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BDX-613-500

PLATING UNIFORMITY

PDO 6984636, Final Report

L. Lantz, Project Leader

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L. Lantz
Department 814

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ABSTRACT

Current channeling and conductive screening are proposed as methods to improve thickness uniformity in plated circuits. The project was cancelled before completion because the uniformity problem was solved by another project as this work was in progress.

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SUMMARY

The objective of this project was the development of methods of improving the thickness uniformity of electroplating on printed circuits. Current channeling and conductive screening were proposed. It was hoped that these techniques would lead to universal plating fixtures that could be used with any pattern plated circuit. A fixture was built to permit precise positioning of the current channeling device or conductive screen with respect to the circuit. The support for the circuit was made to oscillate to eliminate any local nonuniformity created by the nature of the fixtures. Gold plated copper screen wire was used as a conductive screen. The current channeling device was to be a honeycomb structure; however, a satisfactory fixture was not obtained. The effectiveness of current channeling and conductive screening was not determined. The project was cancelled because the thickness uniformity problems were solved by other persons through improved fixturing and improved process controls.

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DISCUSSION

SCOPE AND PURPOSE

The objective of this project was the development of methods of improving the thickness uniformity of electroplating on printed circuits.

PRIOR WORK

There was no prior work at Bendix Kansas City on this project.

ACTIVITY

Thickness Differences in Electroplating

Electrolytic deposition of metals generally results in a nonuniform distribution of the metal over the substrate. The thickness differences depend on the current distribution, which is primarily a function of the geometrical characteristics of the system. This includes the geometrical shape of the anode, cathode, and plating tank and the distance of the electrodes from the walls. The complex patterns of printed circuits produce a nonuniform current distribution with the resulting variation in deposit thickness.

Producing Thickness Uniformity

Thickness uniformity can be improved by improving the current distribution. Common methods use nonconductive screens, robbers, auxiliary anodes, plating boxes, and periodic reverse plating. The objective of this project was to devise a universal plating fixture that could be used with any pattern plated board. The two methods proposed in this work for influencing the current distribution were current channeling and conductive screening.

Current Channeling

With the current channeling concept, nonconductive honeycomb is mounted with the cells very close and perpendicular to the plated surface. Because each unit of plated area draws plating current primarily from the cell directly in front of it, the individual cells act as miniature plating boxes to make the current distribution more uniform. The cells, in effect, are channels through which the current moves to the cathode.

The problem was to determine the effectiveness of the fixture, and to relate cell dimension to effectiveness. The ratio of the cell depth to cell diameter should be large. However, there would be a lower limit to the cell diameter because of the surface tension of the plating bath solution. The optimum distance for positioning the honeycomb with respect to the plated substrate also had to be determined. The construction material for the honeycomb structure had to be nonconductive and chemically inert with cell walls as thin as possible.

Initially, honeycomb made of Nomex nylon paper (DuPont Corporation) appeared to be an obvious choice. However, Hexcel Corporation, Arlington, Texas, quoted a price of \$2500 for seven pieces of Nomex honeycomb covering a range of four cell diameters and four cell lengths. Because of this cost, alternative materials were investigated. Various aluminum, paper, and carbon honeycombs were available "in-house"; however, structural stability, chemical inertness, and proper cell dimensions were not all available in any one of the materials. The cell diameters were generally too large. An epoxy-impregnated paper honeycomb failed a test for chemical inertness in a copper sulfate plating bath.

A urethane foam was impregnated with vinyl plastisol and blasted with air in one direction in the hope of producing a channel structure in the blast direction. This approach was unsuccessful.

In another approach 3-inch lengths of 1/8-inch ID Pyrex tubing were stacked in a close-packed arrangement to form a 9-inch by 7-inch rectangular array. The tubes were bonded by an epoxy adhesive made of a 2:1 mixture of Epon 828 (Shell Chemical Co.) and Versamid 140 (General Mills). The epoxy was affected by acid-copper sulfate solution and the array fell apart within a few days.

Conductive Screening

Conductive screening was also investigated. The screen was placed parallel and close to the cathode. Because of the screen's relatively high conductivity, it formed a constant potential plane thereby straightening the current flow immediately next to the cathode. The conductive screen had to be metallic, but chemically inert to the plating bath. The most readily available materials meeting the requirements were platinum, platinized titanium, and gold. An attempt was made to make a screen from platinum screen wire, but it stretched too easily and deviated too far from a plane. A conductive screen was made by gold plating 25-mesh, copper screen wire and clamping it in a Plexiglas frame.

Plating Fixture

The requirement for precise positioning of the current channeling device and the conductive screen necessitated building a fixture which would hold the circuit board and honeycomb, or screen. The holder for the honeycomb and screen was adjustable allowing the fixtures to be placed 1/8 inch to 2 inches from the circuit. The support for the circuit could be oscillated at variable speeds to minimize any thickness variations caused by the proximity of the fixtures to the circuit board.

Plating Experiments

Copper laminated board was cut into 6-inch square pieces, cleaned by standard methods, and laminated with 1.5-mil DuPont Riston photoresist film. The photoresist was exposed to a typical circuit pattern and developed according to standard procedures. An acid copper sulfate bath was chosen for the plating experiments because its poor throwing power would enhance the differences in thickness.

Circuit patterns were to be plated (1) with no fixture, (2) in a plating box, (3) with a current channeling fixture, and (4) with a conductive screen. The circuits plated with no fixture and the circuits plated in a plating box were to be used as standards for determining the effectiveness of the current channeling device and conductive screen.

The plating experiments consisted of circuit patterns plated to 2.0 mils at 20, 30, 40, and 50 asf with no fixture between the anode and cathode.

Portions of the circuit were selected to be sectioned, mounted, and photographed on a metallograph. The selections included isolated paths and pads, areas of dense circuitry, and large areas. Comparisons were made of equivalent circuit structures at the center and perimeter of the circuit pattern, and of thickness variations on individual cross sections.

The individual circuit structures and the circuit pattern as a whole exhibited similar trends in thickness nonuniformity. The perimeter of the plating was thicker than the center. The thickness uniformity of the individual circuit structures could vary from this trend depending on their proximity to other portions of the circuit. A "robbing" effect tends to occur when there is a nonuniform pattern of circuitry surrounding an individual circuit pad or path.

The plating experiments were then delayed by the problems in developing the current channeling device and the screen. In addition, less time was allotted to this project since other projects had higher priorities.

Coincident with these developments, the problems of thickness nonuniformity on circuit boards, which existed when the project was initiated, were solved by other persons through improved fixturing and process control. Consequently, the need no longer existed and the project was cancelled.

ACCOMPLISHMENTS

The effectiveness of ion-channeling and conductive screening was not determined. The project was cancelled because the thickness uniformity problems were solved by other persons coincident with the efforts on this project, making the proposed approach unnecessary.

FUTURE WORK

No future work is planned.

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