Preface

The past twenty-five years have been marked by unprecedented progress in electronic component development, progress which has provided increases of many orders of magnitude in measures of component performance. This has led to remarkable improvements in the performance, cost, and reliability of computer systems. Much of this progress has been provided by the advances in semiconductor technology and the emergence of the integrated circuit. In addition, the increasing capabilities of components have made possible new approaches and more complex functions in systems architecture and machine design, a symbiotic interaction which continues apace. The simultaneous development of the digital computer and semiconductor component technology has generated the explosive growth of both.

This chapter of the twenty-fifth anniversary issue of the *IBM Journal of Research and Development* is devoted to component technology. Papers on solid state memory and semiconductor logic technology reflect the progress of basic electronic components. These advances were made possible by the support of both electronic packaging and design automation, disciplines which have become indispensible elements of component development and which are the subjects of separate papers. A paper on the highly complex task of manufacturing increasingly sophisticated semiconductor components completes the chapter. These papers, written by long-time workers in their fields, are clearly presented from an IBM perspective and have as their focus the design and development of components for the broad spectrum of IBM products. Semiconductor science is covered in a paper by Keyes and Nathan in the last chapter.

The significant advances in electronic components are the result of steady evolution along a broad front of disciplines and technologies. They have come about because of the contributions of thousands of engineers and scientists in laboratories and production facilities all over the world. The papers in this chapter present a selective picture of this evolution and deal with IBM's mainstream component development. But even within this scope, the treatment is not comprehensive or exhaustive. Josephson device technology was omitted, for example, because a recent entire issue of the *Journal* (March 1980) was devoted to this subject. We have also excluded the extensive work in technology support areas and, to mention a few examples, the technology of displays, communications electronics, and the comprehensive testing facilities in manufacturing areas.

From the time the *Journal* was first published to the end of the 1960s, ferrite core memories were used in the stored-program computers which were then produced. These memories had replaced earlier technologies, such as cathode-ray-tube memories, because they were faster, less costly, and more reliable. However, ferrite cores and magnetic films were superseded in the late 1960s and early 1970s by semiconductor memories, again for reasons of speed and cost. IBM was the first in the industry to introduce semiconductor main memory in its computer products. The paper by Pugh, Critchlow, Henle, and Russell follows this progression of solid state memory technologies, describing ferrite core, magnetic film, bipolar and MOSFET memory; it also includes a discussion of exploratory work on magnetic bubble technology. This paper provides examples of technologies which, upon reaching the limits of their capabilities, have been superseded by superior technologies to continue the accelerating advance of component technology.

For over twenty years, the area of computer logic has been dominated solely by semiconductor technology. At the beginning of the era, the transition from vacuum tubes to solid state circuits had been made. The remarkable progress in semiconductor component technology over this time has made possible dramatic increases in productivity of the end products. And the rate of component advancement is still accelerating and shows no signs of diminishing. Rymaszewski, Walsh, and Leehan trace this progress through both the bipolar and field effect transistors from discrete devices to the beginnings of very large scale integration (VLSI). Logic circuit developments, and in particular IBM's major bipolar technologies, solid logic technology (SLT), as well as monolithic systems technology (MST) and its successors, are discussed. The application of field effect transistor technology to read-only storage and programmed logic arrays is presented, pointing to a future of increasing synergism between the new components and new applications to come.

Our ability to exploit large scale integration (LSI) is directly related to our ability to package semiconductor components. High-performance logic and memory components go hand in hand with better packaging and interconnections. For System/360, IBM took a unique direction in providing connections for semiconductor components: a solder-joining technology which provided potential for higher densities. In the last ten years semiconductor chip densities have increased by approximately three orders of magnitude. The challenges brought on by higher densities led to constant work in materials, cooling, and reliability related to the package. Seraphim and Feinberg trace the evolution of electronic packaging in IBM and consider all levels of the package, the chip, the chip carrier, and the printed circuit cards and boards.

From the very early computer products, the increasing complexity of their electronic components necessitated the development of a computer data base to document and support engineering design. This spawned the new discipline of design automation, which uses computers to design future generations of computers. Design automation has become *sine qua non* for the design and manufacture of electronic computer components: The developments described in the first three papers of this chapter would have been impossible without it, and it is today one of the key limiting factors for LSI development. The paper by Case *et al.* describes the evolution of IBM's design automation systems from their early beginnings. Under the constraint of dealing with such a broad subject, the authors chose to treat three major areas: design verification, test generation, and physical design. While there is some treatment of custom design, many contributions, especially efforts not in the centralized design automation activity, could not be covered.

The introduction of new semiconductor products does not end with the successful operation of an engineering prototype. When these products reach the manufacturing stage, new problems must be solved in assimilating new and more complex technologies. The rapid progress in semiconductor technology has required that manufacturing be highly adaptable, resulting in significant developments in yield management, testing, production control, and logistical systems. This has led to the most highly developed and technologically complex manufacturing facilities of any industry, one in which the use of the computer has become indispensible. A paper by Harding on semiconductor manufacturing, which follows the extensive development of manufacturing technology through IBM's major logic products and its influence on component design, concludes this chapter.

Editor