PROCESS MONITORING SYSTEM

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Published March 1979

Final Report
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PROCESS MONITORING SYSTEM

BDX-613-2113 (Rev.), Final Report, March 1979

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An automated process monitoring and control concept applicable to printed wiring board fabrication has been generated. This conceptual system utilizes a minicomputer to provide improved process control by monitoring, analyzing, and controlling critical parameters and equipment associated with printed wiring board production processes.

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A prime contractor with the United States
Department of Energy under Contract Number
DE-AC04-76-DP00613

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SUMMARY

The concept of a process monitoring instrumentation system is described, which allows for improved control of printed wiring board manufacture.

Two of the primary features include the multiplexed measurement of process variables from as many as 500 sensors in the department, and the incorporation of automated solution analyses and controls. These measurements could provide information for reporting on those process parameters critical to the consistent manufacture of printed wiring boards. The automation of solution analysis and control of the plating and etching solutions are not yet industry norms. As techniques are developed they may be added to this system.

DISCUSSION

SCOPE AND PURPOSE

The goal of this project is to develop concepts for applying automated process monitoring and control to the fabrication of printed wiring boards. Current instrumentation of critical process variables is minimal and values are not recorded. Processes are dependent to a large extent on the operator. Readily available analysis data could remove part of the human variance factor and improve process control and repeatability.

ACTIVITY

Basic Considerations

The proposed process monitoring instrumentation and control system will allow for added improvements and provide information which allows increased control of the many processes involved in the manufacture of printed wiring boards. Real-time data informs the production worker whether his operation is currently in tolerance on many sensed variables, and whether the machines are functioning correctly. It will also indicate to the production supervisor that the departmental processes and maintenance functions are in order and will enable the process engineer to determine the immediate critical values as well as trends leading to future problems.

The hub of the system is a minicomputer with accompanying disc storage, printer, and CRT terminal. Reports generated by the printer, near the production area, permit rapid return of information. The CRT terminal is the main source of manually-entered results from the Solution Control Lab group. Maintenance work completions also would be input here. Under direct control of the minicomputer are six functions (Figure 1), most of which are microcomputer controlled.

- Process monitoring, from approximately 500 thermocouples, flow meters, and liquid level detectors in the department;
- Conveyor controlling for the etchback process, to sequence product rapidly through several tanks with precision;
- Solution analyzing and controlling, wherever critical functions occur;

Figure 1. Automated Process Monitoring System

- Phototool controlling, to ensure that the correct pattern is being employed;
- Bare board testing, an expansion capability, with programmable current and time variables and some self learning features; and
- Interfacing with numerically controlled drills and mills, an optional feature, allowing program storage on something other than mylar tape.

Expansion capability is built-in according to the minicomputer system chosen. Some areas for consideration include providing timing and control signals for the three plating line hoists, humidity controls, and direct control of plating power supplies. Additional terminals may be added for manual input either by manufacturing or inspection. A hardware link to the Mezzanine Data Acquisition System (MEZZDAS), Direct Numerical Control (DNC) or to the Materials Evaluation Lab computer may become desirable. Increased disc storage is feasible.

Parameter Sensing

Each of the 12 major process steps would be instrumented as shown in Figure 2. The sensed variables are not used in a closed loop control, but can be used to prevent the operation of machines when fluid levels are too low or not within a prescribed temperature range. As many as 50 sensors per process may be required. Values from these sensors will be fed into a monitoring device capable of scanning, alarm checking, and displaying data. The multipoint monitor allows input from thermocouples, voltages, and all standard transducers. Inputs should be sequentially scanned at 15 points per second and measured values are compared to preset limits. Outputs would be visually displayed and sent to the department minicomputer. If desired, these outputs could be printed and used to activate an alarm for out-of-tolerance conditions.

The measurement system should have an initial capacity of at least 20 channels with expansion capacity to a minimum of 1000 channels. One or two simple processes may then be instrumented quickly to determine initial startup problem areas.

The visual display consists of the channel number and its most recent data reading. In the alarm mode, the channel in alarm is displayed automatically, even while the remaining channels are being scanned. The printer can be programmed to print the values from all specified channels at preset time intervals. Channels in alarm condition are printed in red and the remainder in black.

Figure 2. Parameter Sensing

Temperature and humidity sensors provide data on those conditions that affect phototooling accuracy. Departmental energy requirements can be monitored for energy conservation purposes.

Etchback Controller

The current etchback process (Figure 3) is performed by manually moving the product from one tank to another. Some form of disciplined product movement and control of timing is required to eliminate undesirable process variations and to prevent scrap. In addition to proper and repeatable sequencing, rapid movement between tanks is required to reduce continued chemical action on product in transit. Total bath time may be as little as 40 seconds, and interbath periods must be short by comparison.

Depending on the product, various material types will need to be processed and each will require different scheduling of elapsed times and/or chemicals. It is very probable that the automated product handling system is not available commercially. If a system must be built, a microcomputer based controller would provide all the flexibility required and could interface directly to the department minicomputer.

Numerically Controlled (N/C) Machine Interface

At the present time all programs for the N/C drilling and routing machines are stored on punched tape. When a new part number is to be manufactured, it is necessary to find and load a different tape into the machine. The proposed system would have the capacity to store tape contents and to load this information into the appropriate machine by entering the part number from a keyboard. An alternate approach would be to interface this portion of the system to the existing Direct Numerical Control (DNC) operation. This feature of the system would be optional.

Bare Board Testing

Requirements for multilayer board quantities and types are increasing. A requirement possible on future types is an electrical test on internal layers that consists of applying a known current through each conductive path for a fixed time. This test would ensure good electrical contact to internal layers via the plated holes. Electrical testing of bare boards is a departure from past experience. Automatic test equipment for testing loaded boards can be adapted to perform the much simpler bare board testing task; however, a microcomputer based tester can easily perform the required tests. In either case, future interfacing to the departmental minicomputer is readily accomplished. Bare board testing capability is an optional feature which may be easily added at any time.

Figure 3. Etchback Process Steps

Reports

Two categories of desired reports are routine daily schedules and on-demand summaries. A daily maintenance schedule will include items such as tanks which need cleaning, filter change requirements, and other prompting messages. A daily Solution Control Lab schedule will list all analysis requirements needed that day and any others that are past due.

The demand summaries should encompass the following:

- Listing of maintenance performed during latest 30 day period;
- Tank additions for past 60 day period;
- Solution control lab test results and when performed (30 day period);
- Alarms during the past 30 days, by channel numbers;
- Histogram of values from any sensors in the department;
- Sensor readings versus time; and
- Time of event information for a change in process, material, or calibration.

The availability of a current status of each process and a historical summary of events would provide an insight into problem areas that was not previously possible.

Phototool Definition Control

The phototool used to expose the desired pattern determines the uniqueness of each part numbered product. The part number is different for each product and the issue letter of the part number varies as changes are incorporated. An identifying number will be made an integral part of the phototool and will be scanned by a light pen connected to the area minicomputer. A comparison of the phototool in use to the latest issue is then made by the computer. A match will be indicated by a light at the scanner. A mismatch will result in an exception message being printed at the computer. When several copies of the same phototool are in use, the capability of correlating the phototool with product quality may also be of benefit.

A similar test for correctness of the numerically controlled tapes used for drilling and contouring may also be incorporated.

Solution Analysis and Control

In addition to monitoring temperatures, pressures, fluid levels, and flow rates, the chemical makeup of plating and etching solutions should be monitored and controlled. The Materials Evaluation Lab is performing the required solution analyses using manual techniques. They were asked to determine which of these analytical functions could be automated. When these functions are established, equipment can be procured or constructed to perform these tasks, with results being transmitted directly to the departmental computer. Until this is accomplished, this information will be entered via a local CRT terminal.

It is also feasible to automatically control chemical additions to some existing solutions. This would involve measuring a parameter of interest, opening a valve to admit a controlled amount of chemical, closing the valve, and remeasuring the parameter. The process is repeated until the chemical mixture is correct. Such an automated control will probably have to be designed and would interface directly to the departmental computer.

ACCOMPLISHMENTS

An automated process monitoring and control concept, applicable to printed wiring board fabrication has been generated. The improved process control proposed by this system would provide a more uniform product through the application of real-time information to processing problems. Trend analysis and improved maintenance scheduling are two other benefits of the system.

FUTURE WORK

Implementation of the process monitoring and control concept requires a cost benefit analysis, and procurement of several pieces of equipment. These include the departmental minicomputer system, the process monitor and associated sensors, a solution analyzer, a phototool scanner, and a bare board tester. The etchback line controller should be developed on a new process development order. Cost analysis, coordination of equipment specifications, purchase and checkout, plus interdepartmental liaison should be pursued on a process development order when capital equipment funds become available.

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