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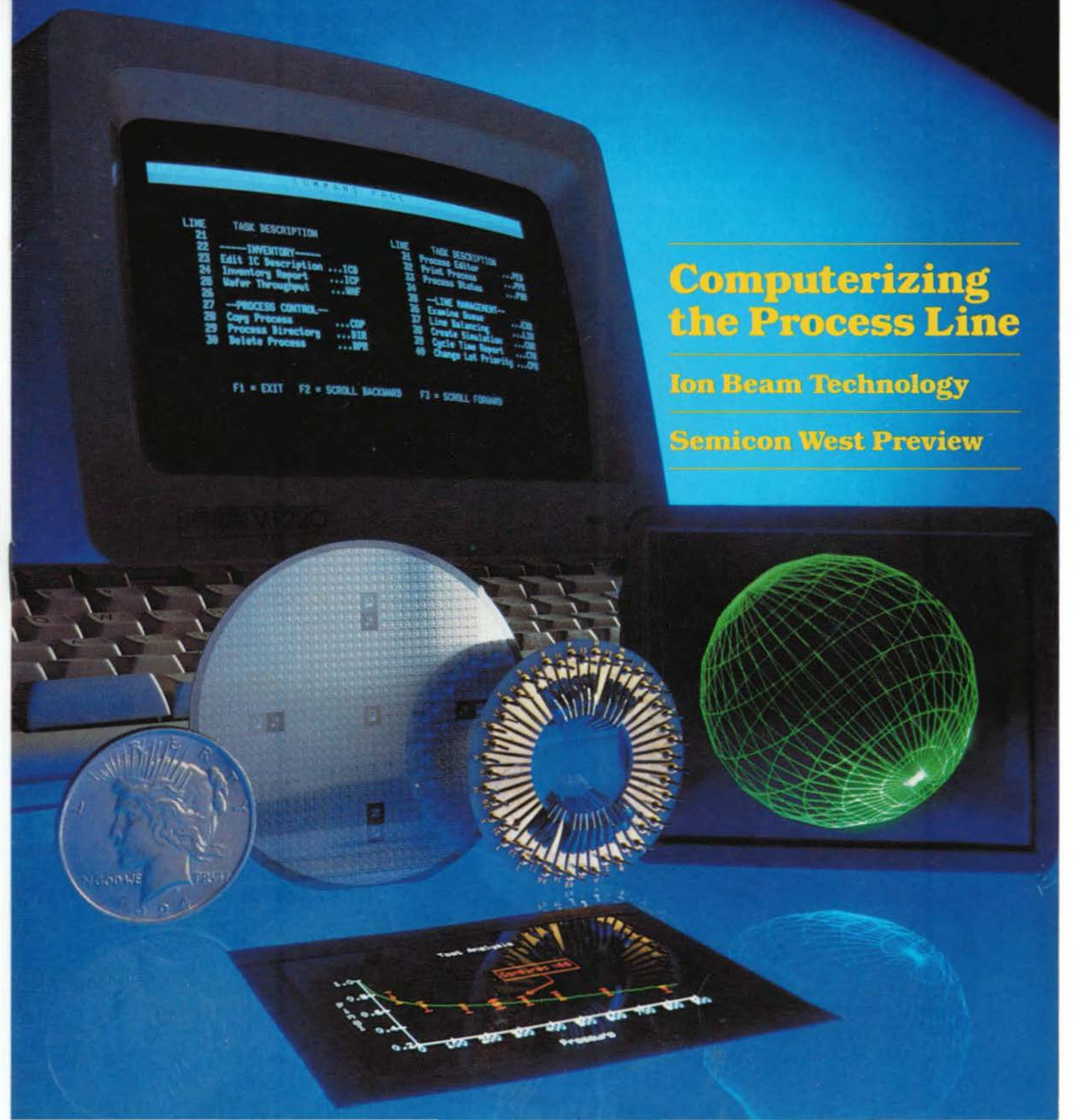


Computerizing the Process Line

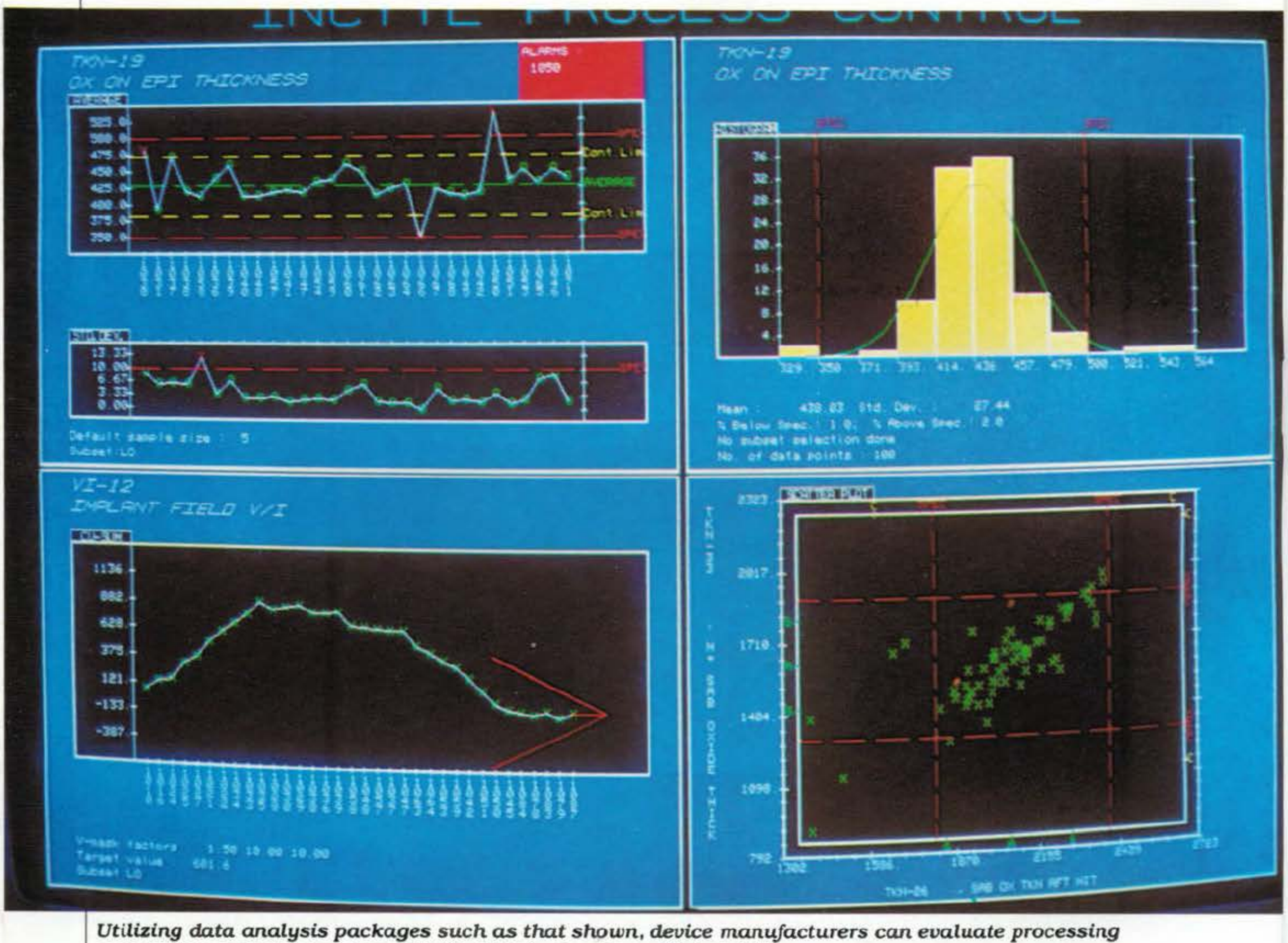
Ion Beam Technology

Semicon West Preview

Computerizing the Process Line: A Must for Automation

It is becoming apparent that automation will be required in the future. An important aspect of automation is computerization and its associated software and hardware.

By Peter H. Singer, Associate Editor



Utilizing data analysis packages such as that shown, device manufacturers can evaluate processing parameters and check process limits. (Photo courtesy of Fairchild).

Automation is becoming a popular term in today's semiconductor industry. It's seen as a way of increasing manufacturing efficiencies by raising yields and lowering cost. The major disadvantage of automation is its very high cost. According to Marlin Shopbell, manager of advanced process automation at Mostek, "The major goal in terms of being able to sell management on spending the millions of dollars it is going to cost for significant automation has to be reducing the unit cost of the products you're making." Higher manufacturing efficiency, achieved through automation, can lead to increased yields and lower cost per unit.

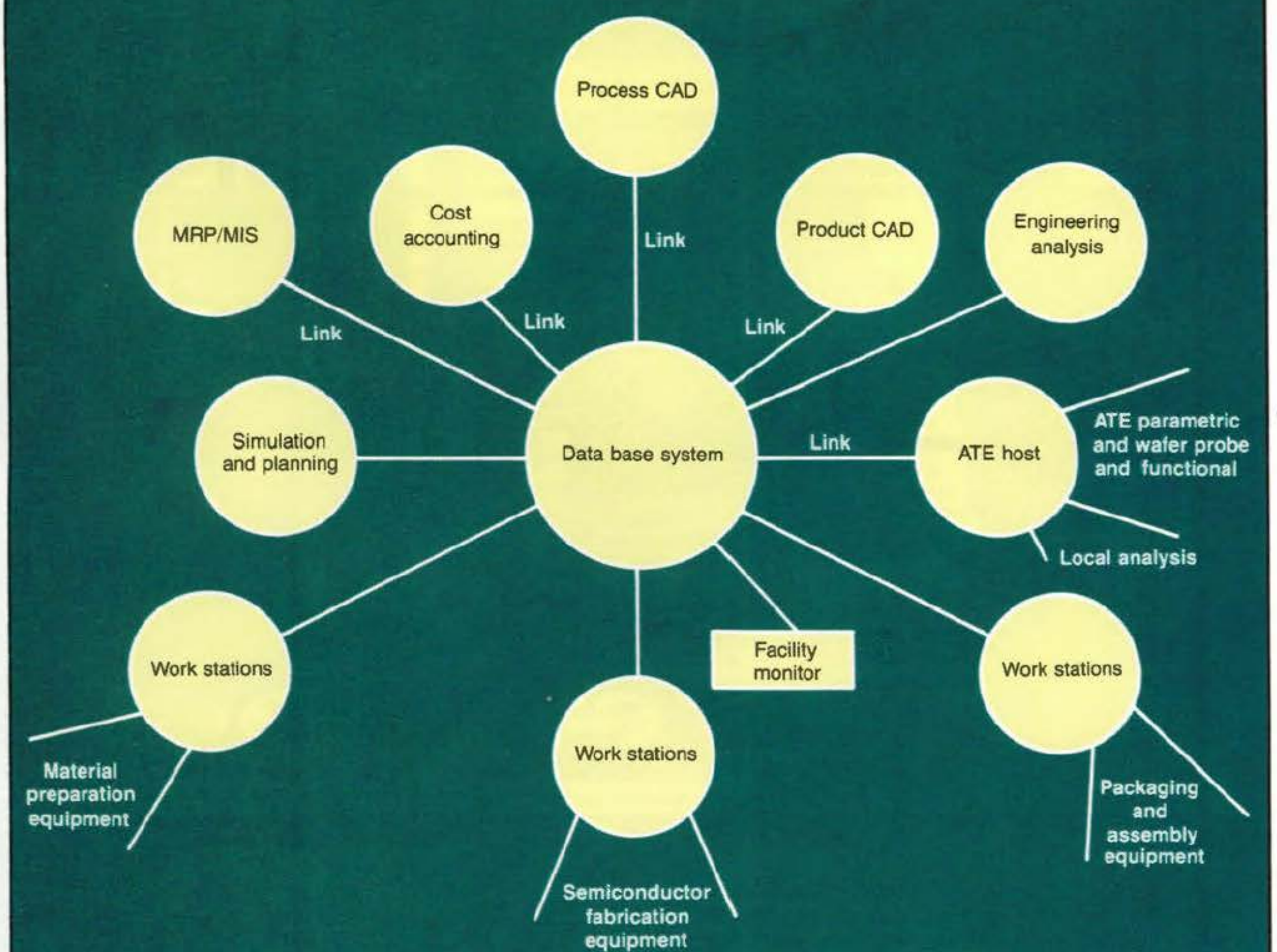
Keeping in mind that profits will usually be the driving force behind most management decisions, it would seem that the focus of the industry would shift from the development of new technology to the refinement of manufacturing efficiency. Current trends indicate that this is valid. Case-in-point: the technical sessions at Semicon/West this year are devoted entirely to automation.

In fact, it is becoming increasingly difficult to attend any semiconductor show or conference (or read the trade press), without being bombarded by automation buzzwords: computer-integrated manufacturing (CIM), computer-aided manufacturing (CAM), networking, local hosts, archival hosts and robotics are but a few examples. Unfortunately, no one seems to be quite sure what any of these terms actually mean.

This confusion can be attributed to the fact that automation is really in its infancy in the semiconductor industry. As with any new technology, there is bound to be some confusion over definitions. C. Richard Deininger, manager of automation and robotics at the General Technology Div. of IBM East Fishkill, points out, "Automation conjurs up different visions in different people's minds. To some it means putting a robot in front of a tool. To some it means putting raw sand in the front end of a factory and getting a finished product at the back end. To others, automation means robotics. The point is, it's all of these and a lot more."

Computerization

Indicative of the industry's interest and level of development is the work being done at Mostek. "We are at the point right now where we have defined and done much of the preliminary engineering work for a fully automated wafer fab. It's a case of deciding exactly where it goes, how many wafers does it have to run, scaling the design to meet the requirements and then actually implementing that and building the



1. A totally automated factory management system must interface with many areas in the manufacturing plant. A database computer can be linked to already established computer networks through established communication protocols. (Illustration courtesy of BTU Engineering Corp./Bruce Systems).

facility. It would probably not be operational until late 1986," says Marlin Shopbell, manager of advanced process automation at Mostek, Austin, Tex.

At the present time, however, the semiconductor industry is a long way from the totally automated manufacturing plant, especially in the process area. On the process line, only a handful of processing equipment is currently advanced enough to support a totally automated facility. According to Dr. Robert Atherton, senior member research staff on automation, Fairchild's Advanced Research and Development Lab, "The real bottle-neck for detailed total control is with the equipment vendors. They don't have sufficient control of their own machines and they don't have the interfaces to communicate with the next higher level. The machine has to be able to control itself and monitor its internal states and communicate those forward."

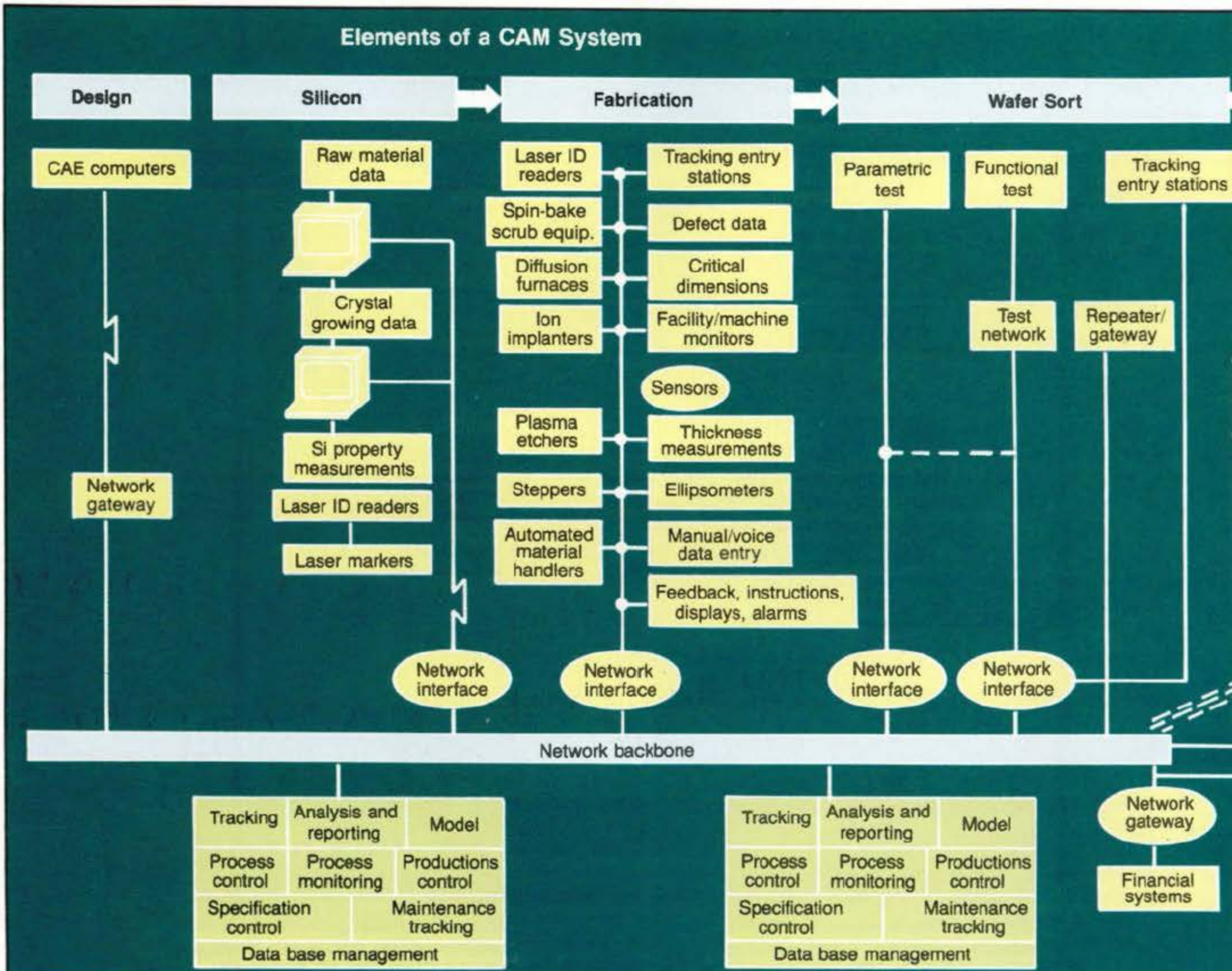
As a result, there has been very little progress in automating the fab line. According to Shopbell, "There is very limited use of direct communications between the process equipment and a host computer at this point. Most of the commercially available equipment has not had the capability to communicate with a host computer until very recently."

Shopbell added that it would be very difficult to take an "old" wafer fab line and try to fully automate it to any great extent.

Factory management

To date, most advances in computerization have taken place in the areas of testing, design and business management. Design was an obvious candidate for automation and advanced CAD systems have long been developed to help the design engineer become more creative and productive. Test systems, which are really advanced computers in their own right, are also well suited for networking. Practically every major manufacturer of test systems currently offers networking capabilities. A host computer is used to link a number of test systems. However, many of these systems can only communicate with equipment made by the same manufacturer.

In addition, CAD/CAT links have recently been utilized to generate test programs during the design phase. This ensures testability and also eliminates excess test program development



times.

Of course, the business management of the industry is also highly computerized, since there are great number of generic business computers and software systems available. These systems usually perform cost accounting, material resource planning (MRP) and other business functions.

In order to automate as much as possible, while waiting for fab line equipment to catch up, the industry has taken a "from the top down" approach. Overall factory management systems have been developed by some manufacturers and some have been developed by commercial vendors. These "systems" are composed of a network of varying levels of controllers and data gatherers, tied into every area of manufacturing (Fig. 1). The key to a successful system lies in the development of software that can be supported by a computer system that can run in *real time*. Immediate acquisition and processing of information is *the* major requirement of automation.

The capabilities of available systems range from the management of one certain area (i.e. wafer processing or test) to total factory and even global company management.

A main consideration of the process line is lot tracking — making sure each lot is the right place at the right time and the correct process recipe loaded into the processing equipment for that lot. Factors such as scheduled equipment downtime for maintenance, reworking, yield loss, test wafer, etc. must also be considered.

At the same time, incredible amounts of test and measurement data are being generated throughout the process line. Wafer flatness measurements, inspection data, parametric test and functional test data, etc. must be collected, condensed, analyzed and stored. Ideally, it is then correlated back to the pertinent process parameters for "fine tuning." Many of the instruments that must be interfaced with are shown in Fig. 2.

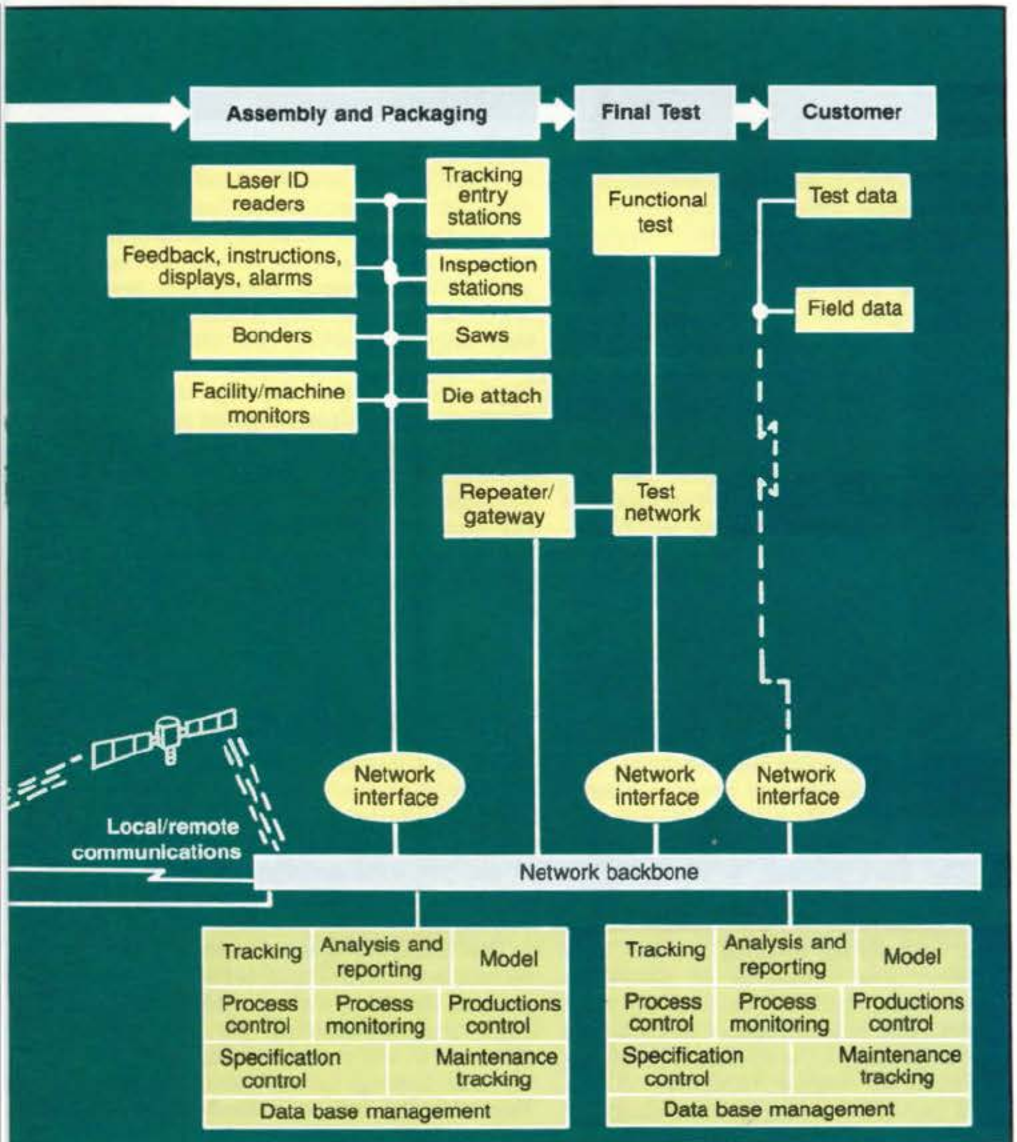
Several of the computer systems currently available address only the lot tracking aspect of wafer manufacturing, with a limited amount of process recipe control. Others address only the collection and manipulation of test data. However, the most advanced systems are capable of controlling both process and test data, as well as interfacing with the various other areas of manufacturing (assembly, CAD, marketing, etc.). Since information is generally not obtainable directly from the processing equipment on the fab line, it must currently be entered on a terminal by an operator. Not only is this subject to error, but it adds an unnecessary level of complexity to the networking system.

It is important to realize that all available systems are generally referred to as "CAM" systems, even though they have extremely varying degrees of capabilities. This is true not only of commercially available test systems, but also systems developed in-house. The same confusion is evident in many different aspects of automation, as previously discussed.

Some attempt has been made to clarify the problem by private consultant groups, such as VLSI Research, Inc., San Jose, Calif. They have given the label of "local host" to systems dedicated to a certain area (such as fab or test) and the label of "archival host" to the more advanced systems, which would link local hosts together.[1] Although this terminology is oversimplistic, it is suitable for this discussion.

Archival host

BTU Engineering Corp./Bruce Systems, North Billerica, Mass., for example, currently market what could be considered both a local and archival host. BTU/Bruce, a traditional supplier



2. Shown is a more detailed diagram of all the elements that must be interfaced with to form a complete computer aided manufacturing facility. (Illustration courtesy of Fairchild).

3. General Electrics programmable process facility in Syracuse, N.Y. utilizes the PROMIS computer-aided manufacturing system.

of diffusion furnaces, became involved in the CAM market through the development of furnace control programs. One of their first developments was FACS, a furnace analysis and control system. This was then expanded to produce a local host for fab, called WICS, a wafer inventory control system. WICS is designed for inventory tracking, product management and data handling for large wafer processing facilities. Although still oriented to the diffusion area, this system is able to obtain information from up to 200 different wafer processing stations. Management information reports utilize these data to provide user-designed lot summaries on any or all wafer lots in the system, locations and wafer counts of lots engaged in specific processes and the exact number of wafers passing through a particular work station.

Using the knowledge obtained from the development of WICS and FACS, BTU/Bruce was able to develop a much more advanced archival host system, called Fasttrack. This system, first introduced in May of 1983, consists of a central data base computer that can be connected to central areas of semiconductor manufacturing, as shown in Fig. 1. For example, the system is quite capable of interfacing with CAD systems, test area networks, business computers and, of course, local hosts in the fab area. The database computer provides a means of obtaining data via several different communication protocols, storing it and then withdrawing the desired information when necessary. The database will support hundreds of users, up to sixty-four separate host computers and up to thirty gigabytes of on-line storage.

For use in conjunction with the database host, BTU/Bruce currently offers two "modules" or "nodes," which would fit under the definition of local hosts: fab-level management and engineering analysis packages. The fab management package is essentially a greatly expanded version of WICS, previously described, but also capable of tracking to the wafer and die level. The engineering analysis package is based on the RS/1 software package from BBN Research Systems, a division of Bolt, Beranek and Newman, Inc., Cambridge, Mass. The RS/1 is a data management and analysis package that provides data entry and retrieval, two and three dimensional graphics, curve fitting, statistical analysis and analytical modeling.

The RS/1 package is also used on another CAM system, called COMETS (comprehensive on-line manufacturing and engineering tracking system). This system was developed by Consilium Associates, Inc., a custom software house, and first introduced in 1982. The development of the system was underwritten by Digital Equipment Corp. and United Technologies in exchange for unlimited internal use licenses.

COMETS is composed of eleven different modules, each dedicated to a specific function. This allows the user to tailor a system to its manufacturing process, key process parameters and organization. Currently available modules include: work in process (WIP) tracking/inquiry, inventory tracking/inquiry, standard cost/management reporting, capacity planning and scheduling, engineering data analysis/report writer, factory communications (mail/message/broadcase), on-line engineering specifications, process control, facility monitoring and engineering data collection (non-lot). Consilium reports they will also be offering modules for company-wide planning and sales order entry, as well as a CAD interface during 1984.

Another system that can be classified as an archival host was developed by Fairchild and is presently in use in most of their facilities. This system, called INCYTE (in-process computer-aided, yield, tracking and evaluation system), is not yet commercially available but will be in "the near future" according to Fairchild.

The INCYTE system, whose architecture is shown in Fig. 2, is "a real-time process control system providing feedback and monitoring for all key elements in the manufacturing, assembly and testing cycles," according to Fairchild. Production control and line

balancing data are used to provide priority scheduling of work through a dispatch system. A special feature of the INCYTE system is its data anlaysis capabilities. Through the use of real-time process control charts, measurement data are automatically reviewed by the system to provide an early warning of process drifts before quality and/or devices are lost. Additionally, data from the process equipment and the in-process testing are immediately available for engineering feedback and management decision making. Process measurement data are automatically transmitted to standard on-line control chart displays available to manufacturing as well as engineering personnel (see lead photo).

Local hosts

In a networking hierarchy, local hosts provide the middle level of control, between factory control and individual machine control. Probably the most advanced local host yet developed is the PROMIS system, developed by I.P. Sharp and Associates, Toronto, Ontario, Canada, in conjuction with General Electric's Solid State Applications Operation. The PROMIS system is currently used in GE's P^2 (programmable process) facility in Syracuse, N.Y. (see Fig. 3). "When P^2 was conceived (1978), there was only one other company using CAM in its wafer production facility that GE knew of," said John R. Debolt, manager of process systems automation at GE. In the P^2 facility, PROMIS is used to track approximately 400 sensors to keep process, safety and environmental conditions within specifications.

PROMIS features a document control system that allows the user to create and display user-defined descriptive information or diagrams about any "object" in the manufacturing environment, such as processes, recipes, operations, devices, work centers, equipment, wafer types, masks, gas tanks, chemicals, etc. Of course, the information must be entered into the system before it can be analyzed.

Hewlett Packard has also developed a local host network as part of their "semiconductor productivity network." This network is composed of six modules, each dedicated to a specific function. Of special interest is the IC-10, which gives on-line production and manufacturing control information. The IC-10 also interfaces with the other five modules: the EN-10 engineering data collection system, the EA-10 engineering analysis system, the PC-10 process control system, the CA-10 cost accounting information system and the SO-10 sales order system. The EN-10 permits the user to define, collect and validate critical process measurements. The EA-10 provides statistical analysis and graphic output. The PC-10 integrates equipment supervision, equipment monitoring, enhanced lot tracking and documentation management with the IC-10. The CA-10 is an administration tool, used to calculate actual, current target, standard and simulated costs at both the process and product levels. The SO-10 is a sales and marketing tool, which handles on-line quotations, sales order entry and reporting, scheduling and shipping control as well as immediate billing and sales analysis reports.

Test data management

As previously mentioned, incredible amounts of test and measurement data are generated during the manufacturing process, and it may take a dedicated system to collect it and analyze it.

Nanometrics, Inc., Sunnyvale, Calif., for example, is currently marketing the Nanonet fab monitoring network. Although oriented to the Nanometrics measurement equipment, it can be interfaced with up to eight instruments or terminals through the SECS protocol. In this manner, the Nanonet can be used for production control, process monitoring, automatic data acquisition and equipment control. The system may be used as a single computer network, or multiple systems may be linked together. The user must define employee identification numbers, fab schedule, process steps and equipment instruction before the system can be used to collect appropriate production and engineering data.

CTX International, Sunnyvale, Calif. has also developed a system directed at fab test and measurement data management, the CTX 300. The foundation of the CTX 300 is an integrated database computer that allows correlation of any data with any other data on a real-time basis. Users can use statistical and graphical analysis programs to diagnose problems and provide information for optimum process control. □

References

1. G.D. Hutcheson, "Testing: After the Recession," *Semiconductor Internationak*, pp. 82-94 (Jan. 1983).

For more information directly from the manufacturers of semiconductor CAM systems, circle the appropriate number on the reader service card at the back of this issue.

Company	System	Circle No.
BTU Engineering Corp.	Fast Track	251
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Consilium Associates, Inc.	COMETS	253
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Cover: A computer network, designed for total control of all manufacturing operations, must interface with wafer fab, test and business management, perform data analysis all on a global scale. (Photograph courtesy of BTU Engineering Corp./Bruce Systems, North Billerica, Mass.)

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