan, C., Barker, D., and Pecht, M., "Solder Creep-Fatigue Analysis by An Energy Partitioning Approach," <u>ASME Transactions, Journal of Electronic Packaging</u>, Vol. 114, No.2, pp. 152-160, 1992.
- 14. Dasgupta, A. and Agarwal, R., "Orthotropic Thermal Conductivity of Plain-Weave Fabric Composites Using Homogenization Technique," *Journal of Composite Materials*, Vol. 26, No. 18, pp. 2736-2758, 1992.
- 15. Dasgupta, A. and Sirkis, J., "Importance of Coatings to Structurally Embedded Optical Fibers in Smart Structures," *AIAA Journal*, Vol. 30, No. 5, pp. 1337-1343, 1992.
- Dasgupta, A., Wan, Y., and Sirkis, J., "Prediction of Resin Pocket Geometry for Stress Analysis of Optical Fibers Embedded in Laminated Composites," *Journal of Smart Materials & Structures*, Institute of Physics (IOP) Publishing Ltd., Bristol, U.K., Vol. 1, No. 1, pp. 101-107, 1992.
- Bhandarkar, S., Dasgupta, A., Barker, D., Pecht, M., and Engelmaier, W., "Influence of Selected Design Variables on Thermo-Mechanical Stress Distribution in Plated-Through-Hole Structures," <u>ASME</u> <u>Transactions, Journal of Electronic Packaging</u>, Vol. 114, No. 1, pp. 8-13, 1992.
- Barker, D., Sharif, I., Dasgupta, A., and Pecht, M., "Effect of SMC Lead Dimensional Variabilities on Lead Compliance and Solder Joint Fatigue Life," <u>ASME Transactions, Journal of Electronic Packaging</u>, Vol. 114, No. 2, pp. 177-184, 1992.
- 19. Barker, D., Dasgupta, A., and Pecht, M., "PWB Solder Joint Fatigue Life Calculations Under Thermal and Vibrational Loading," *Journal of the Institute of Environmental Sciences*, Vol. 35, No. 1, pp. 17-25, 1992.
- Agarwal, R. and Dasgupta, A., "Prediction of Electrical Properties of Plain-Weave Fabric Composites for Printed Wiring Board Design," <u>ASME Transactions, Journal of Electronic Packaging</u>, Vol. 115, No. 2, pp. 219-224, 1993.
- 21. Hu, J., Pecht, M., and Dasgupta, A., "Design of Reliable Die Attach," *International Journal of Microcircuits and Electronics Packaging*, Vol. 16, No. 1, pp. 1-21, 1993.
- Barker, D., Chen, Y. S., and Dasgupta, A., "Estimating the Vibration Fatigue Life of Quad Leaded Surface Mount Components," <u>ASME Transactions, Journal of Electronic Packaging</u>, Vol. 115, No. 2, pp. 195-200, 1993.
- 23. Pecht, M., Barker, D., and Dasgupta, A., "An Approach to the Development of Package Design Guidelines," *International Journal of Microcircuits and Electronic Packaging*, Vol. 16, No. 3, pp. 217-240, 1993.
- 24. Hu, J., Barker, D., Dasgupta, A., and Arora, A., "Role of Failure Mechanism Identification in Accelerated Testing," *Journal of the Institute of Environmental Sciences*, Vol. 36, No. 4, pp. 39-45, 1993.
- 25. Sirkis, J. and Dasgupta, A., "Analysis of a Damage Sensor Based on Elastic-Plastic Metal Coatings on Optical Fiber Sensors," *IEEE Transactions, Journal of Lightwave Technology*, Vol. 11, No. 8, pp. 1385-1393, 1993.
- 26. Verma, S., Dasgupta, A., and Barker, D., "A Numerical Study of J-Leaded Solder Joints Using the Energy-Partitioning Approach," <u>ASME Transactions, Journal of Electronic Packaging</u>, Vol. 115, No. 4, pp. 219-224, 1993.

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- Sirkis, J., Cheng, A., Dasgupta, A., "Image Processing Based methods of Predicting Stiffness Characteristics of Short Fiber Reinforced Injection Molded Parts," *Journal of Composite Materials*, Vol. 28, No. 9, pp. 784-799, 1994.
- 29. These publications were part of an invited series in the <u>IEEE Transactions on Reliability:</u>

Dasgupta, A. and Pecht, M., "Material Failure Mechanisms and Failure Models," Vol. 40, No. 5, pp. 531-536, 1991.

Dasgupta, A. and Hu, J., "Failure Mechanism Model for Excessive Elastic Deformation," Vol. 41, No. 1, pp. 149-154, 1992.

Dasgupta, A. and Hu, J., "Failure Mechanism Model for Plastic Deformation," Vol. 41, No. 2, pp. 168-174, 1992.

Dasgupta, A. and Hu, J., "Failure Mechanism Model for Brittle Fracture," Vol. 41, No. 3, pp. 328-335, 1992.

Dasgupta, A. and Hu, J., "Failure Mechanism Model for Ductile Fracture," Vol. 41, No. 5, pp. 489-495, 1992.

Dasgupta, A. and Haslach, H., "Mechanical Design Failure Models for Buckling," Vol. 42, No. 1, pp. 9-16, 1993.

Li, J. and Dasgupta, A., "Failure Mechanism Models for Creep," Vol. 41, No. 3, pp. 339-353, 1993.

Dasgupta, A., "Failure Mechanism Models for Cyclic Fatigue," Vol. 42, No. 4, pp. 548-555, 1994.

Li, J., and Dasgupta, A., "Failure Mechanism Models for Material Aging due to Interdiffusion," Vol. 43, No. 1, pp. 2-10, 1994.

- 30. Mathieu, B. and Dasgupta, A., "A Fractional-Factorial Numerical Technique for Stress Analysis of Glass-to-Metal Lead Seals," *ASME Transactions, Journal of Electronic Packaging*, Vol. 116, pp. 98-104, June 1994.
- 31. Dasgupta, A. and V. Ramappan, "Simulation of the Influence of Manufacturing Quality on Reliability of Vias," *ASME Transactions, Journal of Electronic Packaging*, Vol. 117, No. 2, pp. 141-146, 1995.
- 32. Ganguly, G. and A. Dasgupta, "Reliability Issues in Plated-Through-Holes due to Insertion-Mount Compliant-Pin Connectors: Damage Caused by Insertion of Insertion Mount Connectors," <u>ASME</u> <u>Transactions, Journal of Electronic Packaging</u>, Vol. 117, No. 2, pp. 147-152, 1995.
- 33. Huang, K.H. and A. Dasgupta, "A Layer-Wise Analysis for Free Vibration of Thick Composite Cylindrical Shells," *Journal of Sound and Vibration*, Vol. 186, No. 2, pp. 207-222, 1995.
- 34. Pecht, M. and Dasgupta, A., "Physics-of-Failure: An Approach to Reliable Product Development," *Journal* of the Institute of Environmental Sciences, Vol. 38, No. 5, pp. 30-34, 1995.
- 35. Huang, K.H. and A. Dasgupta, "A Layer-Wise Analysis for Free Vibrations of Thick Composite Spherical Panels" *Journal of Composite Materials*, Vol. 31, No. 7, pp. 658-671, 1997.
- 36. Kelkar, N., Dasgupta, A., and Pecht, M., "Health Monitoring of "Smart" Electronics Systems," *International Journal for Quality and Reliability Engineering*, Vol. 13, No. 1, pp. 3-8, Jan-Feb, 1997.

- 37. Ling, S. and Dasgupta, A., "A Nonlinear Multi-Domain Stress Analysis Method for Surface Mount Solder Joints," *ASME Transactions, Journal of Electronic Packaging*, Vol. 118, No. 2, pp. 72-79, June 1996.
- Dasgupta, A., Agarwal, R. & Bhandarkar, S., "Three Dimensional Modeling of Woven-Fabric Composites for Effective Thermo-Mechanical and Thermal Properties," <u>International Journal of Composites Science &</u> <u>Technology</u>, Vol. 56, 1996.
- 39. Kannan, K. S., and Dasgupta, A., "A Nonlinear Galerkin Finite Element Theory for Magnetostrictive Smart Structures," *Journal for Smart Materials Systems and Structures*, Vol. 6, pp. 341-350, 1997.
- 40. Ling, S. and Dasgupta, A., "A Nonlinear Multi-Domain Thermomechanical Stress Analysis for Surface-Mount Solder Interconnects; Part II: Viscoplastic Analysis," <u>ASME Transactions, Journal of Electronic</u> <u>Packaging</u>, Vol. 119, No. 3, pp. 177-182, Sep 1997.
- 41. Darbha, K., Ling, S., and Dasgupta, A., "Stress Analysis of Surface-Mount Interconnects due to Vibrational Loading," *ASME Transactions, Journal of Electronic Packaging*, Vol. 119, No. 3, pp. 183-188, Sep 1997.
- 42. Dasgupta, A., Anand, D. K., Magrab, E. B., Eisinger, K., McLeish, J., Torres, M., "Perspectives to Understand Risks in the Electronics Industry," *IEEE Transactions, Components, Products, and Manufacturing Technology*, Vol. 20, No. 4, pp. 542-547, 1998.
- 43. Caruso, H., and Dasgupta, A., "A Fundamental Overview of Accelerated-Testing Analytic Models", *Journal of the Institute for Environmental Sciences*, Vol. 41, No. 1, pp. 16-20, Jan 1998.
- 44. Darbha, K., Okura, J., and Dasgupta, A., "Impact of Underfill Filler Particles on Reliability of Flip Chip Interconnects," *IEEE Transactions, Components, Products, and Manufacturing Technology, Part A*, Vol. 21, No. 2, pp. 275-280, June 1998.
- 45. Dasgupta, A., Pecht, M., and Mathieu, B., "Design-of-Experiment Methods for Computational Parametric Studies in Electronic Packaging," *International Journal of Applied Finite Elements and Computer Aided Engineering*, Vol. 30, Nos. 1-2, pp. 125-146, July 1998.
- Upadhyayula, K. and A. Dasgupta, "Physics-of-Failure Guidelines for Accelerated Qualification of Electronic Systems", published in special issue on Accelerated Stress Testing, <u>International Journal of</u> <u>Quality and Reliability Engineering</u>, Vol. 14, pp. 433-447, 1999.
- 47. Darbha, K, Okura, J., Dasgupta, A., "Thermomechanical Durability of Flip Chip Interconnects without underfill," *ASME Journal of Electronic Packaging*, Vol. 121, pp. 231-236, 1999.
- 48. Darbha, K, Okura, J., Shetty, S., Dasgupta, A., Reinikainen, T., Zhu, J., Caers, J., "Thermomechanical Durability of Flip Chip Interconnects with underfill," *ASME Journal of Electronic Packaging*, Vol. 121, pp. 237-242, 1999.
- 49. Xie, J., Pecht, M., Dasgupta, A., Swift, J. A., and Wallace, S. J., "A Statistical Mechanical Model of Electrical Carbon Fiber Contacts," *ASME Journal of Electronic Packaging*, Vol. 121, pp. 286-290, 1999.
- Sealing, C. S. and Dasgupta, A., "Piezoelectric Actuators and Sensors for Accelerated Stress Testing and Health Monitoring of Laminated Circuit Card Assemblies," *Journal of Reinforced Plastics and Composites*, Vol. 18, No. 6, pp. 509-519, 1999.
- Okura, J., Shetty, S., Dasgupta, A., Caers, J., Reinikainen, T., "Guidelines to Select Flip Chip Underfill and Compliant Interposers for CSP Assemblies," *Intl Journal of Microelectronics Reliability*, Vol. 40, pp. 1173-1180, 2000.

- 52. Darbha, K, Okura, J., Dasgupta, A., "Thermomechanical Durability of Flip Chip Interconnects without underfill," *ASME Journal of Electronic Packaging*, Vol. 121, pg. 231-236, 2000.
- 53. Darbha, K, Okura, J., Shetty, S., Dasgupta, A., Reinikainen, T., Zhu, J., Caers, J., "Thermomechanical Durability of Flip Chip Interconnects with underfill," *ASME Journal of Electronic Packaging*, Vol. 121, pg. 237-242, 2000.

Refereed articles in archival journals that have been accepted for publication.

- 1. Kannan, K. S. and Dasgupta, A., "A Micromechanical Finite Element Scheme For Particulate Magnetostrictive Composites," accepted in *Journal of Intelligent Material Systems and Structures*.
- 2. Chen, M. H. and Dasgupta, A., "A Three-Dimensional Finite Element Scheme for Fiber Microbuckling in Thick laminated Composites; Part A: Unidirectional Laminates; Part B: Multidirectional Laminates," accepted in *Mechanics of Composite Materials and Structures*.
- 3. Shetty, S., Dasgupta, A., and Reinikainen, T., "Cyclic Bending Fatigue in CSP Assemblies," accepted in <u>ASME Transactions in Electronic Packaging</u>
- 4. Darbha, K., and Dasgupta, A., "A Nested Finite Element Methodology for Stress Analysis of Flip Chip Interconnects: Part I: Elastic Analysis, Part II: Viscoplastic Analysis," accepted in <u>ASME Transactions in</u> <u>Electronic Packaging</u>
- 5. Sharma, P., Upadhyayula, K, and Dasgupta, A., "Micromechanics of Cyclic Viscoplatic Fatigue Damage in Eutectic Pb-Sn Solder Alloy," accepted in *Intl J of Damage Mechanics*

Refereed Conference proceedings:

- 1. Vodzak, J., Barker, D., Dasgupta, A., and Pecht, M., "Solder Joint Fatigue: A Total Strain Versus Life Approach," Paper No. 89-WA/EEP-35, <u>ASME Winter Annual Meeting</u>, San Francisco, CA, Dec. 1989.
- 2. Sharif, I., Barker, D., Dasgupta, A., and Pecht, M., "Fatigue Analysis of a Planarpak Surface Mount Component," Paper No. 90-WA/EEP-4, <u>ASME Winter Annual Meeting</u>, Dallas, TX, Oct. 1990.
- Barker, D., Sharif, I., Dasgupta, A., and Pecht, M., "Effect of SMC Lead Dimensional Variabilities on Lead Compliance and Solder Joint Fatigue Life," Paper No. 91-WA/EEP-25, <u>ASME Winter Annual Meeting</u>, Atlanta, GA, Dec. 1991.
- 4. Dasgupta, A., C. Oyan, D. Barker, M. Pecht, "Solder Creep-Fatigue Analysis by an Energy-Partioning Approach," <u>ASME Winter Annual Meeting</u>, Paper No. 91-WA-EEP-19, Atlanta, GA, Dec. 2-6, 1991.
- Dasgupta, A., Verma, S., and Barker, D., "Fatigue Life of Misregistered J-Lead Solder Joints Through an Energy Partitioning Approach," Paper No. 92-WA/EEP-28, <u>ASME Winter Annual Meeting</u>, Anaheim, CA, Nov, 1992.
- Agarwal, R. and Dasgupta, A., "Prediction of Electrical Properties of Plain-Weave Fabric Composites for Printed Wiring Board Design," Paper 92-WA/EEP-24, <u>ASME Winter Annual Meeting</u>, Anaheim, CA, Nov. 1992.
- Barker, D. B., Chen, Y. S., and Dasgupta, A., "Vibrational Fatigue Life Calculations for Components Mounted on PWBs," <u>ASME Winter Annual Meeting</u>, Paper No. 92-WA/EEP-18, Anaheim, CA, Nov. 8-13, 1992.

- 8. Alghamdi, A. and Dasgupta, A., "Micromechanical Dynamic Analysis of an Adaptive Beam with Embedded Distributions of Piezoelectric Actuator/Sensor Devices," AMD-35, <u>ASME Winter Annual Meeting</u>, New Orleans, Nov. 1993.
- 9. Mathieu, B. and Dasgupta, A., "Stress Analysis of Glass-to-Metal Lead Seals," Paper No. 93-WA/EEP-20, <u>ASME Winter Annual Meeting</u>, New Orleans, Nov. 1993.
- Kannan, K. S. and Dasgupta, A., "Finite Element Modeling of Multi-Functional Composites with Embedded Magnetostrictive Devices," Proceedings, <u>AD Vol. 45 / MD Vol. 45</u>, <u>Adaptive Structures and Composite</u> <u>Materials</u>, <u>ASME Winter Annual Meeting</u>, pp. 21-28, Ed. Dasgupta, et. al., Chicago, Nov. 6-11, 1994.
- Jain, A., Alghamdi, A., Dasgupta, A., and Sirkis, J., "Effective Properties of 1-3 Piezocomposites Using Eigenstrain Method and Mori-Tanaka Scheme", Proceedings, <u>AD Vol. 45 / MD Vol. 45, Adaptive Structures</u> and Composite Materials, ASME Winter Annual Meeting, pp. 67-74, Ed. Dasgupta, et. al., Chicago, Nov. 6-11, 1994.
- 12. Ramappan, V. and Dasgupta, A., "Physics if Failure Simulation of the Influence of Manufacturing Variabilities on Reliability of Vias," Proceedings, 94-WA/EEP-2, <u>ASME Winter Annual Meeting</u>, Chicago, Nov. 6-11, 1994.
- 13. Ganguly, G. and Dasgupta, A., "Modeling PTH Damage Caused by Insertion of Insertion Mount Connectors," Proceedings, 94-WA/EEP-1, <u>ASME Winter Annual Meeting</u>, Chicago, Nov. 6-11, 1994.
- Ling. S. and Dasgupta, A., "A Simplified Technique for Viscoplastic Thermomechanical Stress Analysis of Surface-Mount Solder Interconnects," Proc. <u>ASME IMECE</u>, 96-WAA/EEP-7, Atlanta, GA, Nov 18-22, 1996.
- 15. Darbha, K., Ling, S., Upadhyayula, K., and Dasgupta, A., "Stress Analysis of Surface Mount Interconnects due to Vibrational Loading," Proc. <u>ASME IMECE</u>, 96-WAA/EEP-8, Atlanta, GA, Nov 18-22, 1996.
- 16. Darbha, K., Okura, J., and Dasgupta, A., "A Multi-Domain Thermomechanical Stress Analysis for Flip Chip Solder Interconnects," <u>ASME IMECE</u>, 97-WA/EEP-11, Dallas, TX, Nov 15-20, 1997.
- Upadhyayula, K., Dujari, P., and Dasgupta, A., "An Incremental Damage Superposition Approach for Interconnect Reliability Under Combined Stresses", <u>ASME IMECE</u>, 97-WA/EEP-13, Dallas, TX, Nov 15-20, 1997.
- Barker, D., Dasgupta, A., Neel, J., Rajagopal, S., Tiwari, N., and Xie J., "Semi-Analytic Durability Model for Compliant Leaded Surface Mount Interconnects," <u>ASME IMECE</u>, 97-WA/EEP-12, Dallas, TX, Nov 15-20, 1997.
- *19.* Okura, J. H., Darbha, K., and Dasgupta, A., "Effect of Underfill in Flip chip on board assemblies", <u>ASME</u> <u>IMECE</u>, 98-WA/EEP-18, Anaheim, CA, Nov 16-21, 1998.
- 20. Darbha, K. and Dasgupta, A., "A Nested Finite Element Methodology (NFEM) for Stress Analysis of Chip Scale Packages and Flip Chip on Board Assemblies-II: Viscoplastic Analysis, ASME IMECE, Nashville, TN, Nov 99
- 21. Haswell, P., and Dasgupta, A., "Viscoplastic Characterization of Constitutive Behavior of Two Solder Alloys" *ASME IMECE, Nashville, TN, Nov 99*
- 22. Shetty, S. and Dasgupta, A., "Effect of Bending Stresses on Chip Scale Packages" ASME IMECE, Nashville, TN, Nov 99

- 23. Upadhyayula, K. and Dasgupta, A., "Influence of Temperature-Vibration Interactions on Fatigue Damage in Surface Mount Electronic Interconnects: A Micromechanistic Perspective" *ASME IMECE, Nashville, TN, Nov 99*
- Darbha, K. and Dasgupta, A. "A Nested Finite Element Methodology (NFEM) For Stress Analysis of Flip Chip Solder Interconnects - Part I: Elastic Analysis." <u>Proceedings ASME Interpack '99</u>. June 13-99, 1999. EEP - Vol. 26-1, PP. 13-19.
- Sealing, S. and Dasgupta, A. "Alternative Accelerated Testing Method For Localization Of Solder Fatigue Failures On Electronic Circuit Cards." <u>Proceedings ASME Interpack '99</u>. June 13-99, 1999. EEP - Vol. 26-2, PP. 1593-1598.
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- 27. Cho, J., Upadhyayula, K., Dasgupta, A. "Complex Temperature-Vibration Interactions On Solder Durability." *Proceedings ASME Interpack '99.* June 13-99, 1999. EEP Vol. 26-2, PP. 1797-1800.
- Sharma, P., Natarajan, R., Dasgupta, A. "Reducing Accelerated Test Time: Use Of Vibration Loading To Accelerate Aging Damage." <u>Proceedings ASME Interpack</u> '99. June 13-99, 1999. EEP - Vol. 26-2, PP. 1801-1805.
- Darbha, K., Okura, J.H., Shetty, S., Dasgupta, A. "Effect Of Current-Induced Hydrostatic Stresses On Life Of Underfilled Area-Array Solder Interconnects." <u>Proceedings ASME Interpack '99</u>. June 13-99, 1999. EEP - Vol. 26-2, PP. 1913-1920.
- Okura, J.H. and Dasgupta, A. "Effect Of High Temperature Aging On Solder Joint Degradation In FCOB Assemblies." <u>Proceedings ASME Interpack '99</u>. June 13-99, 1999. EEP - Vol. 26-2, PP. 1921-1928.
- Dujari, P., Cho, J., Dasgupta, A. "Comparison Of Vibration Fatigue Damage in Surface Mount Interconnects For Repetitive Shock And Electro-Dynamic Excitation." <u>Proceedings ASME Interpack '99</u>. June 13-99, 1999. EEP - Vol. 26-2, PP. 2089-2097.
- 32. Okura, J., Dasgupta, A., and Caers, J., "Effect of Moisture on Durability of Flip-Chip-on-Board (FCOB) Interconnects," Proc. EEP-Vol. 28, pp. 145-151, ASME IMECE, Nov., 2000, Orlando, FL
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- 42. Cho, S., Natarajan, R., and Dasgupta, A., "Practical Examples of Accelerated Testing in Electronic Systems," ASME IMECE, Nov., 2000, Orlando, FL

Research Facilities

1. **CALCE Surface Mount Microfactory.** This laboratory facility for manufacturing surface mount electronic printed circuit boards was established by this PI in 1994, as part of a cooperative research agreement with the Army Research Laboratory. The goal is to conduct research in: new composite solders, fluxless soldering, lead-free solders, critical manufacturing controls, and identifying the interactions between design and manufacturing on product reliability. This microfactory is also a valuable courseware for hands-on training and education of CALCE researchers and students in the Electronic Products and Systems (EPS) curriculum at the mechanical engineering department.

Existing equipment :

- A. Computer-controlled Rework Station
- B. Plasma Cleaning Equipment
- C. Miscellaneous computing facilities (SUN workstation, PC LAN)
- D. Plasma Assisted Dry Soldering (PADS)
- E. Sequential Electrochemical Reduction Analysis (SERA) for solderability testing
- F. Solder Viscometer
- 2. Accelerated Stress Testing Laboratory. This laboratory was established by this PI in 1994. New research directions include development of combined stress testing, and "smart" circuit card technology for in-situ accelerated stress self-testing and in-situ self-health monitoring.

Existing equipment:

- A. Computer-integrated controller for single-DOF electro-dynamic shaker
- B. Computer-integrated controller for multi-DOF repetitive-shock shaker
- C. Two thermally-enhanced 6-DOF repetitive-shock shakers
- D. 22 Kip MTS servo-hydraulic test frame
- E. Thermal shock chamber
- F. 32-channel, high-speed conditioner & digital data acquisition system for strain gages
- G. Miscellaneous instrumentation: filters, 4-channel strain gage conditioner, three 128-channel transient event detectors, etc.
- H. Thermomechanical Micro-Fatigue Tester
- I. Impact Test Setup (Pendulum type) with high-speed data acquisition

Research-related Honors and Awards

Best Paper, Maurice Stimpson Technical Editor's Award, 1990, "Reliable Electronic Packaging," Dasgupta, A., Pecht, M., and Barker, D., Journal of the Institute for Environmental Sciences., Vol. 33, No. 3, pp. 36-45.

Reliability Test and Evaluation Award, 1996, Institute for Environmental Sciences, Citation: "for vital contributions to the development and promotion of physics-of-failure modeling and analysis as a valuable reliability design and test process in the government, commercial and academic communities."

3. TEACHING AND ADVISING:

Courses Taught:

ENES 100 Freshman Design: F94, S01 [Appproximately 35 students]

ENES 221 Engineering Dynamics: F88 [93 students] ENME 201 Engineering Projects (team taught extra course on voluntary basis) F92, S93, F93 [approximately 100 students each semester] ENME 310 Advanced Strength of Materials: S89 [2 sections with 25 and 33 students, respectively], F90 [30 students] ENME 401 Mechanics of Materials: F88 [31 students] ENME 404 Senior Design Project S96 [approx 30 students] ENME 470 Finite Element Methods (Undergraduate Elective): F92 [25 students] ENME 480 Engineering Experiments (team taught) S90 [120 students] ENME 489M/808J Reliability Engineering (Graduate Special Topic, Team taught): S90 [28 students] ENME 600 Continuum Mechanics: F99 [approx 10 students] ENME 672 Composite Materials: F91, F93, F95, S00 [approximately 10 students each semester] ENME 673 Energy and Variational Methods: F96, F98, F00 [approximately 15 students each semester] ENME 674 Finite Element Methods: F89, S91, S92, S93, S94, S95 [approximately 15 students each semester] ENME 8080 Surface Mount Electronic Assembly (co-developed with Y. Joshi) F95, F97 [approximately 25 students each semester] ENME 808I Interconnect Technologies for Reliable Electronic Assemblies S97, S99 [approximately 30 students] ENME 808X Accelerated Qualification of Electronic Systems S98 [approximately 20 students]

Course or Curriculum Development:

ENME 672 Composite Materials

Designed as a companion course to ENAE 654 (Composite Structures), this course emphasizes the micromechanics science and art of characterizing the effective continuum-scale constitutive and damage properties of heterogeneous materials, based on the properties and microarchitecture of the constituent phases. Composite systems studied include particulate composites, short fiber reinforced composites, continuous fiber composites, woven-fabric composites and laminated plates consisting of one or more of the above forms. Micromechanics of "Adaptive" composites with active inclusions such as electrostrictive and/or magnetostrictive actuators are presented. While the emphasis is on mechanical properties, hygral, thermal, electrical, magnetic, and optical properties are also discussed briefly. Heterogeneities in micro- and nano-continua are discussed.

ENME 673: Energy and Variational Methods:

Approximate solution schemes for solving complicated boundary value problems (BVPs) form the very foundation of modern computational mechanics. However, use of many of these solution schemes requires that the BVPs first be expressed in a "weak" form. This course explores the variational principles and methods available for posing BVPs in "weak" form, and the associated approximate solution schemes. Examples are chosen from solid mechanics, thermo-fluid transport, electrostatics, magnetostatics, and from coupled boundary value problems encountered in transduction materials. Eigen-value formulations encountered in initial value problems and in stability problems are also explored. Variational principles for micro and nano continua are presented.

ENME 674 Finite Element Methods

This course presents the basis and theory of the finite element approximation method for solving boundary-value problems in variational form. Topics include the relationship of the finite element

method to other approximate variational methods; methods for deriving different interpolation schemes in physical and generalized coordinates; and implementational details of the FEM scheme for simple 1D/2D/3D problems. Examples are taken from current research issues in (i) heterogeneous materials and structures; (ii) coupled electro-mechanical and magneto-mechanical boundary value problems for application to "adaptive" ("smart"/"active") materials and structures; (iii) fluid mechanics and heat transfer applications; and (iv) micro and nano continua.

ENME 695 (formerly 808J) Failure Mechanisms and Reliability (teamed with M. Pecht)

This course addresses the role of material failure mechanisms in reliability engineering. Quantitative models are presented for common failure mechanisms, based on mechanics of materials concepts. Statistical theories are presented to examine these failure models within a stochastic framework. Reliability predictions are made based on these quantitative models. Examples are taken from mechanical engineering applications and electronic packaging applications. I was responsible for developing the section on material failure mechanisms.

ENME 775 (formerly 808O): Surface-Mount Electronic Assembly Manufacturing (Teamed with Y. Joshi) (New EPS course developed with funding provided by a \$1 million, 3-year TRP-MET program, PI: Dasgupta, Pecht)

This course presents the fundamental mechanics of the surface mount manufacturing process. The state-of-the-art for individual process steps is presented, the potential for manufacturing defects at each stage are identified, and the impact on product quality and reliability are assessed. Mechanistic process simulation models are developed so that the process can be optimized proactively in a virtual factory setting, before the first hardware is built. The model parameters are connected quantitatively with manufacturing quality. Processes considered include solder paste deposition, component preparation, component placement, soldering, rework, and cleaning. Advantages and disadvantages of different solder materials are presented and solderless interconnect technologies are explored. This course emphasizes in addition to technical core, hands-on learning (in the CALCE surface-mount microfactory), interactions with local industrial colleagues (field-trips to Hughes Network Systems), multidisciplinary teamwork (group semester-projects), communication skills (presentation of group project results), and guest-lecture series from leading external experts from other universities.

ENME 693 (formerly 808I): Reliable Interconnect Technologies in Electronic Packaging (New EPS course developed with funding provided by a \$1 million, 3-year TRP-MET program, PI: Dasgupta, Pecht): The functionality and reliability of various interconnect technologies are explored. Interconnects are considered at all levels of the package: eg. metallization on the die, first-level interconnects from the die to the package exterior (or to substrate, in the case of direct chip-attach technologies), leads and solder joints, solder-less interconnect technologies, optoelectronic interconnects, connectors and flex cables. The goal is to illustrate to students the key technology challenges, research opportunities, and state-of-the-art solutions for next-generation electronic systems.

ENME 808X: Accelerated Qualification of Electronic systems (New EPS course developed with funding provided by a \$1 million, 3-year TRP-MET program, PI: Dasgupta, Pecht):

This is a new course offered for the first time, and is intended to become a permanent offering within the EPAR program. Dominant failure mechanisms causing aging and wearout failures in electronic systems are explored. Failure models are presented. Techniques to accelerate these mechanisms are identified, in order to simulate accelerated life cycles in a compressed time-frame. Effective acceleration transforms are derived, in order to relate results of accelerated tests to actual life cycles. Term projects focus on laboratory experiments to familiarize students with the entire qualification process.

ENME 201 Engineering Projects 1993-1996, (taught as a voluntary teaching activity, in conjunction with D. Bigio)

As a result of my participation in the UMCP Curriculum Transformation Project in summer 1991, I have voluntarily modified the course contents and taught this course as an extra teaching service for the last three semesters. Traditionally, this course has required students to dis-assemble and re-

assemble an engineering assembly of their choice, make an oral presentation to the class, and submit a written report. My contribution has been to encourage the students to consider also the associated holistic issues in engineering decisions, such as examining environmental impact, recycling and waste management concerns, life-cycle costs, economic impact, social implications, biases based on age/gender/disabilities, safety engineering, ergonomic and aesthetic concerns in design, etc.

Note: In the spirit of the new curriculum, emphasis is placed in all of the above courses, on team effort, collective learning strategies, team teaching from experts in academia and industry, hands-on learning experiences, effective communication and presentation skills.

Education-related Publications.

1. Dasgupta, A. and Pecht, M., "Curriculum Development for Introducing Manufacturing Sciences in the Mechanical Engineeering Graduate Program and in Industry-Focussed Short Courses," NSF/TRP-MET Grantees' Conference, April 8, 1997, Arlington, VA.

Teaching Awards and Other Recognitions:

- 1. Special Faculty Award, for two consecutive years ('90 & '91), Pi Tau Sigma Honor Society, University of Maryland.
- 2. *ARL Director's Award* for effective educational and technology transfer strategies developed in the TRP-MET program, October 1996, Aberdeen, MD.

Extension Activities:

- 1. Panel Member: "Surface Mount Reliability Issues", Surface Mount Engineering Round Table, Boston, 1990.
- Workshops presented: "Mechanics and Fabrication of Smart Structures" Full Day Workshop, Society for Experimental Mechanics, Spring Conference, 1992 Full Day Workshop, Society for Experimental Mechanics, Spring Conference, 1993 Half Day Workshop, SPIE Conference on Smart Structures, 1993 Full Day Workshop, SPIE Conference on Smart Structures, scheduled for 1994
- Two sessions presented in Workshop on "Reliability Prediction and Testing of Electronic Packages," Instructional TV, National Technological University Satellite Network, 1992: Highly Accelerated Testing of Electronic Packages Thermomechanical Issues in Electronic Package Reliability
- 4. Panel Member: "Training the Shop Floor Worker", 1993 Surface Mount International Conference, San Jose, Aug., 1993.
- 5. Panel Leader: "Finite Element Methods in Electronic Packaging," 2nd International Electronic Packaging Conference, Binghamton, Oct., 1993.
- 6. Participant, Round-Robin program for solder fatigue property evaluation and fatigue model development, organized by Jet Propulsion Laboratory, Pasadena, CA, 1993.
- 7. One-day Workshop "Physics of Failure in Electronic Packaging", 8 times in 1995-1998.
- 8. Two-Day Workshop "Physics of Failure and Accelerated Qualification of Electronic Systems", 14 times since 1998.

- 9. Half-day workshop: "Physics-of-Failure Issues in Electronic Packaging,"
 - 41st Annual Conference, Institute of Environmental Sciences, Anaheim, CA, 1995.
 - IEEE-TC7, Accelerated Stress Testing Symposium, Pasadena, CA, 1998.
- "Accelerated Testing of Electronic Systems Under Combined Stresses," Presented to: Boeing Commercial Airplane Group, Renton, WA, June 1995. GEC Marconi, Chelmsford, UK, July, 1995. Saturn Electronic Systems, Detroit, MI, Jan. 1996. Philips PCC, LeMans, France, May, 1998. Boeing Commercial Airplane Group, Renton, WA, June 1998.
- 11. "Storage Reliability of Electronic Systems," Presented to Daewoo Electronics, Inchon, Korea, June 1995.
- "Smart Materials and Structures Research at the University of Maryland," Presented to: MITI, Tsukuba, Japan, June 1995. Indira Gandhi Atomic Research Center, Madras, India, June 1995. National Aerospace Laboratories, Bangalore, India, June, 1995. Indian Institute of Science, Bangalore, India, 1995.
- 13. "Physics-of-Failure Principles for Designing-in Reliability in Electronic Systems," Presented to: Samsung Electronics, Inchon, Korea, June 1995. Institute for Microelectronics, Singapore, June 1995. Center for Electromagnetics, SAMEER, Department of Electronics, Govt. of India, Madras, India, June 1995. Center for Components Acceptance/Testing, Dept. of Telecomm., Govt. of India, Bangalore, India, June '95. Indian Space Research Organization, Bangalore, India, June 1995.
- 14. One-week Workshop in "Physics of Failure in Electronic Packaging" UNIDO, Bangalore, India, 1996.
- 1-day workshops on "Accelerated Qualification of Electronic Systems": Lucas Aerospace, Birmingham, UK, 1997 Nokia Mobile Phones, Salo, Finland, 1997 Xerox corporation, Rochester, NY, 1997
- 16. Panel Leader: "Educational needs in the Electronics Packaging Community," sponsored by the Electrical and Electronic Packaging Division, <u>ASME IMECE</u>, Anaheim, CA, Nov 16-21, 1998.
- 17. Panel participant: "Future Directions for electronic and Photonic Packaging," sponsored by the Electrical and Electronic Packaging Division, <u>ASME IMECE</u>, Anaheim, CA, Nov 16-21, 1998.

4. SERVICE:

Professional:

Associate Editor: Journal of Microelectronics and Microdevices, 2000-2003 Associate Editor: ASME Journal of Electronic Packaging, 94-97 Member, Editorial Board: International Journal for Intelligent Material Systems and Structures, 94-97 Member, American Society for Mechanical Engineers (1989-):

- Member, Composites Committee of Materials Division (1992-present), Adaptive Structures Committee of Aerospace Division (1995-present), Electronics Manufacturing Committee of Electronics Packaging Division (1996-present);
- Co-Organizer each year of special mini-symposium on multifunctional composites in ASME Winter Annual Meeting;
- Chaired committee for Best Paper Award (Adaptive Materials), 1996-97;

Member, Society for Experimental Mechanics (1992-):

Member, Composite Materials Committee (1992-): Responsible for organizing Composites Sessions for 1993 and 1994 SEM Spring Conferences.

Member, American Academy of Mechanics (AAM) (1987-).

Member, Society for Advancement of Materials & Process Engineering (SAMPE) (1991-).

Member, The International Society for Optical Engineering (SPIE) (1991-).

Committee Member, Electronic Packaging Sessions, International Reliability Physics Symposium, 93-94.

Committee Member: Society of Automotive Engineers, Reliability Committee (1990-91).

Committee Member: Guidelines for Solder Design and Accelerated Testing, Institute for Interconnecting & Packaging Electronic Circuits (IPC) (1991- 92).

Session chair/co-chair at national and international conferences:

Fiber Optic Smart Structures III, SPIE, Fiber Embedding & Materials Session, 1990 Spring Conference, Society for Experimental Mechanics, Electronic Packaging Session, 1993 2nd International Electronic Packaging Conference, Solder Technology Session, 1993 8th Technical Conference of American Society for Composites, Smart Composites Session, 1993 Chaired 3 sessions (2 in Electronic Packaging and 1 in Adaptive Structures), ASME IMEC, 96. Chaired 1 session in ASME Summer Meeting, Baltimore, MD.

Consultant, PARAMAX, Long Island, NY, 1992-1994.

Consultant, Hobbs Engineering, Denver, CO, 1993-present.

Consultant, General Motors Truck, Detroit, MI, 1998.

Consultant, ITT Automotive, Kokomo, IN, 1998.

Reviewer:

ASME Journal of Electronic Packaging ASME J. of Vibration & Acoustics ASME J. of Engineering Materials and Technology ASME J. of Applied Mechanics Mechanics of Materials Intl. J. Intelligent Material Systems and Structures Smart Material Systems and Structures IEEE Transactions on Reliability IEEE Trans. on Components, Hybrids and Manufacturing Technology OSA Applied Optics

Composites Science and Technology

Mechanics of Composite Materials

University

Department:

Solid Mechanics subcommittee for Graduate Admission Evaluations, 1992 Infrastructure Committee, 1993 Ph.D. Qualifier Examination Panels, (1990-) Revamping of ENME 201 course-plan (1992- 94) Founding co-PI, CALCE Electronic Packaging Research Center (1990) Founding faculty member of EPAR program (1994-) EPAR subcommittee for Grad. Admissions Evaluations (1994-) Member, Search Committee for EPAR Faculty (1996-97) Founding co-PI, Smart Materials & Structures Research Center (1996) Subcommittee for planning new Engineering Applied Sciences Building (1996-97) Salary Committee (1996-98) Member, Search Committee for EPAR Faculty (1997-98) Chair, Search Committee for Mechanics and Materials Faculty (1997-98) Member, Graduate Programs Committee (1998-) Chair, Tenure committee for B. T. Han (2000)

College:

Engineering Council Member (1990-1992) Co-chair, Engineering Council Subcommittee on Campus Governance, 1991 Curriculum Development Committee (Nuclear & Materials Engineering Dept., 1993) College APT Committee (1997-99) Subcommittee for planning new Engineering Applied Sciences Building, (1997-present) Member, Search Committee for Composite Structures Faculty, Aerospace Engineering Dept., (1997-98) Materials Engineering Department Review Committee (2000-2001) M.E. Department Chair Search Committee (2000-2001)

Campus:

Campus Senate (1997-)

Other:

EIT Dynamics reviews (once every semester) Faculty Co-Advisor, SAMPE student Chapter, 1996

Teaching Evaluations: Abhijit Dasgupta					
Semester	Semester Course		Program		
		Grade	Average		
Fall 88	ENME 401	3.25	3.24		
	ENES 221	3.15	3.14		
Spring 89	ENME 310	3.33	3.20		
	ENME 310	3.58	3.20		
Fall 89	ENME 808F	3.47	??		
Spring 90	ENME 808J	3.58	3.18		
Fall 90	ENME 310	3.58	3.17		
	ENES 221	3.14	3.15		
Spring 91	ENME 808F	3.58	3.24		
Fall 91	ENME 808S	3.67	3.14		
Spring 92	ENME 808F	3.75	3.149		
Fall 92	ENME 470	3.513	3.110		
Spring 93	ENME 808F	3.36	3.30		
Fall 93	ENME 808S	3.36	3.42		
Spring 94	ENME 674	3.68	3.48		
Fall 94	ENES 100	3.51	??		
Spring 95	ENME 674	3.50	3.39		
Fall 95	ENME 672	3.52	3.34		
Spring 96	ENME 404	2.98	2.85		
Fall 96	ENME 673	3.59	3.36		
Spring 97	ENME 808I	3.42	3.35		
Fall 97	ENME 808O	3.44	3.50		
Spring 98	ENME 808X	3.30	3.50		
Fall 98	ENME 673	3.82			
Spring 99	ENME 808I	3.23			
Fall 99	ENME 670	3.21			
Spring 00	ENME 672	3.52			
Fall 00	ENME 673	3.53			
Spring 01	ENES 100				
Average		3.45	3.26		