MICROWAVE/MILLIMETER WAVE MONOLITHIC INTEGRATED CIRCUITS (MIMIC) PROGRAM

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The Microwave/Millimeter Wave Monolithic Initiative (M^3I) was started by concerns in the smart munitions guidance and control community over the projected costs of millimeter wave seekers. A survey of monolithic analog integrated circuits was made by a DoD Working Group, consisting of personnel from OSD, Army, Navy, Air Force, DARPA and SDIO. The team visited 23 companies and several government facilities engaged in development of the technology.

The conclusions and recommendations were presented to the Under Secretary of Defense for Research and Engineering on 16 June 1985. These conclusions led to the DoD initiation of the Microwave/ Millimeter Wave Monolithic Integrated Circuits (MIMIC) program whose management structure will be similar to that of VHSIC, a DoD centrally managed tri-Service program.

DOD INITIATIVE

A broad range of advanced microwave and millimeter wave system capabilities, using gallium arsenide (GaAs) technology, have been demonstrated based on a miniature integrated circuit approach. To date, few of these have transitioned into operational inventory principally because of the cost of the precision fabrication and labor intensive processes. Funding currently available to the Services, for system development, is limited and thus precludes short term establishment of monolithic integrated circuit capability, resulting in the continued use of labor intensive hybrid circuits.

The Services have recognized the need for development of GaAs microwave and millimeter wave monolithic devices, as evidenced by the increasing number of related programs. Due to the increased activity, a fledgling industry has emerged to service these needs, with over 40 companies in the U.S. providing some capability.

In the microwave and millimeter wave arena, DoD applications dominate and are projected to remain the dominant factor in the market. Size/cost reduction, performance assurance and availability of Gallium Arsenide analog integrated circuits are critical to such items as transmit/receive array antennas, conformal antennas, frequency agile antennas, antenna control components, frequency synthesizer components, transmitters, receivers, seeker/sensor components for smart and precision munitions, decoys, as well as associated circuit and components for current and future military systems. No single company and no single application can afford to invest enough effort to solve the problems of implementing affordable systems based on the monolithic approach. Even with all the current Army, Navy, Air Force, DARPA and SDIO programs, these efforts fall short of pushing this technology over the threshold into a routine fabrication capability which will satisfy the needs of tactical systems.

The MIMIC program was started for the following reasons:

a. The MIMIC program will provide advantages to the "eyes and ears" of systems similar to those provided to the "brains" by VHSIC, advantages in performance, size, weight, cost, power, and reliability.

10-100:1	Reduction in Size/Weight
100:1	Improvement in Reliability
30:1	Reduction in Part Count
10:1	Lower Life Cycle Cost

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b. Individual efforts, in the past, have made a start but lacked sufficient resources to allow affordable deployment.

c. A major portion of MIMIC is GaAs technology development generic to all military Services.

d. MIMIC will identify major barrier problems and allow industry to concentrate on the most critical issues.

e. MIMIC will allow individual Service needs to be addressed but will encourage multi-Service cooperation in system development.

f. The program focus and visibility will increase the likelihood of earlier achievements of desired goals.

Major problems to be solved are developing a sufficient supply of high quality starting material, being able to produce desired levels of performance at acceptable and cost effective yields, developing cost effective packaging, developing the testing hierarchy from wafer to module and be effective at a minimum cost, developing the automatic test equipment, and also studying how best to incorporate MIMIC technology into systems to maximize system performance.

The 1990's and beyond will bring the need to further modernize and improve our weapon systems and hence our microwave and millimeter wave integrated circuit technology. The MIMIC program will establish the avenue for such modernization. The Services must then utilize the tools for rapid development of new technologies and must be aggressive in maintaining state-of-the-art technology at all levels of deployment. They must be willing to take the risks associated with new technology development. Similarly, industry must provide an atmosphere that addresses specific military needs in a timely, cost effective manner.

Some of the identified deficiencies were that Microwave and Millimeter Wave Monolithic Integrated Circuits (MIMIC) were critical technology to the DoD and there is no industrial base or commercial investment motivation apparent in the near term. GaAs MIMIC complements VHSIC in many systems. Progress in VHSIC processors causes the front-end wide band microwave and millimeter wave analog electronics to dominate system size, maintainability and production cost. Large phased array active apertures require MIMIC for radar, ECM, and communications. Full spectrum ESM/EW radar warning demands MIMIC. Millimeter wave seekers for small missiles need the size and cost reduction brought by MIMIC. The MIMIC program will develop the technology and electron devices needed to demonstrate that microwave and millimeter wave integrated circuit technology can be produced and utilized in an affordable manner in new surveillance, communications, electronic warfare, missile guidance, and smart munitions systems. Emphasis will be placed on system demonstrations which lead to early technology insertion.

POINTS TO CONSIDER

The United States must maintain a technological lead over our potential adversaries to counter serious numerical advantage they may have.

The United States must deploy state-of-the-art technology as soon after development as possible to minimize the opportunity our potential adversaries have to employ similar technology against us.

The Department of Defense must inspire industry to develop military specific technology and as industry profits from commercial application of defense technology they must also share the cost of defense technology development.

The Department of Defense must reduce the acquisition cycle for new microwave and millimeter wave integrated circuit technology to no more than five years.

The Department of Defense must insure that existing systems and new developments are producible, affordable and available.

PROGRAM OBJECTIVES

The MIMIC program is a multi-phase, tri-Service, OUSDRE managed effort to develop and deploy microwave and millimeter wave monolithic integrated circuits.

The major goals of the MIMIC program are to:

a. Establish a cost effective development program which minimized duplicative efforts by providing centralized DoD/tri-Service planning, while still maintaining a decentralized

Service program execution. The bottom line is AFFORDABILITY.

b. Encourage industry to develop a family of military specific MIMIC components, with design and manufacturing tools necessary for high yield (affordable) production.

c. Reduce the acquisition cycle to five years or less.

d. Accelerate the advance of the state-of-the-art.

e. Gain the United States a technological lead in developing and deploying state-of-the-art, MIMIC based military systems.

Recognizing that the current programs do not meet the need for affordable advanced systems deployment, the DoD has established the MIMIC Program Office.

The charter of the MIMIC Program has to address and overcome the problems of developing military specific MIMIC components while maintaining the security and control necessary to prevent a compromise of the program and it's goals. The DoD program management plan will:

a. Establish the MIMIC Program Office at the OSD level with full participation of the Army, Navy, and Air Force.

b. Develop an industrial contracting program for a new generation of advanced MIMIC's specifically designed to meet military system needs.

c. Initiate an aggressive application oriented program which minimizes the financial and schedule risk to the system program manager.

d. Encourage, with sufficient financial resources, the semi-conductor industry to develop a MIMIC productioncapability that will continue to meet specific military needs while complementing the commercial goals of the semi-conductor manufacturers.

PROGRAM STRUCTURE

The MIMIC Program Director and immediate staff are in the Office of the Under Secretary of Defense for Research and Engineering (OUSDRE). The MIMIC Program Director, with Program Directors from each of the three Services, manages technical, financial and policy matters. Day to day contract management and technical expertise are provided by the Services, under the leadership of the Service Program Directors. Together they conduct frequent program reviews and monitor the overall technical progress of the contractors in each of the various phases of the program.

PROGRAM PLAN

The MIMIC program is designed with four complementary phases, structured so that technology developed along the way can be carried directly into production. The program also calls for extensive and timely technology transfer between Services, and between participating and other qualified contractors. Emphasis will be placed on using device/circuit developments to meet system needs.

Using the lessons learned in the Very High Speed Integrated Circuits (VHSIC) program, a program has been scoped out consisting of:

Phase 0 - October 1986 to September 1987 - This phase consists of concept definition studies to do the detailed engineering analysis which relates system needs to device capabilities. Team building among the Services, systembuilders, device manufacturers and material suppliers will be emphasized. Contracts will be awarded to approximately nine teams of defense contractors to conduct intensive preliminary studies and then define a detailed development program to accomplish the technical objectives set out by the MIMIC Program Office. The definition studies will include, but not be limited to, determining the base-line state-of-the-art for GaAs analog integrated circuits, as it pertains to materials, devices, packaging and testing and then defining a program which will accelerate the development and application of these integrated circuits. The program definition will address the resolution of such problems as;

a. Assurance of adequate quantities of high quality starting materials.

b. Characterization and standardization of material and device processes such that a viable link is established between material properties, device fabrication and yield.

c. Development of realistic rf performance specifications linked to the ability to produce high yield and reliable cost effective devices.

d. Selection of architectures and development of Computer Aided Design capability for complex MIMIC devices.

e. Development of integrated circuit packages and packaging techniques.

f. Development of automated test equipment for on-chip and packaged chip testing.

g. Methods for capitalizing on existing fabrication capability to provide early insertion into military systems and to establish new and/or upgrade existing facilities to provide advanced fabrication capabilities which will enable demonstration and insertion of sophisticated system capabilities into military hardware.

Phase 1 - October 1987 to September 1992 - This phase will consist of multiple contract awards using the team concept established in Phase 0 and capitalizing on current fabrication facilities and device capability to get early system demonstrations and component fallout to systems in production. This phase will also concentrate on process and device development, pilot line inception, expansion of the yield data base, establish yield and cost limits, identify technical barriers, maintain close interaction between technologist and system/platform designers, develop producible circuits with maximum system leverage and provide brassboard demonstrations of GaAs analog chip applicability to the solution of military system problems.

Phase 2 - January 1989 to September 1992 - This phase will develop and demonstrate advanced fabrication pilot lines which enable sophisticated system capabilities.

Phase 3 - January 1988 to September 1992 - This phase will provide additional support for various efforts dedicated to solving technical problems that arise in pursuit of the main program objectives. Specifically it will provide support in the infrastructure area for materials, CAD, lithography, defects, testers and packaging technology.

TECHNOLOGY INSERTION

Paramount to the success of the MIMIC program is the rapid deployment of military systems designed or improved with MIMIC. The goal of the Technology Insertion is to insure that chips, chipsets and brassboards, or similar devices designed in Phase 1 and Phase 2, are used in military systems before the close of the decade.

The MIMIC Program Office has strong confidence in projected accomplishments and achievements of the Service managed efforts. It is important to note that the Services and system contractors will be pursuing independent technology insertion efforts, all intended to achieve the primary goal to utilize state-of-the-art MIMIC technology in military systems as soon as possible.

The primary benefits which will result from the MIMIC program are listed below:

Reliability, availability and maintainability
System performance enhancements
New system capability
Technology growth designs
MIMIC/VHSIC synergism
Reduced size/weight/power
Reduced acquisition cycle
Reduced life cycle cost

PROGRAM STATUS

The MIMIC program is a FY87 new start project. It is anticipated that a draft Statement of Work for Phase 0 will be available in the July-August 1986 time frame. The Services have begun holding application workshops to assist in selecting the military systems for early technology insertion.