

Preface

In addition to semiconductor chip fabrication, the manufacturing of computer parts involves many disciplines which must be carefully controlled to produce the very complex components that make up a computing system. The editors of the *IBM Journal of Research and Development* were intrigued by the challenge of providing some insight into the technology that makes the present computer generation possible. We gave our readers a view of the advanced packaging concepts used in the IBM 3081 processor in the January 1982 issue; in the May 1982 issue we further explored computer circuitry packaging trends. In September 1982 we investigated IBM's semiconductor manufacturing technology. In this issue we delve into the disciplines and machinery which are used to assemble and test the component parts of a large-scale computer.

Semiconductor wafers are diced into chips and soldered to ceramic substrates that provide the thermal and electrical interconnections between circuits residing on different chips. These ceramic substrates are mounted on printed-circuit boards which provide for further power distribution and signal interconnections. These larger conglomerates constitute what we call higher-level packages. In this issue we shall try to highlight some of the disciplines involved in what has become a highly computerized manufacturing process. This includes the creation and subsequent testing of higher-level packages of computer constituents whose complexity is expanded by shrinking three levels of packaging into two, and yet preserving high-quality parts in a large-quantity production environment.

One paper summarizes the discipline of product quality in mathematical terms. Two papers are devoted to multi-layer ceramic substrate processes, one to the multi-layer printed-circuit board inspection, and three to the electrical and logical testing of the field-replaceable circuit units, cards or thermal conduction modules. Finally, one paper discusses the modeling of assembly/rework processes. Together, these articles offer an insight into some of the more fascinating problems encountered by engineers in manufacturing with regard to cost and quality control of mass-produced high-technology computer parts.

Burger and Weigel give us a view of the multi-layer ceramic substrate technology pioneered by IBM as a means

for packaging a large number of circuits in a very small space. This is accomplished by very stringent controls on the materials that make up the ceramics, by computer-aided monitoring of the processes, including the inspection of unfired substrate layers and the punching of interlayer holes, and by careful control of the sintering temperature and atmosphere, among other things. Without the aid of computer monitoring, the processes described would not be feasible and the technology would most likely not exist.

Sanborn details a simplified numerical control method for positioning the tools needed to work with the ceramic surface irregularities of the sintered ceramic substrates. He explains how the need for repair and rework can be accommodated through a one-time measurement of the location of key points on the ceramic surfaces. The measured data are centrally stored for the life of each substrate produced. They are retrieved and used, in conjunction with his simplified interpolation algorithm, to position needed tools when a repair activity is required.

The paper by Curtin and Waicukauski develops the methodology involved in arriving at a plan to test multi-chip ceramic modules after the chip-mounting process to meet the product quality requirements of this step. Also, the diagnosis to repairable units is performed automatically. The authors discuss the different diagnostic analyses used by the MCMDIAG program to arrive at the necessary information and they also present results on the effectiveness of the test plan implementation.

Pierson and Williams describe the LT1280, a tester for exercising up to 1280 logic input/output pins simultaneously, which is a requirement for testing thermal conduction modules (TCMs) for IBM 3081 processors. The features of this machine and the accompanying system of programs which make it economically feasible to implement such a test system are also presented.

In a companion paper, Barry details the automated diagnostic programs supporting the LT1280 tester and the method of localizing a problem by means of two probes which can be moved to any contact on the TCM surface to measure the signals present. She also discusses results obtained with this tool.

West, DeFoster, Baldwin, and Ziegler detail the computer-controlled optical system and especially the distortion-correcting algorithms needed in order to detect and check for minute features on the different layers of the printed-circuit TCM board before it is laminated.

The factors relating to the product quality level (PQL) are referred to by many authors in this issue. In his paper, Cleverley explains the term PQL and its effects on the subsequent hierarchically assembled products. He makes a case for constant surveillance of the manufacturing processes and recurring defect identification by quality engineers in order to find the lowest possible assembly level at which different defects can be found, thereby minimizing repair and retesting.

Dooley describes a general-purpose simulation model that is used in manufacturing planning of assembly/rework processes. The higher-level packages used in IBM computers are designed to be fully repairable in a manufacturing environment. Since the tools and manufacturing processes are highly complex, this simulator aids in determining the right number and combination of tools needed for a given plant production capacity.

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