PROCEEDINGS of the 1986 INTERNATIONAL SYMPOSIUM ON MICROELECTRONICS

PROCEEDINGS of the 1986 INTERNATIONAL SYMPOSIUM ON MICROELECTRONICS

OCTOBER 6-8, 1986
GEORGIA WORLD CONGRESS CENTER
ATLANTA, GEORGIA

SPONSORED BY THE INTERNATIONAL SOCIETY
FOR HYBRID MICROELECTRONICS

Edited and Assembled
by the
1986 Technical Program Committee
and the
Society Staff

ISBN 0-930815-16-5

International Society for Hybrid Microelectronics
P.O. Box 2698
Reston, Virginia 22090
(703) 471-0066

Introduction to the 1986 International Microelectronics Symposium

The theme for this year's symposium "The Ever Expanding World of Hybrid Microelectronics" is certainly exemplified by the technical spectrum covered by this year's papers. Every effort has been made by the Selection Committee to ensure that the papers disclose new information to supplement existing technology.

The international character of this symposium has been retained with papers from Asia, Japan, Europe and Canada.

In sheer numbers (though this was not the only goal) this symposium sets a record with 140 papers spread over 18 sessions and three full days, and that is not counting the tutorials and short courses—all of which have been updated with reference to course content. The SMT short courses have been biased toward the reliability aspects of that technology.

The sessions on Automated Assembly/Inspection and Manufacturing/Operations present a response to the often repeated criticism that we have become a nation of inventors that cannot successfully convert such inventions into products.

Doug Bokil
Technical Program Chairman

1986 SYMPOSIUM COMMITTEE

General Chair	Ron Overko, Analogic Corporation, Wakefield, MA
Technical Program Chair	Doug Bokil, Analog Devices, Wilmington, MA
Technical Program Vice-Chair	Tim LeClair, Analog Devices, Wilmington, MA
General Arrangements Chair	Don Levine, Cerprobe Corp., Winthrop, MA
Exhibits Chair	Scott Wallgren, Teradyne, Boston, MA
Registration Chair	Alvin Neller, DuPont/EMD, Hampton, NH
Finance/Budget Chair	Willard Flagg, Sylvania, Topsfield, MA
Publicity Chair	Gladys M. Gittings, Technical Instruments, Inc., Wilmington, MA
Spouse Program Chair	Debbie Levine, Facilities Systems, Inc., Winthrop, MA

INTERNATIONAL SOCIETY FOR HYBRID MICROELECTRONICS

The International Society for Hybrid Microelectronics (ISHM) is a non-profit technical society dedicated to the advancement of microelectronics. The Society's prime objectives are to provide a forum for the dissemination of knowledge within the field of microelectronics, and to serve as a common denominator for the diverse engineering disciplines on which microelectronics is based.

ISHM encourages the exchange of information among the complementary technologies of ceramics, thin- and thick-films, semiconductor packaging, discrete semiconductor devices, and monolithic circuits. Microelectronics has developed into a distinct field of activities embracing materials, design, processing techniques and equipment, and fabrication and applications engineering. ISHM's technical meetings and publications reflect the full range of these engineering specialties.

The Society now has more than 70 chapters located throughout the United States, Western Europe, and the Far East. Its annual international symposia have been highly successful, due primarily to the excellence of their technical programs. ISHM has more than 7000 members in 24 countries throughout the world, an international headquarters to coordinate and manage its many comprehensive and diverse activities, a dynamic educational program for colleges and universities, and an active publications program.

Today, ISHM stands as a thriving and vigorous technical society, immensely proud of its distinguished reputation and totally committed to the service of its dedicated membership and the flourishing microelectronics industry.

1986 ISHM EXECUTIVE COUNCIL

President	James R. Keski, Ceramics Process Systems Corp., Cambridge, MA
President Elect	Paul F. Parks, Sr., P/M Industries, Inc., Portland, OR
Vice President	Gregory K. Caswell, Galaxy Microsystems, Inc. Cedar Park, TX
Technical Vice President	Manford H. Williamson, Boeing Aerospace, Seattle, WA
Secretary	Judith L. Resutek, DuPont, Irvine, CA
Treasurer	John A. Wagnon, EMCA, Dallas, TX
First Past President	Alan M. Hirschberg, Teledyne Microelectronics, Los Angeles, CA
Second Past President	John R. Thome, Motorola, Inc., Fort Worth, TX
Regional Directors	
Northeast	M. Don Levine, Cerprobe Corporation, Winthrop, MA
Mid-Atlantic	George G. Harman, National Bureau of Standards, Gaithersburg, MD
Southeast	Edward C. Wyatt, Honeywell, Inc., Clearwater, FL
North Central	John H. Wood, Heraeus-Cermalloy, Inc., Northfield, IL
South Central	Steve Stach, MCC, Austin, TX
Southern California	Glen R. Heidler, Hughes Aircraft Company, El Segundo, CA
Southwest	Julian A. Blankinship, DuPont, Scottsdale, AZ
Pacific Northwest	Terrence H. Courtney, Government Systems Corp., Mountainview, CA
*Executive Director	Walter H. Biddle, CAE, ISHM, Reston, VA
*Non-voting Member	
Division Chairs	
I/SMT Division	Michael Stein, ESL, King of Prussia, PA
Materials Division	Robert Jung, EMCA

Daniel C. Hughes, Jr., Memorial Award

Presented to
Rene E. Cote

For his total dedication to ISHM and his leadership in initiating and guiding the Society in its most innovative programs in education and publications, as well as his continuing leadership in thick film hybrid and material technology.

Corporate Recognition Award

Presented to
Electro Science Laboratories
(ESL)

In recognition of its achievements in the areas of thick film in microelectronics and displays and its continuing active support of the Society directly and through its employees by their participation in local and national offices and their many technical presentations.

Technical Achievement Award

Presented to
Gregory K. Caswell

For his untiring work in Surface Mount Technology.

David K. Flattery

For his untiring work in Infrared Sintering of thick film materials.

Technical Achievement Award

Presented to
Akira Ikegami

In recognition of his many contributions in microelectronic sensors.

Fellows of the Society

Robert E. Holmes
Dr. T. Kubota
Deitrich Riemer
John R. Thome
Gilbert C. Waite

ISHM ORGANIZATIONAL MEMBERS

(As of August 1, 1986)

***indicates ISHM '86 Exhibitor**

*A.I. Technology, Inc.
*A-B Lasers, Inc.
A-B Tool & Manufacturing
AAI Corporation
*Ablestik Laboratories
*Accumet Eng. Corporation
Accuprobe, Inc.
*Advance Reproductions Corp.
*Advanced Semiconductor Matl's
*Aegis Laser, Inc.
*Aegis Inc.
*Aerofeed
Aeroflex Labs, Inc.
*Affiliated Manufacturers, Inc.
*Air Prod. & Chemicals, Inc.
*Airpax/Cambridge Division
*Alcatel Vacuum Products
*Alessi Industries, Inc.
Algorex Corporation
*Allied Corporation
*Allied-Kelite Division
Aloha Associates
Alpha Industries
*Alpha Metals, Inc.
*American Etching & Mfg.
American Fine Wire Corp.
American Tech. Ceramics
*American Volpi Corporation
*Amicon Corporation
Amperex Electronic Corporation
Analytical Service Center
Andersen Labs, Inc.
Anrich Microscreens, Inc.
Applied Laser Systems
Aptek Microsystems, Inc.
*Arconium Specialty Alloys
*Aremco Products, Inc.
ASM America, Inc.
*ASPE, Inc.
Auburn Univ. Elec. Eng. Dept.
Automotive Controls
Avnet Tech. Group/Sertech Labs
*AVX Corporation
*Azimuth Electronics, Inc.
Ball Aerospace
*Balo Precision Parts, Inc.
*Balzers Optical Group
*Barnes Engineering Company
*Barry Industries
*Bausch & Lomb
*Beckman Industrial Corporation
BEI Microelectronics
*Benchmark Industries, Inc.
Betatron Inc.
Bishop Graphics, Inc.
*Blackstone Ultrasonics
*Boeing Company
*Brush Wellman
*BSI Industries, Inc.
*BTU Engineering
Buckbee/Mears Company
*Bullen Ultrasonics
*Burr-Brown Corporation
C H P S, Inc.
*C. W. Price Company
California Fine Wire Company
*California Micro Devices
Canon Communications, Inc.
*Carl Zeiss, Inc.
*Celmacs Corporation
*Ceramics Process Systems Corp.
*Cerprobe Corporation
Chamberlain Manufacturing Corp.
Chemart Company
*Chicago Laser Sys., Inc.
*Chip Supply, Inc.
*CIBA-Geigy Corporation
*Cincinnati Elects. Corporation
Circo Craft, Inc.
Circuit Tech, Inc.
*Circuits Processing Tech.
*Cobehn, Inc.
Coherent General
*Coilcraft, Inc.
*Comatel USA, Inc.
*Comco, Inc.
Comlinear Corporation
*Commonwealth Scientific
Composite Tech Alloys, Inc.
*Coors Ceramics
*Corning Glass/Electronics
*Corpane Industries, Inc.
*Crest Ultrasonics Corporation
Crockett Southwest Co., Inc.
*Crystal Mark, Inc.
*CTS Corporation/Halex Division
D. Brown Associates
*Dage Precision Industries
*Danam Industrial Company, Ltd.
Degussa Corp.-Hybrids Division
*deHaart, Inc.
Delco Elec. Division/GMC
Delvotec, Inc.
Device Closures Division
Dexter Hysol Electronic Chem
*Dicing Technology, Inc.
*Die-Tech, Inc.
*Disco Abrasives Sys., Inc.
Ditronix, Inc.
Dow Corning Corporation
Dunegan Corporation
*Dupont/Berg Electronics
*Dyna/Pert
Dynacircuits, Inc.
Dynapert-HTC
*E.I. Dupont DeNemours
*E. Leitz, Inc.
East Coast Sales Co., Inc.
Eastern Smelt. & Refin. Corp.
Eastman Kodak/Apparatus Div.
Ebtec Corporation
*Edgetek Corporation
Edison Welding Institute
*EEV Inc.
*Electro Science Labs
*Electro Scientific Industries

Electro-Films, Inc.
Electromagnetic SC., Inc.
*Elmo Semiconductor
*EMCA/Furane
*Engelhard Corporation
Engelhard/Millis
*Engineered Technical Products
*Enthone, Inc.
Environmental Comm.
*Epoxy Technology
ESEC SA
*Excellon Automations
Factory Automation, Inc.
*Fancort Industries
*Federated Fry Metals, Inc.
Ferranti Electric, Inc.
*Ferro-ECA Electronics Company
Fineline, Inc.
*Fischer Technology, Inc.
*Florod Corporation
*Fox Tech. Laboratories
*FTS Systems, Inc.
*Fusion, Inc.
*GE Electric Cermics, Inc.
*General Ceramics
*Genrad, Inc.
Gordos Arkansas, Inc.
GTE Government Systems, Corp.
Gulton Industries
Gyrex Corporation
*Haake Buchler Instruments
*Halcyon Microelectronics
Handy & Harman
*Henry Mann, Inc.
*Heraeus Cermalloy
*Hermetite Corporation
Hewlett Packard Company
Hi-Rel Laboratories
Hi-Tech Phototool Division
HMH Design Group, Ltd.
*Hoechst Ceramtec N.A. Inc.
Honeywell Electro-Optics Div.
Honeywell-Marine Division
*Honeywell, Inc.
*Hughes Aircraft Company
*Hunt Chemical
Hy-Tec Industries
*Hybond, Inc.
*Hybrid Components
Hybrid Screens Inc.
*Hybrid Tech Group
*Hycomp, Inc.
*Hydrostatics, Inc.
*Hysol/Electronic Chemicals Div.
*Hytek Microsystems, Inc.
I. P. Sharp Assoc., Ltd.
IBM Corporation
Icon Corporation
Iden Industries, Inc.
*ILC Data Device Corporation
IMS, Inc.
Indus Corporation
Indy Electronics
*Infinite Graphics, Inc.
Insouth Microsystems, Inc.
Integrated Microcircuits
*Interamics
*Intergraph Corporation
*Intertest Corporation
*Intex International
*Ismeca U.S.A., Inc.
*Isotronics
J & J Materials, Inc.
J. T. Stimy, Inc.
*Johanson Dielectrics
John Fluke Mfg. Company, Inc.
*Johnson Matthey/Elec Matls Div
*Kazmierowicz Instrument Co
*Keller Technology Corporation
Kenix Industries, Inc.
Kester Solder Company
Ketri
*Kulicke & Soffa Industries
*Kyocera International, Inc.
L. Gordon Packaging
*Lake Publishing Corporation
Laser Services, Inc.
*Laser Tech
*Laserage Technology Group
Laserage Technology Group SE
Laserfab
*Lasermation, Inc.
*Lastec, Inc.
*Laurier Incorporated
Leach Corp/CTL Products Div.
*Leybold Heraeus Tech., Inc.
*LFE Corporation
LFG Micro
*Lindberg-Unit/Gen Signal
*Linkease Test Systems
Litton Advanced Circuitry
Litton Guidance & Control
Litton Systems, Canada, Ltd.
*Luxtron Corporation
*M&T Chemicals, Inc.
M-Tron Industries, Inc.
*Macdermid, Inc.
Machine Vision Int'l
Magnavox Electronics Systems
*March Instruments
Martin Marietta Aerospace
Masden Industries, Inc.
Mass. Bay Community College
*Massachusetts Components
Masters Design & Technical CTR
*Materials Research
MC Systems, Inc.
*Mech-el Industries, Inc.
Mepco Electra, Inc.
Metz Metallurgical
MIC Technology Corporation
MICRA Corporation
*Micro Auto.—Unit of Gen. Signal
Micro Component Techn.

Micro Contacts, Inc.
Micro Technology Corporation
Micro-Die Systems, Inc.
Micro-E Company
*Micro-Screen Prec. Products
*Microcircuit Engineering Corp.
Microelectronic Specialties
Micromech, Inc.
Micropac Industries
*Micropen, Inc.
Microtel, Limited
*Minco Tech. Labs, Inc.
*Mini Systems, Inc.
Monolithic Components
*Motorola Inc/Semicon Prod. Sec.
*Motorola, Inc.
*MPM Corporation
MSN Products, Ltd.
MTE Associates
*MTI Corporation
Mullen Equipment Company
*Multicore Solders
*Murata Erie North America
*NAS Electronics
*Natel Engineering Co., Inc.
National Micronetics
*NEC America, Inc.
NGK-Locke, Inc.
*Nicolet Instrument Corporation
Northern Telecom
*Novacap
*NTK Technical Ceramics
OCS
*Ohmtek, Inc.
*Oneida Research Services, Inc.
*Optical Associates
*Optical Radiation Corporation
Optometric, Inc.
Orbot Systems, Ltd.
*Oriel Corporation
*Orthodyne Electronics
*P/M Industries, Inc.
PAC, Inc.
Pacific Hybrid Microelec.
*Paine Instruments, Inc.
Parts Technology, Inc.
*Perkin-Elmer Corporation
*PGP Industries, Inc.
*Photo Research Vision Systems
Photo Sciences, Inc.
Photofab Tech, Inc.
*Photofabrication Eng., Inc.
Photometrics, Inc.
*Photon Sources, Inc.
*Photonic Automation, Inc.
*Piconics, Inc.
Platina Laboratories
*Polaris Electronics Corp.
*Presidio Comp., Inc.
Probe-Rite, Inc.
*Probotech
Pulse Engineering
Quad Systems Corporation
R G B Northwest
*Radiant Technology Corporation
Raydx Satellite Systems, Ltd.
*Raytheon Company
Raytheon Company/Laser Center
*Reeves-Hoffman Division
*Remex Corporation
*Research Devices/Amer. Optical
Research, Inc.
Reverse Electrofilm Corp.
*RFE Industries, Inc.
Rockwell International
S & W Enterprises
San Fernando Elec. Mfg.
*Saxonburg Ceramics, Inc.
*Schott Electronics
Scientific Calculations
*Scientific Sealing Tech
*SCM Metal Products
Scrantom Engineering, Inc.
Seakr Engineering, Inc.
Sealweld Industries, Inc.
Secon Metals Corporation
Secrest Willowbrook
*Seiko Instruments USA, Inc.
*Semi Dice, Inc.
*Semiconductor Equipt. Corp.
Sermed, Inc.
*Shigma, Inc.
*Shoei Chemical, Inc.
Siemens Components, Inc.
Signatone
*Sikama International
*Site Magazine
*Sloan Technology Corporation
*Small Precision Tools
*Solid State Equip. Corporation
*Solid State Testing, Inc.
*Solitron Devices
*Sonic Mill Albuquerque
*Sonoscan, Inc.
Sparton Corporation
Spec Industries, Inc.
Spectrum Ceramics, Inc.
Sperry Corporation
*Sprague Electric Company
Stanley-Vidmar, Inc.
*State of the Art, Inc.
*Statek Corporation
Stettner Electronics, Inc.
Summit Corporation of America
Sundstrand Data Control
Super Linear-Weld Elec. Co.
*Superwave Technology, Inc.
*Synthetic Vision Systems
Taiyo Yuden (USA), Inc.
*Tam Ceramics, Inc.
Tamarack Scientific Company
*Techni-Quip Corporation
Technology Glass Corporation
Tektrel Semiconductors

*Tektronix, Inc.
Teledyne Microelectronics
*Teledyne Tac
*Temptronic Corporation
*Tencor Instruments
*Teradyne, Inc.
Terra Universal, Inc.
*Testamatic Corporation
Tetko, Inc.
*Texas Instruments
Texas Optoelectronics, Inc.
Texel Components Corporation
*The Indium Corporation Amer.
The Jade Corporation
*Thermoset Plastics, Inc.
*Thick Films Systems/Ferro Corp.
*Thin Film Technology, Inc.
Tong Hsing Electronics
Tracor, Inc.
*Trebor Instrument Corporation
Turbo Braze Corporation
*U S Hybrid Supply, Inc.
*Ultronix, Inc.
*Ungar Div. Eldon Industries
*Union Carbide Corporation
Unitrode Corporation
*Universal Instrument Corp.
UTHE Technology Corporation
UTI Instruments Company
*UTZ Engineeering, Inc.
UVOCS, Inc.
Valley Design Corporation
Ventronics, Inc.
Via Systems, Inc.
Vichem Corporation
*Villa Precision, Inc.
*Viox Corporation
Vision Engineering, Inc.
Vitarel, Inc.
*Vitramon, Inc.
*Vitronics Corporation
Watkins-Johnson Company
Weatherman Associates, Inc.
*Weltek International, Inc.
*Wentworth Labs
*West-Bond, Inc.
Western Electric
Westrep
*Williams Gold Refining Company
*Xeram
*XMR, Inc.
*Xynetics Corporation
Yield Engineering Systems
Zenith Microcircuits Corp.
Zeva Electric Corporation
*Zevatech, Inc.
Zuken America
*3M Electronic Product Division
*3M-Commercial Chemicals

TABLE OF CONTENTS

Poster Session—Reliability and Failure Analysis
Chairman: Larry Burton, VPI
Vice Chairman: Raymond Peluso, Amplica

Interconnection Technology
Chairman: Peter Moy, Digital Equipment
Vice Chairman: Walter Trybula, General Electric

Soldering Technology
Chairman: Norman Cox, Research Inc.
Vice Chairman: Donald Hamer, State of the Art

Reliability and Failure Analysis
Chairman: Dr. Thomas Hitch, RCA
Vice Chairman: Daniel Epstein, ILC Data Devices

Multilayer Technology
Chairman: Subash Khadpe, Khadpe Technology
Vice Chairman: Bob Jung, EMCA

Thin Film Technology
Chairman: Jean Madden, Electro Films, Inc.
Vice Chairman: Dietrich Riemer, Honeywell

511 **High and Low Sheet Resistance Processing for Simultaneous Integration of Thin Film Resistors on the Same Substrate** by **G. P. Ferraris** and **A. Tersalvi**, GTE Telecomunicazioni S.P.A.

519 **Multilayer Thin-Film Technology** by **Karl-Peter Ackermann** and **Rolf Hug**, Brown Boveri & Cie, Inc.

525 **"State-of-the-Art" Third Generation Thin Metal Resistive Films** by **P. R. Simon**, Sfernice Group and **Jerry Krebill**, Ultronix, Inc.

529 **A Practical Diffusion Barrier for Limiting Nickel Silicide Intermetallic Formation of Gold-Silicon Attached Die on Thin Film Modules** by **J. J. Borzych**, **D. A. Granitz** and **R. A. Salisbury**, CTS Corp.

Manufacturing/Operations
Chairman: John Farrell, RADC
Vice Chairman: Robert Allen, Amperex

537 **Bare Chip Semiconductor Procurement System** by **Alan J. Simon** and **Gordon L. Bailey**, Westinghouse Electric Corp.

541 **Versatile Manufacturing with Automated Inventory Management and Material Handling** by **R. M. Bain** and **J. G. Harper**, VEECO Integrated Automation, Inc.

547 **Cash Budget Your Way to Success** by **Paul F. Parks, Sr., P/M Industries, Inc.**

557 **A System to Monitor Source Inspection In Receiving Inspection** by **Bonnie J. Spencer**, Teledyne Microelectronics

562 **The Custom Hybrid Microcircuit Qualified Manufactures List and the Procurement Process** by **Christopher T. Shillito**, Defense Elec. Supply Ctr., **John P. Farrell**, Rome Air Development Center, and **James E. Blanton**, Defense Electronics Supply Ctr.

Poster Session—Thick Film
Chairman: Kinzy Jones, Florida International University
Vice Chairman: Dr. Roy Propst, UNC

572 **Ultrasonic Impact Grinding** by **David O. Moore**, Bullen Ultrasonics, Inc.

576 **High Resolution Thick Film Printing** by **Rudolph J. Bacher, E.I. DuPont DeNemours & Co., Inc.**

582 **Screen Printing—An Integrated System** by **Douglas O. Brown**, 3M

591 **Microelectronics Process Technician "A Course Outline"** by **James A. Angeloni**, NATEL Engineering, **Robert B. Tholl, Ph.D. Ventura College**

594 **Examination of the Effect of Firing Technique on Thick Film Resistor Properties** by **Ray Freeman**, Beckman Industrial

599 **Thick Film Leadless Chip Resistor Networks Prepared with an Orifice Writing System** by **Franklyn M. Collins, John Ott** and **Michael Vertino**, Ohmtek, Inc. and **Alan Drumheller**, Micropen, Inc.

604 **A Model for Deposition of Thick Films by the Screen Printing Technique** by **H. Rangchi, B. Huner** and **P. K. Ajmera**, Louisiana State Univ.

Poster Session—Polymer Epoxy
Chairman: Samuel Goldfarb
Vice Chairman: John Tower, RCA

610 **Advanced Polymer Materials and New Manufacturing Methods to Create High Density Circuits for Microelectronics** by **Ken Russell**, MINICO/ASAI America, **Art Kabe**, ASHI Chemical Research Japan

617 **Ultraviolet Curing: A New Path to Productivity** by **Steven Schick**, UVEXS, Inc.

CONDUCTIVE ADHESIVES
Chairman: Ronald Hunadi, Furane Products
Vice Chairman: Joe Vacarro, Furane Products

621 **A Reworkable High Reliability Thermoplastic Die Attach Adhesive** by **Lincoln Ying**, M&T Chemicals Inc.

632 **Comparison of Microwave Assisted and Conventional Epozy/Polyimide Curing** by **Prasad V. Nevrekar** and **Narges Zahedi**, Superwave Technology, Inc.

642 **Adhesive For Microelectronics MIL-A-87172 & Beyond** by **Richard H. Estes**, Epoxy Technology, Inc.

657 ***Measurement and Significance of Extractable Ionic Impurities From Cured Epoxy Adhesives*** by **J. C. Bolger, M. W. Peterson** and **C. H. Ketley**, Amicon Corp.

665 **Adhesion Mechanisms in Silver/Glass Die Attachment of Gold Backed Die** by **Nigel M. Davey**, Johnson Matthey Technology Centre, **Frederick W. Wiese, Jr.**, Johnson Matthey Material Tec

Polymer Technology
Chairman: Richard Estes, Epotech
Vice Chairman: Cornelius Huang, ESL

675 **Bonding of High Frequency Stripline Assemblies** by **Doris A. McGee**, Litton Systems

691 **Improved Adhesion in a UV Curable Dielectric For Membrane Touch Switches and Flexible Circuitry** by **Christina N. Lazaridis**, E. I. DuPont DeNemours

702 **New Polyimide System For Multilayering** by **Pascaline H. Nguyen** and **Frank R. Russo**, Engelhard Corp.

707 **Glob Top Material Selection For Flip Chip Devices** by **T. Gabrykewioz, K. Sengupta, T. Thuruthumaly** and **L. Frazee**, Micro Switch

714 **Passivation For Microelectronic Packages** by **Ramaswamy Padmanabhan**, Motorola, Inc.

Advanced Packaging
Chairman: David Hallowell, Digital Equipment
Vice Chairman: Dennis Kling, Harris

722 **Interconnection Design Considerations for VLSI Multichip Packaging** by **E. T. Lewis**

730 **Measurements of Key Electrical Parameters For High Module Application** by **Leonard T. Olson** and **Richard K. Sloma**, IBM Corp.

741 **Co-Fired Metallized Ceramic Technology and Fabrication Using Electoless Plating** by **Beth Anne Hassler**, Medtrinic, Inc.

749 **A New Hybrid Technology: High Density Thin Film Copper/Polyimide Multilayer System** by **D. Kompelien**, and **T. J. Moravec**, Honeywell Physical Sciences Center, and **M. Deflumere**, Honeywell Electro-Optics Division

758 **Planar Hybrid Interconnection Technology** by **R. Wayne Johnson, Michael Johnson, Jimmy L. Davidson**, and **Richard C. Jaeger**, Auburn Univ.

766 **Electrical Characterization and Design of Multilayer Thick Film Circuit Boards for High Speed Digital Applications** by **Guy Clatterbaugh** and **Harry K. Charles, Jr.**, Johns Hopkins Univ

CAD/CAM
Chairman: Walter Trybula, General Electric
Vice Chairman: Peter Moy, Digital Equipment Corporation

775 **Evaluation of a CAD/CAM System for Direct Writing of Thick Film Conductors, Resistors and Capacitors** by **Deepak Nayak** and **Lih-Tyng Hwang**, Microelectronics Center of NC and **Arnold Reisman**, NC State Univ.

784 **A Data Management Model for Tracking and Control of the Computer Aided Design Process** by **William S. Johnson**, Sherpa Corp.

THICK FILM TECHNOLOGY
Chairman: Philip Creter, GTE Government Systems
Vice Chairman: Dr. Charles Chen, Univ. of S. Florida

Copper Technology
Chairman: Robert Jung, EMCA/Furane
Vice Chairman: Subash Khadpe, Khadpe Technology

Poster Session—Hybrid Interconnections
Chairman: Samuel Goldfarb
Vice Chairman: John Tower, RCA

List of Authors

IN-LINE MACHINE VISION INSPECTION AND CONTROL OF THICK-FILM PRINTING

by

Richard A. Walker, Gary E. Frame and D. Alan Fridge
Photo Research -- Vision Systems
A Division of Kollmorgen Corporation
Burbank, California 91504

Abstract

The requirements and use of machine vision systems for verification and process control of thick-film printing are discussed. A new in-line machine vision inspection system, which can inspect the printing and feed back process control information to the printer, is described. Two material handling systems are also described -- a "fixed automation" system and a "flexible automation" industrial robot; the robotic approach appears to have the greatest potential.

1.0 INTRODUCTION

1.1 Optical Inspection in Hybrid Circuit Manufacture

The first stage of hybrid circuit manufacture involves the use of thick-film and/or thin-film fabrication processes to print an electrical circuit pattern on a ceramic substrate[1]. These circuits typically require multilayer printing, often involving as many as 6 to 20 consecutive printing operations to make a finished substrate.

Since these multilayer circuits can not be tested electrically until most or all of the circuit layers have been printed, optical inspection is used to verify proper printing of lower-layer circuitry before the upper layers are superimposed. This procedure has a significant advantage because it allows defects to be detected -- and repaired if possible -- before the added expense of the many top layers is added to the substrate, which would then have to be scrapped at final electrical test (when it is too late to repair the defective lower layers).

If electrical testing is not done, or is not feasible until all the circuit devices are added, even greater waste will result by attaching circuit devices to a substrate which has a printing defect in a non-repairable lower layer.

Finally, optical inspection can detect potential or incipient defects that can not be found by ordinary electrical testing. Such defects as near-shorts and partial opens may pass initial electrical test, but fail in the field when "real-world" high current or voltage surges are introduced into the circuit!

1.2 Why Machine Vision?

Human visual inspection has certain advantages over machine vision systems, such as the ability to view objects with greater understanding. However, the advantages of traditional human optical inspection techniques are far outweighed by the disadvantages. Everything that is inspected by a human being is subjected to the individual's mental processes. This is where such strictly human qualities, such as fatigue and lapses in concentration, will affect the inspection decision (pass or fail).

Several objective studies in production situations have shown that, over the long term, human operators will miss from 10% to 40% of all circuit defects! This makes reliable quality control nearly impossible in real-world production situations!

With increasingly faster production lines and the introduction of denser, more complex circuits, the inadequacies of human visual inspection techniques becomes more serious. Today's quality and production speed requirements demand more sophisticated inspection methods. Automatic optical inspection techniques can meet these needs while offering many important benefits to hybrid manufacturers -- such as increased throughput, inspection reliability and consistency[2].

1.3 Why In-Line Inspection?

Having determined the superiority of machine vision for inspecting hybrid circuitry during the substrate printing cycle, the next issue to be addressed is whether to utilize machine vision in an in-line or off-line capacity. Machine vision systems can be used effectively in either mode. However, there are significant benefits to employing such a system in-line as opposed to off-line. Generally, in-line inspection systems offer greater reliability and allow for more effective process control. Circuitry defects can occur at any time and for many different reasons; in-line inspection enables the manufacturer to detect defects early. This eliminates the cost of printing thousands of copies of a defective circuit.