COMPENDIUM OF GIULIO DI GIACOMO BIOGRAPHY

Education

**Studied Ragioneria (Accounting) in Italy nell'Istituto Tecnico Commerciale in Sulmona, L'Aquila.
Graduated from Brooklyn College (CUNY) with a BS in Physics cum laude (1963), and a MS Degree in Physics from the Polytechnic Institute of Brooklyn while working in the Material Science Division of the Naval Applied Science Laboratory (NASL) in Brooklyn, associated with the Naval Research and Development Center (NRDC) in Annapolis. Meanwhile, took courses to fulfil undergraduate Metallurgical Engineering requirements and matriculated for admission into the Ph.D Engineering Program, which he pursued for three years until January 1970, but came short of completing the program when the Laboratory closed and was to transfer to NRDC in Annapolis, but he chose to work for IBM..**

NASL Employment

Worked for seven years with the Material Science Division of the NASL in the field of optical spectroscopy, X-ray spectrographic analysis, X-ray diffraction, electron microprobe analysis, ultrasonic application and alloy development. In four year, promoted from GS-7 to GS-13 level, becoming a *senior task leader w*ith the title of Research Physicist and supervising, 15 professionals with expertise in the fields of chemistry, metallurgy, physics, and mechanical engineering.Conducted Projects with Southwest Research Institute on Ultrasonic Scanning, and with MIT professors on microcreep metrology. Received one patent on *ultrasonic crack detection* and another on *precision elastic limits measurement through microcreep.* ***In 1967 went to MIT to take special courses to be able to perform electron microprobe quantitative analysis on alloys based on X-ray emission requiring intensity corrections for electron backscattering, atomic number effects, and secondary emission, which varied from alloy to alloy. This was a new field in the primordial stage. On the other hand, our advances in X-ray diffraction stress analysis prompted professors from Leigh University, the Polytechnic of Brooklyn, and from Europe to visit our Lab. .***

IBM Employment and Contributions

**Joined IBM as Staff Engineer Feb.2, 1970.
Promoted to Advisory Engineer in 1971.
Promoted to Senior Engineer in 1980.
& Senior Technical Staff Member in 1991.**

Developed electron Microprobe techniques forsemi-conductors circuitry. Contributed to introduction of Field Effect Transistors (FET), Multilayer Ceramic (MLC), Thermal Conduction Module (TCM), and enhanced Reliability Engineering by developing semi- empirical models describing failure mechanisms of semiconductors and microeletronic systems: mechanisms of diffusion, electromigration, corrosion, metal migration, and mechanism involving electrochemical, thermomechanical, and electrical phenomena. Also developed macro-scale modeling for soft error rate due to cosmic rays and alpha particles from packaging materials. Monitored research projects with Berkeley and Northwestern University. Contributed to the development of key IBM technologies emerging in the period 1970-2002. Retired July 31, 2002.

Recognitions

**Member of <u>Who's Who in Thechnology</u> 1986
Elected member of New York Academy of Science
Mentor for Semiconductor Research Consortium (SRC} and Northwestern University.
Outstanding Contribution Award (IBM)
Division Awards (IBM)
Best Paper Awards (International Society for Hybrid Microelectronics)
Outstanding Author Award (Van Nostrand Reinold)**

Member of Societies

Electron Microbeam Society, Metal Research Society (MRS), Int. Soc. for Hybrid Microelectronics (ISHM), Sigma Xi, The Research Scientific Society, IEEE Reliability Soc., IEEE Electron Devices Soc. Int. Symp. on Microelectronics (IMAPS)

Books and Book Chapters Publications

Di Giacomo G., *SURVIVAL World War II North of Cassino Through the Eyes of a Ten-Year-Old, and His Immigration to the United States,* p.360 , AuthorHouse Publishing Co., 2005. (Preview published in the Sunday Poughkeepsie Journal, Oct.16, 2005).

Di Giacomo G., *Reliability of Electronic Packages and Semiconductors Devices*, p.410, New York, McGraw Hill, 1996.

From the Publisher: "...Reliability issues are a hot topic in the global electronics industry, and here at last is...the first book on this extremely important subject. Using empirical modeling, Di Giacomo expertly covers all major types of failure mechanisms that can greatly reduce the active life of semiconductor components... He also shows how to use statistical analysis to project failure rates. By cutting across different technologies and materials, this unique text will prove invaluable to engineers in the numerous fields that rely on semiconductor components... Written by one of the top experts in the field, this book offers you in-depth coverage of empirical modeling for a wide range of failure mechanisms, including interconnection fatigue, solder creep, electromigration, thermomigration, current leakage, and more...This complete reference also takes you through early fails, wearout fails, types of fail distributions, failure mechanisms and modeling, and failure rate projection based on statistical analysis. With the help of this unique sourcebook, you'll be able to use reliability not only as a statistical tool, but also as a design and development resource for greatly improving all kinds of electronic packages and semiconductor devices."

Di Giacomo G. 1992 "Electrochemical Migration" Chapter 6, pp.255-292, *Electrochemistry of Semiconductors and Electronics*, ed. John McHardy and Frank Ludwig, Noyes Publications.

Editors' Comments: "As conductors become finer and more closely spaced, the incidence of electrochemical migration phenomena become increasingly critical. In Chapter 6, G. Di Giacomo reviews the principles underlying these phenomena. Understanding gained from this review will provide a basis for controlling and avoiding migration-related failures in future circuit designs."

Di Giacomo G. 1999 "Design for Microelectronics Reliability" Vol. 5, pp.186-208, *Wiley Encyclopedia of Electrical and Electronics Engineering (EEEE)*, 24 volumes, ed. John G. Webster, Wiley Interscience Publications. *(A detailed scientific analysis by Universities and Industry worldwide on 20th century technologies).*

Di Giacomo G. 1993."Reliability/Defect Severity." Chapter 18, pp.536-580, *Microelectronics Manufacturing Diagnostic Handbook,* ed. A. Landsberg, New York: Van Nostrand Reinold, New York

Di Giacomo, G. et al. 2001 "Reliability of Die-Level Interconnections." Ch.13, pp.500-548, *Area Array Interconnections Handbook*; ed. K. Puttlitz and P. A. Totta, Kluwer Academic Publishers;

Di Giacomo G. et al. 2001 "Board-Level Array Interconnect Reliability." Ch. 22, pp. 882-945, *Area Array Interconnections Handbook*; ed. K.Puttlitz and P. A. Totta, Kluwer Academic Publishers.

Papers Publications (Partial list: 30 papers out of 55)

Di Giacomo, G. et al. "Reliability of Flip Chip Applications with Ceramic and Organic Chip Carriers." *13th European Symp. Reliability of Electron Devices, Failure Physics and Analysys,* Rimini, Italy, 2002.

Di Giacomo, G. et al. "Generic Fatigue Model for C4, CBGA, CCGA, and PBGA Interconnects at Package Structure Level."International System Packaging Symposium , San Diego, pp.156-162, 1999.

Di Giacomo, G. et al. "Fatigue Reliability of Solder Interconnects for First and Second Level Packaging." Proc. Int. Electronics Manufacturing Technol. Symp." Austin, TX, 1998

Di Giacomo, G. "Thermal Cycle Frequency-Threshold Below Which Solder-Joint Fatigue Damage Saturates as Stresses Relax." *Proc. Int. Packging Symp. (IMAPS)*, San Diego, pp. 203-208, 1997.

Di Giacomo, G. "Effect of Mini-Cycles on the Solder Joint Fatigue Behavior as a Result of Their Superimposition on Main Cycles." *Proc. ISHM*, Minneapolis, pp.302-307, 1996.

Di Giacomo, G., "Modeling the Effect of Oxygen on the Fatigue Lifetime of Solder Joints", *Int. Reliability Phys. Proc*., Las Vegas, pp.93-96, 1995.

Di Giacomo, G. "Modeling Solder Joint Cyclic Creep." *Proc. 1994 Int. Electronics Packaging Conf.,* Atlanta, pp.748-758, 1994.

Di Giacomo, G. , "Thermal Diffusion Model Describing Transient Strain in Chip Solder Joints Under Thermal Cycling." *Proc. Int. Symp. Microelectronics,* Reston, VA, pp.737-742, 1992.

Di Giacomo, G. et al. "Current Leakage Kinetics across Cr/Cu Thin Film Conductors Having Polyimide Coating." *Proc. Int. Symp. Microelectronics,* pp.38-42, 1991.

Di Giacomo, G. "Thermomechanical Fatigue Damage Limit in Solders Due to Their Anelasticity." *Proc. ISHM First Joint Materials and Interconnect/Surface Mount Technol. Conf.,* San Diego, 1990.

Di Giacomo, G. "Effect of Oxidation on the Thermal Performance of Metals and Modeling." *Proceedings of Technical Program, Nepcon East '89*, pp.159-167, 1989.

Di Giacomo, G. "Oxidation of Pb-Sn Eutectic Solder and Degradation of Contact Thermal Resistance." *Proc. Int. Symp. Microelectronics*, Atlanta, pp.322-327, 1986.

Di Giacomo, G. "Oxidation Kinetics of Pb-Sn Eutectic Solder by AES Analysis." *Microbeam Analysis*, pp.321-324, 1986.

Di Giacomo, G. "Current Leakage Kinetics across Tinned Cr/Cu Lands Having Epoxy Overlay." *IEEE Trans. Components , Hybrids, and Manuf. Technol*., Vol.CHMT8, No.4, pp.440-445, 1985.

Di Giacomo, G . "Phosphorous Migration Kinetics from PSG to Glass passivation Surface." *22nd Ann. Proc. Reliability Phys*., pp.223-228, 1984.

Di Giacomo, G. "Metal Migration (Ag, Cu, Pb) in Encapsulated Modules and Time-to-Failure Model as a Function of the Environment and Package Properties."*Proc. Reliabilty Phys Symp*., pp.27-33, 1982.

Di Giacomo, G. "Reaction Kinetics of Al Films with Phosphosilicate Glass (PSG) in Semiconductors." *Proc. Intern. Reliability Phys. Symposium,* pp.218-222, 1981.

Di Giacomo, G. "Corrosion Model for Plastic Encapsulated and Hermetic Modules." *18th Ann. Proc. Reliability Phys.,* pp.275-281, 1980.

Di Giacomo, G. "Electromigration Depletion in Pb-Sn Films." *Proceedings Reliability Physics Symposium,* San Francisco, pp.72-76, 1979.

Di Giacomo, G. et al. "A Method for Determining The Permeability and Solubility of Sulfur in Poly(dimethylsiloxane) (RTV)." *Journal of Applied Polymer Science,* Vol.23, pp.261-274, 1979.

Di Giacomo, G. et al. "Electromigration Damage in Aluminum-Copper Films." *Thin Solid Films,* Elsevier Sequoia, S.A., Lausanne, Vol.34, pp.165-169, 1976. (Also presented at a symposium in Hungary, 1975)

Di Giacomo, G. "Microprobe Technique for Determining the Thickness of SiO2 and Si3N4 Ultra-Thin Film Composites of FET Wafers and Devices."*Thin Solid Films,* Elsavier Sequoia, S.A., Lusanne, Vol. 38, pp.35-47, 1976.

Di Giacomo, G. "Microprobe Technique for Determining the Thickness of Thin Metal Films in Multilayered Structures." *Thin Solid Films*, Vol.26, pp.311-320, 1975.

Di Giacomo, G. "Microprobe Technique for determining the Thickness of Ag2S Films as a Function of sulfur Vapor Pressure at Saturation an below." *Proc. 10 Ann. Conf. Microbeam Analysis Soc.*, Las Vegas, pp.125-129, 1975.

Di Giacomo, G. et al. "Diffusion Coefficient and Electromigration Velocity of Cu in Thin Silver Films." *Journal of Applied Physics*, Vol.45, No.4, pp.1626-1629, 1974.

Di Giacomo, G. "Microprobe Technique for Determination of Thickness and Phosphorous Concentration of Gate Oxide PSG in FET Devices." *Electrochemical Society*, Vol. 21, No.3, pp.119-122, 1974.

Di Giacomo, G. "An Ultrasonic Method for Measuring Crack Depth in Structural Weldments." *Materials Evaluation, J. American Soc. for Nondestructive Testing ,* pp.189-194, September 1970.

Di Giacomo, G. et al. "Development of an Ultrasonic Method for Determination of Grain Size in Cast Steel." *Materials Evaluation, J. American Soc. for Nondestructive Testing ,* pp.271-276, Dec.!970

Di Giacomo, G. "Residual Stresses in High-Strength Steel Weldments and Their Dimensional Stability During Welding and Stress Relieving." *Mat. Science and Engineering - Elsevier Sequoia S.A.,Lausanne,* pp.133-145, 1969.

Di Giacomo, G. Et al. "X-Ray Diffraction Studies on Selected Bacterial Cell Walls." *Journal of Bacteriology,* pp.122-124, Jan.1967.

Internal Publications

Published internally, within IBM, well over 100 formalTechnical Reports (TR type) usually *confidential* dealing with the development of the technologies at hand and part of the IBM library accessible to those who have a need to know.

IBM Patents

Received 20 patents grouped in 5 categories which mainly consist of developing :

Electron microbeam and X-ray diffraction analysis techniques for *corrosion / metal migration* of chip and substrate circuitry.

Thin film conductors resistant to *electromigration, electrochemical/Galvanic corrosion, and metal migration*.

Solders interconnections more resistant to *thermomechanical fatigue, electromigration, and thermomigration.*

Thick film alloy structures for substrates/packages metalization resistant primarily to *corrosion and metal migration*.

Metallurgy for thermal conductivity optimization in *thermal management* of large high-power modules.

Other Inventions

Additional 59 inventions (not patented) published in the IBM Technical Disclosure Bulletin.

Teaching

Taught courses in Electron Microprobe Analysis, X-ray Diffraction and Crystallography, and Reliability Physics through the IBM Engineering Education Program.