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A LSI FACTORY OF THE NEW AGE

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Because of the continuous trend of increase in circuit function complexity, LSI devices have larger bar areas and smaller pattern geometries, making these devices more sensitive to many manufacturing problems than SSI and MSI products. In order to achieve good yield and device performance at acceptable cost, a LSI wafer fabrication factory must be built and operated on a basis of high technology and good common sense. Introduction of manufacturing machine systems capable of highly repeatable, essentially defect-free processes with minimal contamination becomes absolutely necessary. In addition, a reduction in manual wafer handling and manual data recording and processing by operators is desirable. One must have good process feedback on real-time basis in order to achieve the desired device parametric distribution. Quick turn-around, short cycle time should be maintained. This condition can be met only with automation in both wafer production and device assembly/testing in conjunction with computer-assisted factory management. This is particularly true in a society where labor instability exists and operator turnover is a problem.

In LSI manufacturing, two kinds of automated machines are commonly used: Batch machines and fast sequencing, one-slice-at-time machines, many equipped with microprocessor control. The machines have been used in different combinations to match process requirements, but the choices are not as flexible as one would like. I will discuss some of the trade-offs and limitations during the talk. Automated machinery performs wafer handling and processing, also machine parameter monitoring and control. The selection of proper control inputs and outputs plays an important role. End-point detection is ideal but not always possible. A control computer may be used to back up process controllers. If we have control computers in a factory, it is relatively simple to introduce process and manufacturing data acquisition, processing, storage and display; in other words, management computer support and control. In doing so, many people related problems such as misprocessing and machine malfunction can be significantly reduced.

In an automated LSI factory, a manufacturing system is usually composed of a combination of machines configurated in such a way as to perform a processing flow efficiently. A typical example is photoresist processing and image pattern in wafer fabrication. Many steps involved are carried out on one-slice-at-a-time machines, with the standard twenty-five wafer cassettes as convenient interface media. Different ways to lay out such lines are used to accommodate different device types for maximizing thruput or process flexibility.

Attention should also be given to material logistics, wafer traffic, space and capital investment. Basic requirements for the automated machine systems will be discussed. With these machine systems properly set up running smoothly, one can significantly reduce process uncertainty, cycle time, parts and material inventory and number of people, thus improving the overall factory performance. However, new processing technologies such as E-beam or X-ray lithography must be given consideration in new factory designs.

To manage the business of LSI wafer production or device assembly, a real-time knowledge of all aspects of the total operation must be readily available. This can only be achieved by implementing a factory computer system. Several levels of computers, ranging from process and machine controllers to a factory management computer, may be used in combination to support the total business and to interface with corporate control computer system. At Texas Instruments, we have established a very effective distributed process control and distributed computing. Each individual factory can rationalize the utilization of its full capacity and reducing process uncertainty. In a sophisticated system, computers talk to one another directly, thus improving data transmission and processing. Anything from order entry through product shipping, from product definition to final test, from silicon crystal growth to failure analysis on field-returned devices, can be handled effectively. Compared to the first industrial revolution when machinery supplemented human muscle power, this second industrial revolution has introduced computers to extend human brain power beyond description. Its influence on social and technological changes is simply overwhelming.

As we begin to move into the realm of VLSI, the functional complexity of the devices has introduced considerable difficulty in process design, device testing and device yield/failure analysis. Test devices and process monitors designed into the product mask sets can help relieve this situation. In addition, one needs to build up a library of device and process computer models to improve understanding of these LSI/VLSI products. Since the users must acquire the knowledge of how to use these devices in their applications, the components manufacturer's responsibility does not end with product shipment. In other words, the products should consist of both hardware and software. Therefore, there may be technology gaps in circuit design, device fabrication, product engineering and applications. A modern LSI factory must be designed and built with flexibility to meet this challenge.