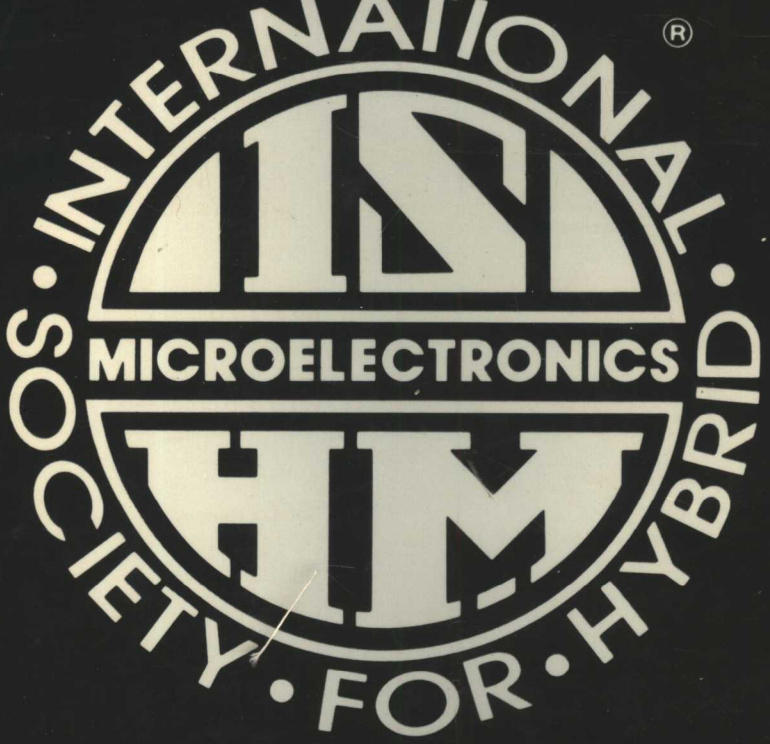

CHICAGO, ILLINOIS

1990 PROCEEDINGS INTERNATIONAL SYMPOSIUM ON MICROELECTRONICS

PROCEEDINGS of the 1990 INTERNATIONAL SYMPOSIUM ON MICROELECTRONICS

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FOR HYBRID MICROELECTRONICS

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by the
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and the
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Introduction to the 1990 International Symposium on Microelectronics

Welcome to Chicago, The Windy City and home to ISHM 1990. The theme chosen by the Symposium Committee is the "Winds of Change In Microelectronics." This year's symposium ushers in the 90's, a time that promises to bring tremendous change to our industry. These *Proceedings* represent the latest work from 118 of the finest research, development, and engineering groups in our field. The information presented here will be of value to newcomers to the industry as well as the "hardened" veterans. In keeping with industry trends, this volume presents the information found in twenty-five technical sessions concerned with surface mount technology, multichip modules, TAB, materials, analysis and reliability, processing, and applications of hybrid circuits.

The Technical Program Committee has spent countless hours trying to ensure the best possible symposium and written technical *Proceedings*. The Technical Session Chairs have reviewed each manuscript for appropriateness and technical content prior to publication. I would particularly like to thank Harry K. Charles, Jr., Ph.D., Richard Gehman, Thomas Luin, Mark Naretto, and Bernie S. Aronson for their willingness to review the abstracts and final manuscripts prior to publication. A special thanks must go to the people at ISHM headquarters, the people who work behind the scenes and whose efforts have made these *Proceedings* possible. I would also like to thank Loren Saar, Symposium General Chair, for allowing me to serve ISHM.

Alan P. Genis, Ph.D.
Technical Program Chair

Important ISHM '91 Dates

Date	Activity
January 18-20	Executive Council Meeting Hyatt Reston, Reston, VA
January 30-2/1	ATW—Advanced Placement Technology Sedona, AZ
February 15	ISHM '91—Abstracts Due
April 8-9	JTC '91—Materials and SMT Symposium
April 15	ISHM '91 Exhibit Space Deadline
April 18-21	Leadership Conference & Executive Council Mtg Hyatt Reston, Reston, VA
May 1-3	ATW—EC '92 Washington, DC area
May 29-31	IMC—Rotterdam, Netherlands
June 15	ISHM '91 Papers Due for Proceedings
June 19-21	ATW—Multichip Modules II Coastal Maine
July 20-22	Executive Council Meeting Hyatt Reston, Reston, VA
September 19	ISHM '91—Registration and Housing Cut-off
October 21-23	ISHM '91 Orlando Convention Center, Orlando, FL

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The International Society for Hybrid Microelectronics (ISHM) is a not-for-profit professional society, dedicated to the advancement of hybrid 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 upon which the microelectronics industry is based.

ISHM encourages the exchange of information among the complementary technologies of ceramics, thin and thick films, semiconductor devices, and monolithic circuits into a distinct field of activities embracing materials, design, processing techniques, equipment, fabrication, and application engineering.

The Society is composed of almost 7,000 individual members in over 60 regular and student chapters in the United States and Canada. Our nearly 600 organizational members worldwide supplement the Society's technical strength.

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For his significant technical contributions to ISHM in the field of thick film materials technology and his untiring efforts as National Treasurer and Executive Council member to advance the technical and administrative programs of the Society.

Corporate Recognition Award

Presented to
Teledyne Microelectronics

In recognition of its achievements in the development and manufacture of hybrid microelectronic circuits and support of ISHM by its employee participation in technical symposia, local and national offices.

Technical Achievement Award

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For his work in the field of thick film resistor wafers, liquid crystal displays, and the design and development of new hand held electronic calculators and hybrid packaging technologies, in addition, his many technical presentations and publications.

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EVOLUTION OF THE MICROELECTRONIC INDUSTRY

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ABSTRACT

Microelectronics were developed to solve specific problems. This has become a key factor in the evolution of the industry. Problems of space, weight reliability, power, thermal management, and manufacturing had to be solved. The industry throughout the years has worked with the systems designers to provide the products that were needed to solve important issues. Four elements have contributed to the evolution of microelectronics: materials, processes, equipment, and design requirements.

Documentation of the evolution of microelectronics is scattered throughout literature. The ISHM Symposium proceedings is one of the valuable sources of the industries evolution. Roger Cadenhead and Donald DeCoursey initiated a series of articles on the History of Microelectronics. Part one of the series has been published in the ISHM Journal of September 1985.

DISCUSSION

The microelectronic industry had its beginnings during World War II. There was a need for smaller electronic circuits as part of proximity fuses. It took almost a decade for the industry to develop into a viable force in the electronic industry.

To simplify the discussion of the evolution in microelectronics, I have chosen to divide the evolutionary process into decades beginning with 1940.

The decade 1940-1949.

This is the decade of developing the first hybrid microelectronic circuits. The substrates were steatite. The materials and equipment used to make the first hybrids were crude by today's standards. Conductors were made of silver oxide that, when fired, reduced to silver. Resistors were formulated using carbon and organic binders. Carbon resistors could be trimmed using a rubber eraser to remove material after it was cured.

The developers of these early products considered their materials and processes to be proprietary. Thus there was no interchange of information within the industry. This attitude of keeping technology a closely guarded secret continued until the late 1960's.

The decade 1950-1959

This was a decade that created many of the fundamental technologies that became the basis of the microelectronic industry.

Circuits etched into copper laminated onto a variety of substrate materials provided improved reliability and the ability to mass produce electrical circuits. This was the beginning of the printed circuit board industry as we know it today.

Discrete semiconductors, diodes and transistors were another key development during this decade. The semiconductor devices promised to reduce power requirements as well as save space in electronic circuits. All of these devices were provided as packaged components. Hybrids and printed circuit boards were able to take advantage of these devices. These were the fore-runner of the integrated circuits that are so vital to electronics today.

Thin film circuits on glass, quartz, alumina, and glazed alumina were developed. Thin films were primarily used as resistor networks to provide improved stability and lower temperature coefficient of resistance. Since these circuits were processed using the photolythographic techniques developed for semiconductors, these circuits were considerably smaller than their thick film counterparts. However, they were limited in sheet resistance value by the materials available at the time. Most resistors were nickel-chromium alloys deposited by evaporation.

The ruthenium based thick film resistor compositions were developed during this decade. This development is the backbone of the thick film resistor materials still used today.

Tape cast 96% alumina substrates became available late in this decade. Because tape casting provided a more consistent and less expensive substrate, it became the standard process for providing thick film substrates. Tape casting proved to be the basis for many technologies still in use today.

The decade 1960 - 1969

The 1960's saw the rapid expansion in the use of hybrids. Hybrid engineers visualized hybrids replacing printed circuit boards within a short time. Thick and thin film engineers developed a strong competitive attitude toward the other technology. This attitude prevailed throughout the decade. There was a strong feeling within companies that their processes were proprietary and they had a leading edge over their competitors.

The military and space programs started to demand smaller, more complex circuits that used less power with improved reliability. Reliability studies demonstrated that a major cause of system failures was due to interconnections - solder joints, sockets, and wire bonds.

The military made an effort at standardizing on hybrid size, shape, and format. The initial effort at standardization became known as the RCA module. The module was made up of 0.3 inch square substrates with notches in all four sides. Each substrate contained a portion of the circuit. The substrates were stack assembled and spaced with vertical wires being soldered into the notches forming a module that was 0.3 inches square and could be of most any height. This technology met with very limited success. Manufacturers did not want to accept the idea of a competitor.

Thick film material development continued with the availability of new conductor, dielectric and resistor materials. Ruthenium based resistor compositions became commercially available.

With the new thick film resistor materials a change in the trimming method was required. Abrasive trimming was introduced and rapidly became the prevalent technique for adjusting resistors.

Thin film advancements included the introduction of tantalum nitride resistors. Tantalum nitride was formed by sputtering tantalum in a partial pressure of nitrogen. Western Electric was a dominant force in developing tantalum nitride for thin film hybrids. Western Electric developed equipment for the continuous sputter deposition of tantalum nitride and licensed the process to a number of companies. At the same time a larger size substrate 3.75 X 4.5 X 0.025 inches became available from several ceramic suppliers. This larger substrate was tape cast using 99.5% alumina.

Assembly of hybrids consisted of soldering packaged transistors and diodes to the thick or thin film substrates. Capacitors, inductors and other components were off-the-shelf leaded components that were also joined to the substrate by soldering.

The integrated circuit was introduced in this decade. Some IC engineers predicted that their devices would replace hybrids (just as some hybrid engineers predicted that hybrids would replace printed circuit boards). Unpackaged ICs and discrete devices became available. The unpackaged devices required that wire bonders be used in assembling the hybrids.

Researchers worked on interconnecting methods to eliminate wire bonding. Two technologies appeared in the mid-sixties. Beam leads were electroplated gold beams that extended over the edge of the silicon chip. The chip was bonded face down using the gold ribbon to attach the IC to the hybrid circuit. (Beam leads are still used today to provide interconnections for high speed semiconductor chips.) The second process was the solder bump or flip chip technology. Flip chips have been used in computer assemblies as well as in the automotive industry. These technologies rely on the interconnection to remove the heat from the IC. Elaborate systems have been developed to remove heat from flip chips used in computers.

Multilayer ceramic assemblies, utilizing molybdenum and manganese as the metalization between layers, was developed during this decade. A primary use for this technology was for the fabrication of hermetic packages for semiconductor devices.

In 1966 four individuals: George Doyle, John Hinchey, Robert Waer and George West began discussions on what could be done to improve communication within the micro-electronic industry. Their discussions lead to two technical thick film symposia, one held in Palo Alto and the other in Los Angeles. A proceedings was printed of all papers presented at the two meetings and distributed to all attendees. The symposia were so successful, as shown by the attendance and interest at both locations, that an organization was formed to provide communication within the industry. The organization became the International Society for Hybrid Microelectronics (ISHM). ISHM has provided a forum to discuss issues and problems related to microelectronics for 23 years.

The decade 1970 to 1979

The military and space programs continued to have influence on microelectronics during this decade. The emphasis was still on reliability while increasing circuit density. There was some continued attempts at standardization - with little success.