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MicroCIM

Computer Integrated Manufacturing in the Hybrid Microelectronics Industry

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BACKGROUND

The MicroCIM program is managed by the Manufacturing Technology Branch at NOSC under sponsorship of the Director, Navy MANTECH Program, Office of the Assistant Secretary of the Navy for Research, Development, and Acquisition. Funding is provided from the Navy Industrial Preparedness budget which has the purpose of assisting American industry to be economically competitive with foreign suppliers and therefore sufficiently capable of meeting the needs of the United States Navy during any emergent situation. The intent is to develop new or improved processes, methods, techniques, or equipment to enhance industrial base capability. While this has focused on cost benefits, quality is also seen as an important value.

MicroCIM is an outgrowth of the Integrated Facility for Automated Hybrid Microcircuit Manufacturing (IFAHMM). The purpose of IFAHMM was to develop a test facility to evaluate state-of-the-art technology for the manufacture of hybrid microcircuits. This technology could be used to enhance production capability and, as a result, produce parts at a lower cost to the DoD. This work was performed by Teledyne Microelectronics in Los Angeles, with much of the factory modeling performed by their Chief Scientist, Ralph Redemske. Teledyne concluded two phases of effort and the project ended in November 1988. Currently, Teledyne is conducting demonstrations of their factory management software developed in association with IBM.

GOALS

The goals of MicroCIM are CIM implementation, advanced technology development, technology transfer, and cost reduction. Other benefits may also be realized, such as quality improvements and shorter delivery schedules.

CIM Implementation -

The improvements in automated equipment have greatly benefited industry by increasing throughput with faster performance, increasing yields through consistant high quality performance, and by reducing production costs overall. However, there is rarely any integration of this automated equipment and significant costs are still being incurred through the manual transfer of information between machines. Because of the chance of error being introduced by the manual transfer, there are additional costs to check for errors and make the necessary corrections. MicroCIM will be used to show the benefits of integrating these "islands of automation".

Advanced Technology Development -

It is the intent of MicroCIM to develop neutral formats for the transfer of information from a computer-aided design station down to the automated equipment on the factory floor and from the automated equipment back up to the design station. Neutral formats are not specific to any vendor equipment or host system, but are based on the use of a common set of subroutines to call for data. Where needed, new software and hardware interfaces will be developed. New technology such as laser imaging, machine vision, or neural networks, will be investigated to provide enhancements to data collection and data transfer.

Technology Transfer -

Government funding serves only as a stimulus for CIM implementation in the industry. Benefits are derived primarily through technology transfer. MicroCIM will result in information or systems that are useable by other companies in the industry. By developing neutral data formats, a broad segment of the industry will be able to use the interfaces that are developed. The program also brings together representatives from the hybrid industry for Ad Hoc Advisory Panel (AHAP) sessions twice yearly. Not only does this provide knowledgeable input to the program but it also allows the representatives to learn about new findings or developments by MicroCIM. The two MicroCIM companies have teamed with other companies to further promote the transfer of technology.

Cost Reduction -

In order to reduce costs, less expensive ways must be found to manufacture components. This involves everything either directly or indirectly associated with the manufacturing process. IFAHMM, as well as other programs, has discovered and documented the fact that there are many contributors to the cost of a part, some of which are not directly related to the manufacturing process. This includes such areas as design, shipping and receiving, and material handling. These functions are required to know what product to make and what it should look like, to provide the materials to make the part, and then deliver the part to the customer. Depending on the cost accounting system, these tasks may or may not be directly charged to a particular parts order. If not a direct charge, then an indirect charge is made either as an overhead or general administrative cost. There are other support functions which are definitely indirect support. These include marketing and sales, accounting, contracts, purchasing, and legal. The costs associated with these are generally combined and added to overhead costs. However, they definitely support the manufacturing process. They are specific tasks which must be done to, respectively: have a reason for manufacturing a product; for receiving adequate compensation for making the product; and for buying the materials needed to make the product. Therefore, any one of these factors which contribute to the cost of making the product is a candidate for cost reduction efforts.

Other Benefits - Other benefits include increases in yield, quality, reliability, shorter delivery schedules, and technical achievements which advance the state-of-the-art of the industry. Other considerations are commercial usage, competition with foreign suppliers, and usefulness to both small and large companies.

APPROACH

MicroCIM is being accomplished in two phases with the first phase ending in February, 1991, and the second phase beginning immediately thereafter.

Phase I involves the assessment of present capabilities and technology, and the demonstration of one prototype system to determine risk and feasibility of implementation. To date, the two companies have completed their assessments of what is currently available, have identified specific capabilities which must be developed, and are presently working on the design of the prototype systems which they will demonstrate in January, 1991.

Phase II is planned to start February, 1991 so that there will be no break in the program. The second phase involves the design and development of several selected projects to implement the CIM technology. Selection is based on the degree to which the projects address the goals of the MicroCIM program.

RAYTHEON

Raytheon is representative of a large company. They have teamed with BDM because of BDM's participation on the IFAHMM project. BDM is assisting with the plans for system integration and the design for an enhanced computer system architecture. Raytheon's program is managed by John Buckley and Sanders Cox heads the BDM analysis team.

Prior to MicroCIM, Raytheon had concentrated on the integration of equipment on the factory floor. They have already realized significant benefits through automation, including a 90% improvement in wirebonding yields and a 159% improvement in die attach yields.

For MicroCIM, a broader analysis was performed. Raytheon found the costs of production labor contribute 56% to total part cost. Material accounts for 30% of costs, with design and manufacturing engineering each contributing about 7%.

Raytheon found information gathering for customer required documentation to be a major cost driver and a major upgrade to their computer system will be undertaken. To determine requirements for the systems architecture, BDM used the IDEF modeling technique developed by the Air Force. They are recommending that networking be handled by a token ring Ethernet, using Novell Netware. Because of the extremely large data requirements at Raytheon, a broad band fiber optic cable will be used to connect nodes.

Raytheon and BDM have identified about 40 distinct problem areas where additional development will have to occur before effective computer integration can be performed. These include the lack of capability for direct CAD to CAM data flow, the lack of intelligent interfaces in the substrate processing equipment, the lack of integration between inspection and process control, and the lack of neutral or generic interfaces for the wide variety of equipment in the assembly area.

For the Phase I demonstration project, Raytheon has focused on the transfer of CAD data files down to a die attach machine. The CAD file from an Apollo/Mentor workstation will be output to an IBM PC and translated into a form which is recognizable and usable by the operating control program within an MRSI 501 pick and place robot at die attach.

Raytheon has identified six major industry needs which they would like to address during Phase II:

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A Raytheon-lead team will develop an enhanced die attach robot. An open data architecture will be developed to provide a CIM capability and to facilitate technology transfer. The architecture will permit integration with other factory floor systems from various vendors including CAD stations and PC-based cell controllers. To improve quality, open architecture software will also be developed to permit real-time data collection from the robot for statistical process control. To enhance technical performance, an improved vision system will be developed to permit recognition of dies of all types.

Automated Substrate Assembly Cell

Develop an automated substrate cell which combines the process steps of autoscreening, firing, visual and electrical test. A combined assembly cell integrates the substrate area. Hardware interfaces and open architecture software will be developed to provide integration to CAD systems, centralized data bases, and follow-on work cells such as laser trim, inspection, or epoxy screening. Requirements and specifications will be developed with inputs from AHAP team members. Off-the-shelf vision, bar code, and control systems will be used to enhance performance. Direct labor efficiency should substantially increase, resulting in improved quality, increased capacity, and higher yields.

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Develop an automated inspection prototype system, using machine vision, to assist at Pre-Cap Visual. The system will provide real-time quantitative information to inspectors for defect determination, thus reducing rework and associated scrap. Data entry terminals will forward inspection results to process engineers for statistical process control, to rework technicians for fault isolation, and to purchasing for material reorders. Only selected criteria from Mil-Std-883, Method 2017, will be automatically inspected for this proof-of-concept prototype.

Automated Loading of Automatic Testers

Design and build a machine to automatically place hybrids into socket jigs for electrical test and to automatically remove them when testing is completed. This is a simple application of robotics to optimize labor mechanics and decrease downtime, but it can have far greater benefits. Based upon efforts by Teledyne and Hughes, the technical challenge is to design a generic hybrid carrier so that costs for the carrier design can be amortized over several different part orders. This will facilitate the integration of a common transport and handler system connecting workstations from kitting through to shipping.

Benign (Environmentally Clean) Hybrid

Although this does not address issues involving computer integration, environmental contamination is increasingly both an ethical and an economic concern to the hybrid industry. The Director of Navy MANTECH is urging all program managers to explore technical solutions to environmental issues. This project will explore ways to increase the rate of recovery of solvent vapor, such as trichloroethane, in degreasing operations, which might otherwise attack the earth's ozone layer. Possible replacement chemicals for trichloroethane will be investigated.

Computer-Aided Engineering with Central Database

Develop a knowledge-based expert system to assist in the design-layout-prototyping cycle. This system will be specifically designed to assist members of concurrent engineering teams. Designed with an open architecture to permit application to a variety of vendor and host systems, the database will be accessible to all engineering stations. This system will have the additional benefits of downloading operating specifications text on computer screens, allowing electronic review and approval of engineering changes, and providing automated configuration control.

CTS

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CTS has found that most cost drivers are information related and are not involved solely with shop floor technology. By actual function, 40% of actual part cost is production related, 16% associated with quality assurance, 15% is associated with engineering, and 12% is associated with administration and management.

CTS used a Yourdan-DeMarco modelling scheme to determine requirements for a system architecture. They examined computer usage throughout the factory including not only those computers on the factory floor but also those in accounting, purchasing, and contracts. They found that data flow is heavily redundant and usage is often not specified. An architecture designed to support a centralized data base is the best solution to this problem. For this, they have selected a Hewlett Packard 9000 computer system. Analysis of data traffic requirements indicate that a simple network technique, such as Ethernet, can be used for data distribution. Network rules must be drafted to collect and disseminate only that data needed to support the manufacturing processes. CTS is concentrating on the collection of electrical test data. They are developing a prototype system for process control, based upon statistical analysis of the test data, as their Phase I demonstration project.

For Phase II, CTS has submitted the following efforts for consideration:

Electrical Test Data Collection

During Phase I, CTS teamed with Battelle to design a low cost system to automatically collect data from electrical test and to store this data for later analysis and program development. For Phase II, they have proposed to extend this concept to the other twenty test stations at their facility. Benefits include reduction in paper records, faster use of statistical process control, reduced scrap, and reduced labor in testing, data analysis, and test programming.

Statistical Process Control

The data collected from electrical test data can be used for statistical process control. CTS proposes to implement SPC at 9 workstations - wirebonding, epoxy deposit, die shear, QA visual inspection, clean room atmosphere control, thin film processing, thick film processing, hermetic sealing, lead shear, and PIND test. CTS will team with the Naval Avionics Center (NAC) who will evaluate results.

Shop Floor Data Collection

CTS proposes to develop an open architecture, low-cost, PC based shop floor data collection system. They would concentrate on product tracking, labor reporting, and work instructions. Benefits of shop floor data collection are primarily labor savings in data gathering and report generation. Although this duplicates the capabilities of many existing MRP systems, those systems are cost prohibitive to small companies, both up-front and in maintenance support.

Ink Jet Marking

CTS proposes to develop a generic, low-cost method of data transfer between a CAD station and an ink jet marking station. This work would follow guidelines established by the CAD to CAM efforts at NIST and by the Meet-in-the-PC efforts of CSC. CTS would team with Intergraph to develop the generic CAD file. Battelle would help develop the generic interface to the ink jet marker.

Parametric Design of Experiments

This is a follow-on effort to Statistical Process Control. CTS will team with Automated Technology Associates (ATA) for design of experiments. ATA designed the integration software purchased by CTS for their CIM networked architecture and has worked with NAC personnel in the past. NAC will evaluate results in terms of process yields. Any cost savings will result from a combined SPC effort.

AHAP

An Ad Hoc Advisory Panel (AHAP) composed of government, industry, and academic representatives was formed during the IFAHMM program to review the work performed, assess the impact on the industry, and to make suggestions on future work. This forum has continued with the MicroCIM program. CTS and Raytheon are able to share their goals for the MicroCIM program and to describe their current progress. Workshops have been held to address specific issues such as the use of machine vision and laser technology, statistical process control, neural networks, human factors, and configuration control. AHAP also provides a convenient forum for technology transfer through tours and discussions on current applications of technology.

There have been two AHAP meetings to review MicroCIM. The first was held in January 1990 and was hosted by Texas Instruments in Dallas Texas. The Panel emphasized that improvements are still needed in die attach, wire bonding, and all testing stations. After reviewing information models from Teledyne, Raytheon, and CTS, the Panel concluded that there is little correlation between companies as far as information requirements. The possibility of developing a common data dictionary was discussed and this effort may become part of the work on a standard data format or communications protocol. In any case, only higher levels of operation should be described until cost drivers are determined, then only those areas of significant cost benefit should be analyzed in greater detail. It was also determined that a rough measure of cost effectiveness is a 50%

return in two years.

The second AHAP meeting was in July and was hosted by CTS in West Lafayette Indiana. A complete review of the analysis performed by CTS was presented and Raytheon and CTS discussed their findings on cost drivers. Both companies feel that equipment modifications are needed to enable a factory wide integration. However, presentations by Hughes, Micro Robotics Systems Inc, and Intergraph, highlighted the concerns by equipment manufacturers that the development of CIM interfaces is not a priority of the hybrid industry. It was concluded that such development will not occur without funding support from the government, such as provided by the MicroCIM program.

A third AHAP meeting will be held to review the accomplishments of Phase I. This is tentatively scheduled for the last week of January, 1991, and will be hosted by Raytheon in Boston. During the week of January 7, CTS and Raytheon will demonstrate the performance of prototype systems each developed during Phase I.

RELATED EFFORTS

In support of the MicroCIM effort, NOSC initiated development of the Communication Protocol Specification, based upon the Meet-in-the-PC concept first posed by Robert A. Unger of Computer Sciences Corporation. Mr. Unger has completed the specification, which is titled "Communications Protocol for Microelectronics CIM". In this document, he describes the concept as a flexible generic connection between factory computers and process equipment. In separate supplements, he provides process models, common subroutines, and executable recipes for six assembly areas most likely to be integrated into a common network. These areas are laser trim, epoxy coat, die attach, wirebonding, wirepull test, and marking. He provides descriptions and process models for 19 other assembly areas that could be integrated if external interfaces are developed.

By itself, the specification only serves as a guide. MicroCIM intends to develop interfaces for selected equipment to prove the utility of the specification. These interfaces may enable the direct downloading of CAD data to factory floor equipment with very little operator teaching. By using generic or neutral subroutines, software development and support will be minimized.

In a related effort, Hughes Aircraft Equipment Division has developed a wirebonder which can be accessed by an external PC. Micro Robotics Systems Inc has also done this with a pick and place robot. Both of these equipments still require the teach stage for initial file development and the interface is specific to the particular equipment.

In another effort, NOSC is working with the National Institute of Standards and Technology (NIST) to develop a data format specification for hybrid microelectronic assemblies. The format could be used for data storage or for file transfer of all data required to manufacture, test, and ship hybrids.

For additional details, any of the persons mentioned in this article may be contacted. For copies of any documentation, please contact T. Joseph Sampite', Naval Ocean Systems Center, (619) 553-3265.

MicroCIM: Computer Integrated Manufacturing in the Hybrid Microelectronics Industry

By T. Joseph Sampite,
Naval Ocean Systems Center

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Goals

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Cost Reduction

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CTS proposes to develop a generic, low-cost method of data transfer between a CAD station and an ink jet marking station. This work would follow guidelines established by the CAD-to-CAM efforts at NIST and by the Meet-in-the PC efforts of CSC. CTS would team with Intergraph to develop the generic CAD file. Battelle would help develop the generic interface to the ink jet marker.

Parametric Design of Experiments

This is a follow-on effort to Statistical Process Control. CTS will team with Automated Technology Associates(ATA) for design of experiments. ATA designed the integration software purchased by CTS for their CIM networked architecture and has worked with NAC personnel in the past. NAC will evaluate results in terms of process yields. Any cost savings will result from a combined SPC effort.

AHAP

An Ad Hoc Advisory Panel (AHAP) composed of government, industry, and academic representatives was formed during the IFAHMM program to review the work performed, assess the impact on the industry, and to make suggestions on future work. This forum has continued with the MicroCIM program. CTS and Raytheon are able to share their goals for the MicroCIM program and to describe their current progress. Workshops have been held to address specific issues such as the use of machine vision and laser technology, statistical process control, neural networks, human factors, and configuration control. AHAP also provides a convenient forum for technology transfer through tours and discussions on current applications of technology.

There have been two AHAP meetings to review MicroCIM. The first was held in January 1990 and was hosted by Texas Instruments in Dallas, Texas. The Panel emphasized that improvements are still needed in die attach, wire bonding, and all testing stations. After reviewing information models from Teledyne, Raytheon, and CTS, the Panel concluded that there is little correlation between companies as far as information requirements. The possibility of developing a common data dictionary was discussed, and this effort may become part of the work on a standard data format or communications protocol. In any case, only higher levels of operation should be described until cost drivers are determined; then only those areas of significant cost benefit should be analyzed in greater detail. It was also determined that a rough measure of cost effectiveness is a 50% return in two years.

The second AHAP meeting was in July 1990 and was hosted by CTS in West Lafayette, Indiana. A complete review of the analysis preformed by CTS was presented, and Raytheon and CTS discussed their findings on cost drivers. Both companies feel that equipment modifications are needed to enable a factory-wide integration. However, presentations by Hughes, Micro Robotics Systems Inc., and Intergraph highlighted the concerns by equipment manufacturers that the development of CIM interfaces is not a priority of the hybrid industry. It was concluded that such development will not occur without funding support from the government, such as provided by the MicroCIM program.

A third AHAP meeting was held to review the accomplishments of Phase I. This meeting was held in January 1991, and was hosted by Raytheon in Boston. Raytheon and CTS both demonstrated the performance of prototype systems each had developed during Phase I.

Related Efforts

In support of the MicroCIM effort, NOSC initiated development of the Communication Protocol Specification, based upon the Meet-in-the-PC concept first posed by Robert A. Unger of Computer Sciences Corporation. Unger has completed the specification, which is titled "Communications Protocol for Microelectronics CIM." In this document, he describes the concept as a flexible generic connection between factory computers and process equipment. In separate supplements, he provides process models, common subroutines, and executable recipes for six assembly areas most likely to be integrated into a common network. These areas are laser trim, epoxy coat, die attach, wirebonding, wirepull test, and marking. He provides descriptions and process models for 19 other assembly areas that could be integrated if external interfaces are developed.

By itself, the specification only serves as a guide. MicroCIM intends to develop interfaces for selected equipment to prove the utility of the specification. These interfaces may enable the direct downloading of CAD data to factory floor equipment with very little operator teaching. By using generic or neutral subroutines, software development and support will be minimized.

In a related effort, Hughes Aircraft Equipment Division has developed a wirebonder that can be accessed by an external PC. Micro Robotics Systems Inc. has also done this with a pick and place robot. Both of these equipments still require the teach stage for initial file development, and the interface is specific to the particular equipment.

In another effort, NOSC is working with the National Institute of Standards and Technology (NIST) to develop a data format specification for hybrid microelectronic assemblies. The format could be used for data storage or for file transfer of all data required to manufacture, test, and ship hybrids.

For addition details, all of the persons mentioned in the article may be contacted. For copies of any documentation, please contact T. Joseph Sampite, Naval Ocean Systems Center, (619) 553-3256.