DISCRETE VLSI PACKAGE REMOVAL/REPLACEMENT

by

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ABSTRACT

The advent of VLSI, with high-density, extremely fragile beam leaded and high I/O leadless packages requires the implementation of a controlled process to successfully deal with special production situations such as rework. Since the value of a single VLSI package is so high, rework situations will require the removal of a previously soldered package, totally intact, from a fully populated PWA without disturbing the surrounding components and their solder joints. Subsequent to removal of a discrete package, solder must be delivered to the rework site, and a new package must be precision placed and soldered, again, without disturbing adjacent devices. These rework tasks cannot be accomplished with traditional package handling devices or soldering processes.

Part I of this paper describes methods and equipment used to successfully accomplish the rework situation on surface mounted devices described above.

Part II of this paper describes a method of delivering solder to the site of an LCC being replaced onto a PWA which involves preforms capable of delivering precise volumes of solder to the castellations of the LCC prior to performing the actual component reflow.

PART I

BACKGROUND

Removal and replacement of discrete components from printed wiring assemblies (PWAs) is important to the defense electronics industry and to the electronics industry in general. Components may have to be removed and replaced due to design change, component failure or other reasons. It is essential that the entire PWA is not heated while doing this.

Two types of equipment and their respective technologies were

investigated for the removal/replacement of surface mounted VLSI devices: One was the Programmable Matrix Heater (PMH) type where the leads and pads are heated with hot nitrogen gas while room temperature nitrogen flows over the remainder of the component and surrounding area. Process variables such as temperature, time, gas flow and heating pattern are programmed into a microprocessor which is a part of the machine.

The other was the continuous wave YAG laser. This was investigated for component replacement and not for removal. Here the process variables such as current and time of dwell of the laser beam are precisely controlled by a N/C controller. The N/C controller also controls an X-Y-Z movement: the X-Y axis moving the PWA while the Z axis moves the laser optics.

Both the above types of equipment are relatively new and were purchased with the intention of exploring their capabilities so that there would be a choice of solutions for a given problem. Also, experience with the laser would enable us to use it in special situation production applications.

EXPERIMENTAL WORK

Component removal with the PMH:

The component to be removed was positioned under a TV camera and monitor which form an integral part of the equipment. The cross hairs on the TV monitor aided in centering the component. The component was "locked" in place with reference to its position under the PMH. RMA flux was applied to the component and the equipment arm was moved so that the component was under the PMH. Heaters along the component periphery were programmed into the microprocessor of the equipment. Heating times and nitrogen gas flow rates were also programmed. A specially designed gripper mechanism was used to "twist" the component from the PWA while the component was still hot. The twisting motion was necessary due to adhesive that is applied under our components.

The following parameters were found to be best for most of the components that were removed to include flatpaks, LCCs and VHSIC type devices (20 mil centers):

PMH Temperature	200°C
Nitrogen Flow	90 CFH
Time	2 to 3 minutes
Bottom Heater Temperature	200°C

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It must be noted that every component removed had its own custom heater program.

Component attachment with PMH:

The board area where the component was to be attached was initially prepared. All pads were desoldered by removal of the spent solder by a suction device. Fresh solder was applied to the pads either by hand, using the appropriate resin cored solder wire or by the application of solder paste to the pads with a pneumatic dispenser. The component to which epoxy was applied was now placed on the area where the previous component had been removed. This was done under microscope to ensure proper placement. It must be mentioned here that the PMH equipment can also be used for part placement using the camera, TV monitor, and part placement fixturing that is built into the PMH system. However they were not used to place the component due to the presence of epoxy. Best process parameters for component attachment were found to be virtually identical with those employed for component removal.

Component attachment using CW Laser:

Components were placed using the microscope after the board pads were prepared as explained earlier. The PWA assembly was mounted on the X-Y table and the various leads were programmed on the N/C control using a high magnification camera, cross hairs and TV monitor, that are a part of the laser soldering cell.

Best results were obtained by using reflowed pads and tinned components. Experiments with components placed in solder paste were tried initially, however, due to the formation of solder balls with this method, it was decided to reflow solder onto the pads prior to component placement.

Epoxy adhesive was used on all components being soldered with the exception of Leadless Chip Carriers (LCCs) which were held by the tackiness of the RMA flux. Epoxy could not be used on LCCs since they have to directly sit on their pads without any gaps.

The most difficult part of the project was being able to form Mil-spec. toe fillets on flatpaks since there is very little amount of solder on the toes to begin with. This is due to the fact that we at Westinghouse form and cut flatpak leads after they have been tinned, consequently, there is a very small amount of tinning at the toe ends. (During the cutting process, a small amount of solder gets smeared onto the toe end of the leads.) This problem was finally solved by applying a

large amount of RMA flux at the toe ends and by applying the laser beam to the center of the foot. Various earlier attempts such as using a circular or diamond shaped beam pattern in order to produce Mil spec. solder joints were unsuccessful primarily due to the fact that we were vaporizing the flux at the toes prior to the formation of a toe fillet. The following parameters gave best results:

- 4" focal length lens
- Current on laser ammeter at 11.5 amps
- Dwell time 400 millisecs
- N/C I/Os were used to automatically turn the laser on the off at each pad. It was also used to vary the laser heat to accommodate the different board pad heat sinks.
- Focused beam directed to the middle of the foot, vertical beam.
- Toe ends heavily fluxed with RMA type flux.
- 80% reflective mirror in the laser cavity.

Figure 1 shows a flatpack lead laser soldered to Mil-spec. Destructive pull tests on 38 flatpack leads performed on a Dage BT-22 Microtester showed an average pull of 1.45 Kg was required to remove the soldered flatpack lead from the board.

For LCCs the following parameters produced the best results:

- 6" focal length lens
- Current on laser ammeter at 16.0 amps.
- Dwell time 600 millisecs (6/10 of a sec. per joint)
- The N/C control was used as explained earlier to turn the laser on and off.
- Focused beam directed at the fillet, laser beam at 45 degree angle.
- 80% reflective mirror in laser cavity.

Figures 2 and 6 shows a row of LCC laser soldered joints. Also shown in figures 3 and 4 is the method employed to flatten the LCC leads prior to laser soldering. Figure 5 shows a cross section of a laser soldered LCC.

For VHSIC devices (20 mil leaded), the following parameters produced the best results:

- 6" focal length lens
- Current on laser ammeter at 10.25 amps.
- Dwell time 1.0 sec (lower times at higher power settings caused burning of the leads and poor solder joints).

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- The N/C control was used as explained above to turn the laser on and off.
- Focused beam was directed at the middle of the foot, vertical beam.
- 80% reflective mirror used in the laser cavity.

PART II

BACKGROUND

One of the key problems with reworking leadless chip carriers (LCCs) in today's high density PWBs is the question of how to reapply new or additional solder to the PWB pads after a bad device is removed. Current techniques include the use of solder paste applied by positive displacement syringe and wire solder applied with a soldering iron.

Development of a technique to apply a specific volume of solder to the castellation of an LCC prior to the device being placed on the PWB for reflow is currently under investigation. Preforms are reflowed onto the LCC to form solder "bumps" at each castellation. Upon completion of the process, the LCC is a stand-alone system which will supply its own solder to the rework site (Figures 7 and 8).

EXPERIMENTAL WORK

This portion of the experiment was performed with 68 I/O, 50 mil pitch and 32 I/O, 40 mil pitch LCCs. Solder volume of the 50 mil joint is $3.120 \times 10^{-5}\,in^3$ and volume of the 40 mil joint is $1.940 \times 10^{-5}\,in^3$. The PWB is polyimide with bare copper tracks and no solder mask. The solder alloy is 63/37 Tin/Lead. Mylar tape was placed at the neck-down point of each land site to prevent solder from wicking down the track. A small piece of 10 mil thick spacer material was used beneath each device to obtain the required 10-mil spacing between the LCC and the PWB. All LCCs were pretinned in a flowing solder pot prior to attaching the spheres at the castellations.

One of the methods used for reflowing the solder of a reworked device is laser soldering with a CW YAG laser system. The device to be reworked is removed from the PWB using a hot gas Programmable Matrix Heater (PMH) rework station. The pad sites are then cleaned off using a braided wick and soldering iron or a vacuum removal device. Once the site has been

prepared, the new device is placed in position with the solder "bumps" aligned over the pads. Flux is applied by either spray or syringe application methods and the PWB is placed in an oven at 125°C for 15 minutes to dry the flux and evaporate out the solvents. The flux must be dry to prevent ignition by the laser beam.

Actual reflow on the laser is accomplished with the parameters shown in Table 1. The critical factor in the laser reflow is the impact point of the beam with relation to the solder "bump". The beam is set to a 45 degree angle with respect to the solder "bump". If the beam is too high the solder will droop but will not flow enough to reach the pad on the PWB and form a good joint. If the beam is too low the joint will be formed between the LCC and the PWB but the upper portion of the castellation won't reflow and the joint will be metallurgically uneven. The actual point where the beam should impact is indicated in figure 7.

Figure 9 shows a first time joint reflowed in a vapor phase system. Figure 10 shows a joint with identical solder volume reworked using the laser system. Similarity between the shapes of the joints indicate the ability to duplicate joint geometries utilizing the different reflow methods.

Pitch	Volume (in^3)	Laser Time (sec)	Current (A)
.050	0.00003120	1.000	16.5
.050	0.00004680	1.100	16.5
.040	0.00001940	0.800	16.5

Table 1 - Laser Parameters

In addition to using the laser, a PMH rework station was tested with the solder "bumped" LCCs and found to give acceptable results. The machine parameters are shown in Table 2. Figure 11 shows a joint reflowed using the PMH system.

Parameter	Preheat	Reflow
Time (min)	2:45	1:00
Top Heater (°C)	200	200
Top Heater Flow	90 CFH	90 CFH
Bottom Heater (°C)	200	200
Bottom Heater Flow	90 CFH	90 CFH
Force		lo
Quench		yes

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METALLURGICAL FINDINGS

Analysis was performed on sample joints built with each of the three processes: vapor phase (the control process), laser, and hot gas (PMH system). Items of particular concern were the frontal and cross-sectional geometry of the joints, the presence of any intermetallics, and the homogeneity of the Tin-Lead grain structure throughout the joint.

Frontal views of the three types of joints (Figures 9, 10, and 11) show virtually identical joint geometry. The joint configuration is slightly bulbous in nature with an abrupt end to the joint at the toe due to the placement of the mylar tape strip to prevent wicking of the solder down the bare copper leads. Cross-sectional Scanning Electron Microscope (SEM) photographs of each of the joints (Figures 12, 13, and 14) show identical formation of the joint in all areas to include the 10 mil spacing beneath the LCC.

SEM enlargements of the interface between the solder and the LCC (Figures 15, 16, and 17) and the solder and the copper pad on the PWB (Figures 18, 19, and 20) show no evidence of excessive intermetallic buildup in any of the processes. All three processes formed similarly homogenous grain structures throughout the joint.

SUMMARY

Examination of solder joints made by the PMH equipment and the laser found both methods satisfactory for rework applications.

The results of this experiment have also shown the laser to be a viable alternative as a production process for reflowing solder joints due to the speed and accuracy of the system.

The addition of solder preforms to LCCs is a viable means of preparing devices for use in reworking densely populated PWBs. Advantages include being able to prepare the device in advance of and separate from the rework operation and the ability to use precise volumes of solder as required for specific applications. Tests with 3 different reflow methods indicate identical geometrical joint formation with similar metallurgical structures using each method.

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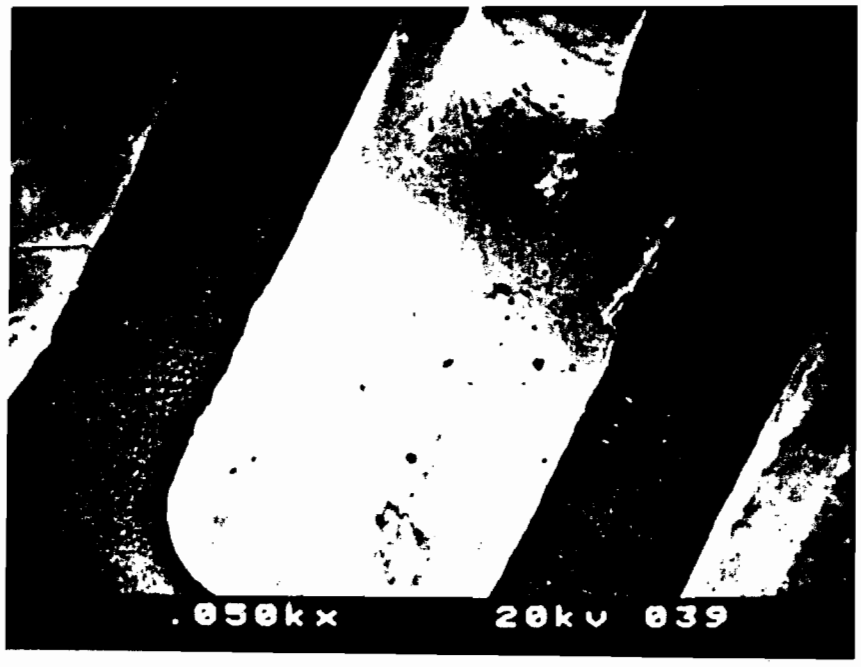

Figure 1

Laser Soldered Flatpak Lead. Note the fully formed Toe Fillet.

Figure 2

A Row of Leads Laser Soldered on a LCC.

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Figure 3

The above picture shows the bottom pads of an LCC. These pads had to be flattened prior to laser soldering so that they would touch the board pads. (Without flattening, only a few pads touched the board pads. These pads were readily laser soldered, however, those that did not touch the board pads were re-formed by surface tension).

Figure 4

The above picture shows the same LCC with flattened bottom pads. This was accomplished by placing it on a flat ceramic surface that had been coated with RMA flux and placed in an oven to melt the solder. A small weight (2.5 gm) was placed on the LCC to aid flattening.

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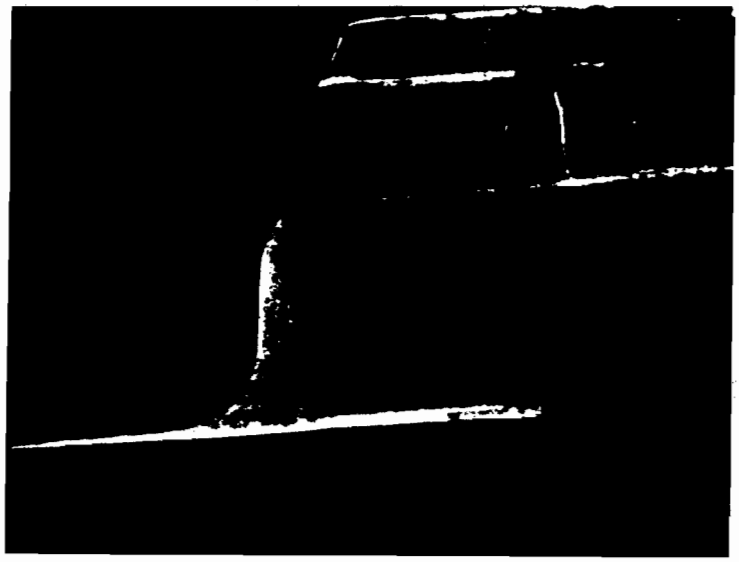

Figure 5

A cross section of a laser soldered LCC is shown. The LCC was placed on a board after its bottom pads were flattened as explained earlier. RMA flux was used to hold the LCC in place during laser soldering.

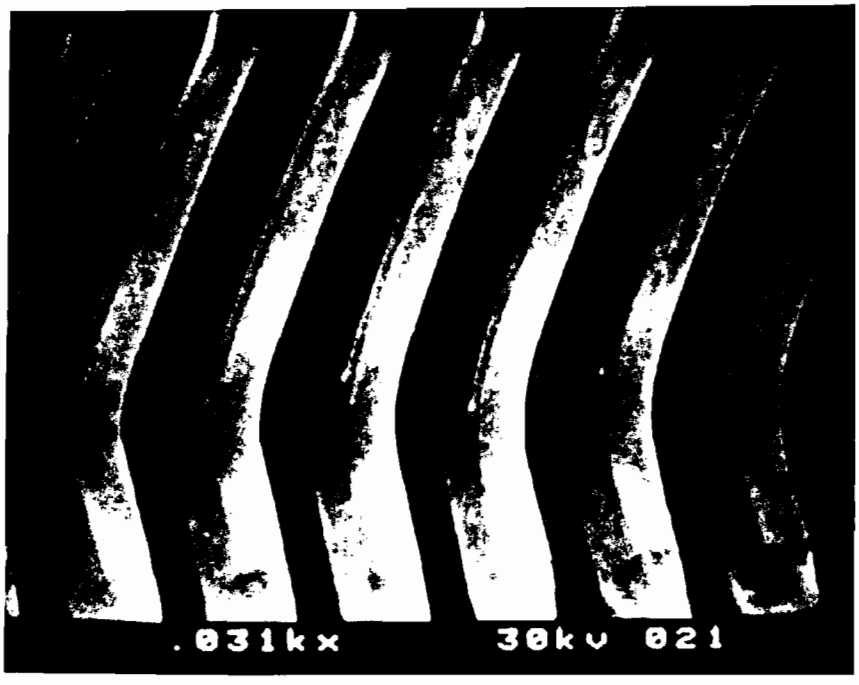

Figure 6

A row of laser soldered VHSIC leads. Accurate forming and placement of leads is most essential for successful soldering of these devices.

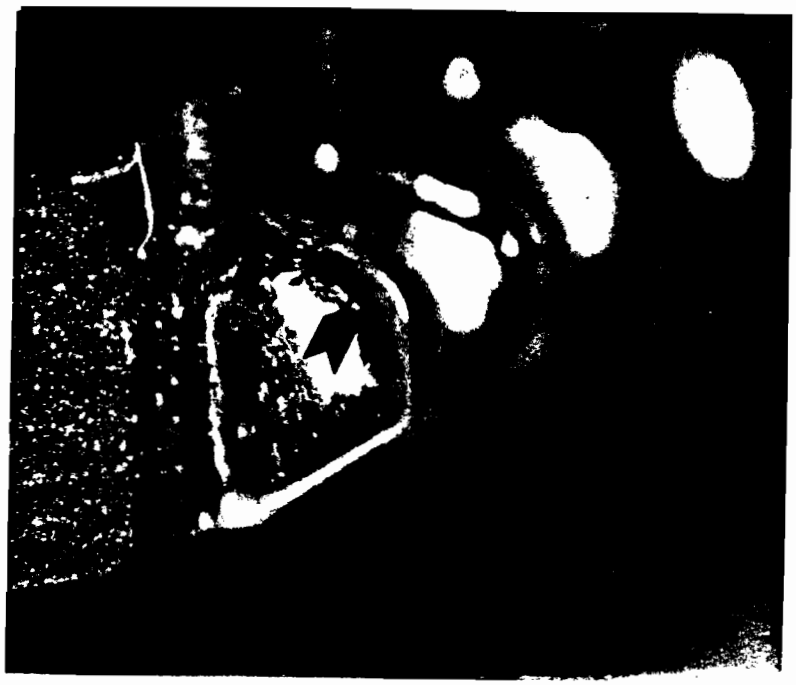

Figure 7

Side view of solder "bump" on LCC castellations (note arrow indicating point of LASER impact).

Figure 8

Front view of solder "bump" on LCC castellations.

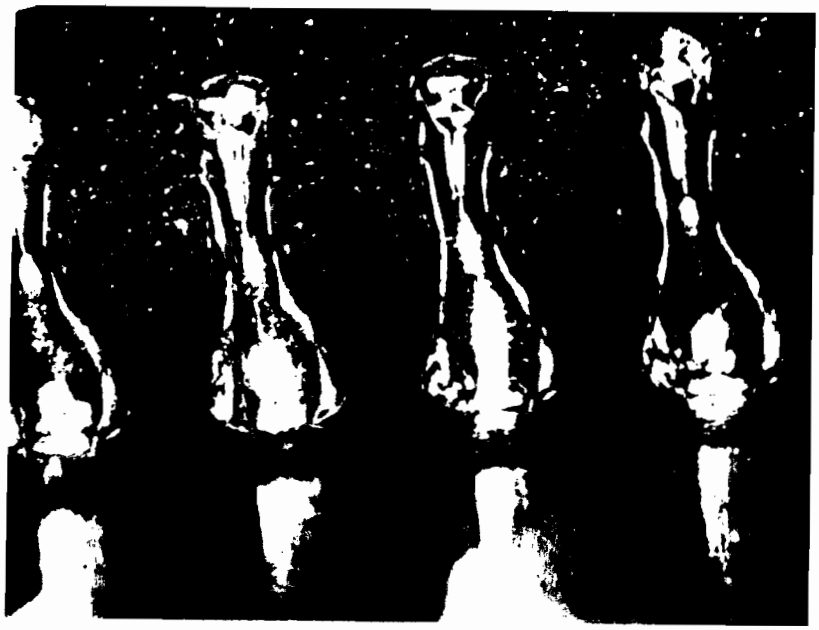

Figure 9

Front view of solder joint reflowed using vapor phase reflow system.

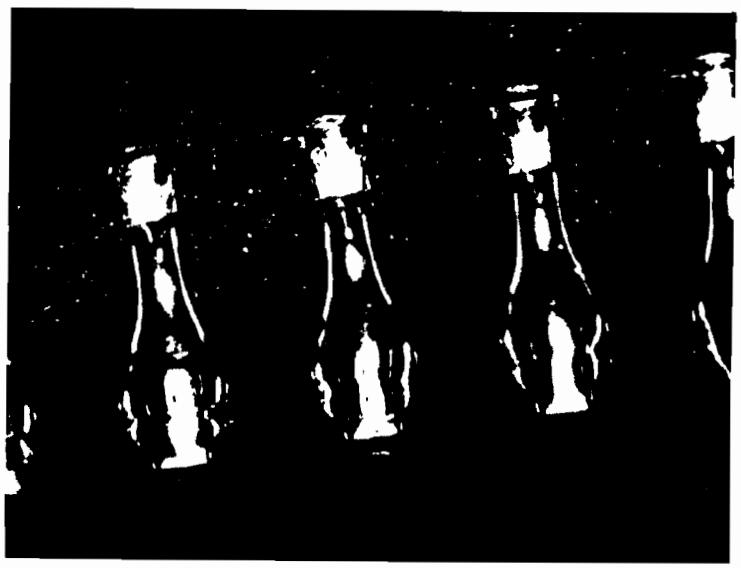

Figure 10

Front view of solder joint reflowed using a CW-YAG LASER.

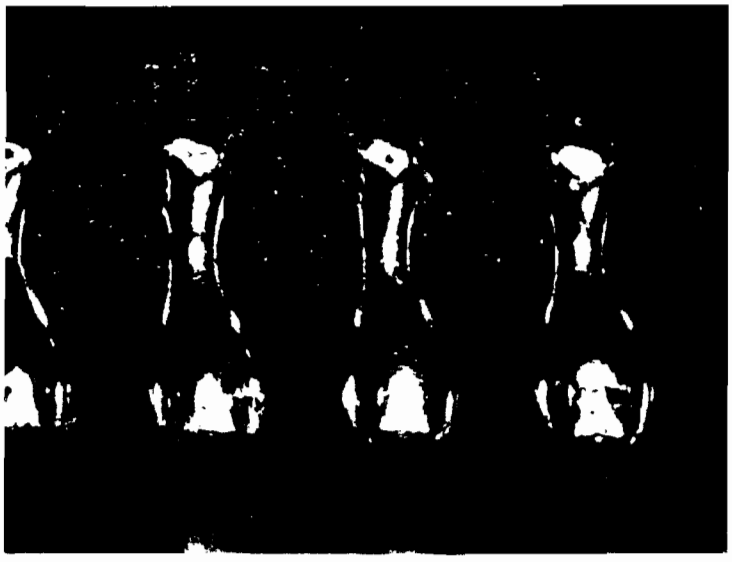

Figure 11

Front view of solder joint reflowed using a PMH system.

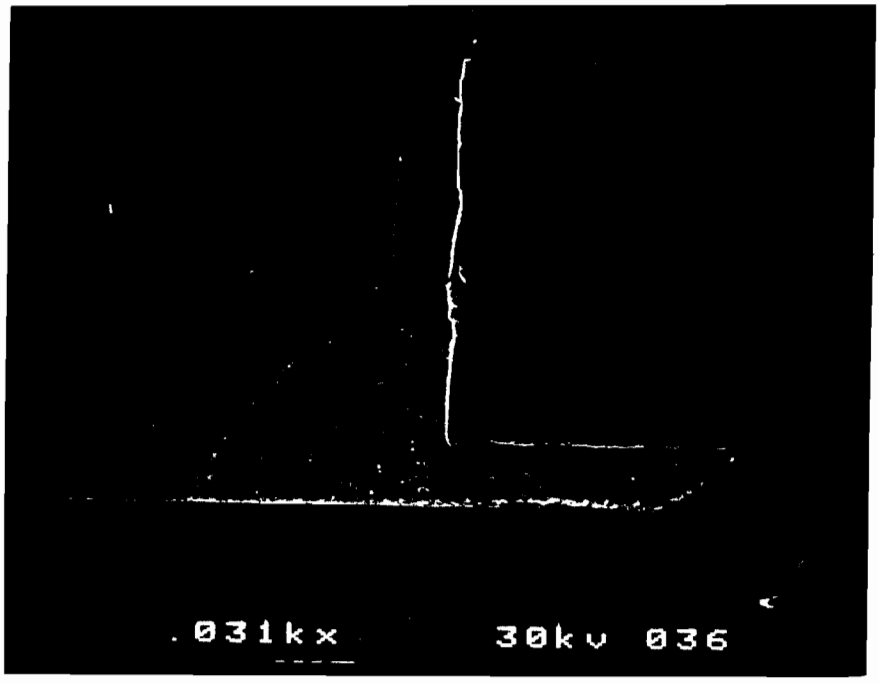

Figure 12

SEM photograph of cross section of solder joint reflowed using vapor phase reflow system.

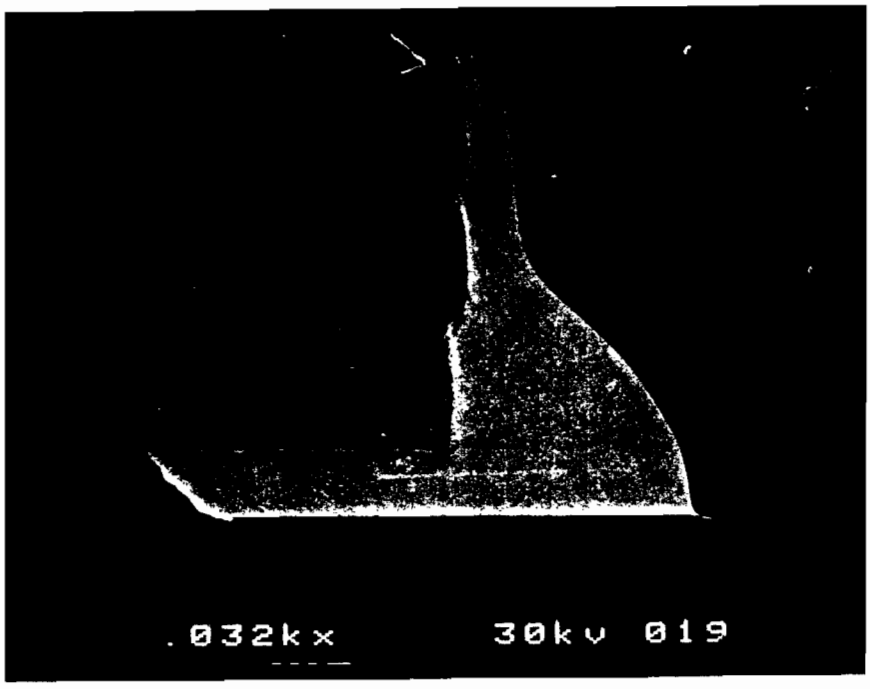

Figure 13

SEM photograph of cross section of solder joint reflowed using a CW-YAG LASER.

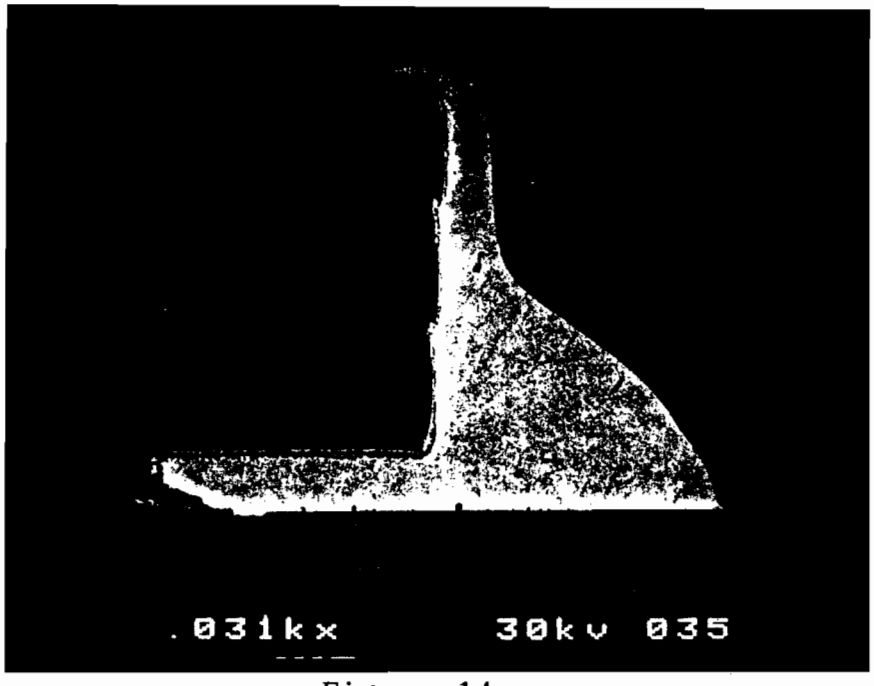

Figure 14

SEM photograph of cross section of solder joint reflowed using a PMH system.

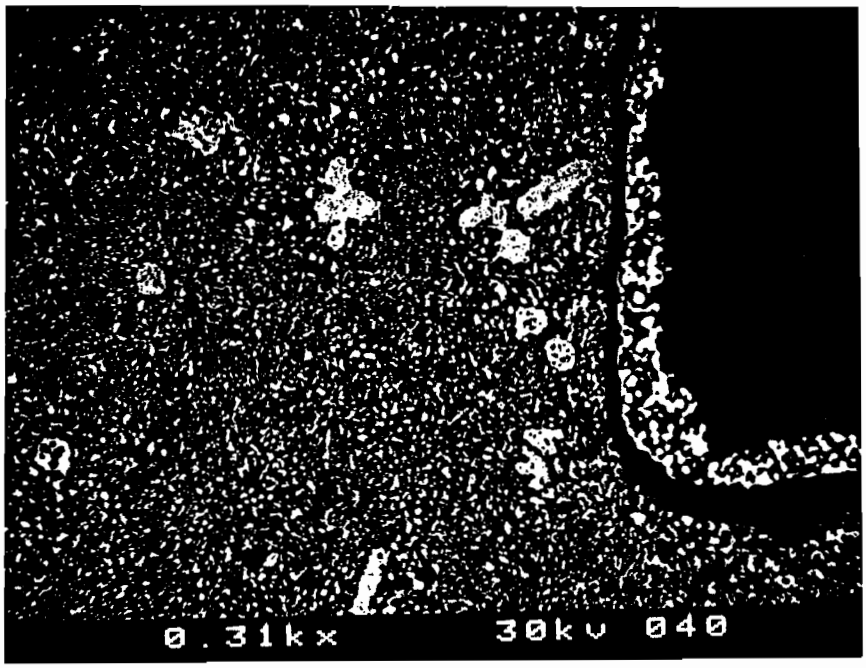

Figure 15

SEM photograph of interface between LCC corner and vapor phase reflowed solder joint.

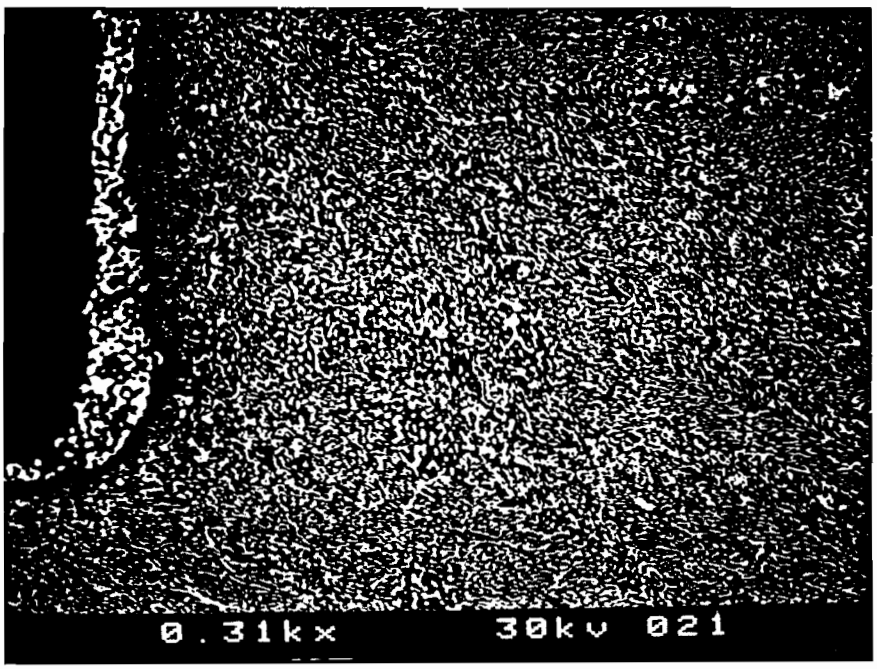

Figure 16

SEM photograph of interface between LCC corner and LASER reflowed

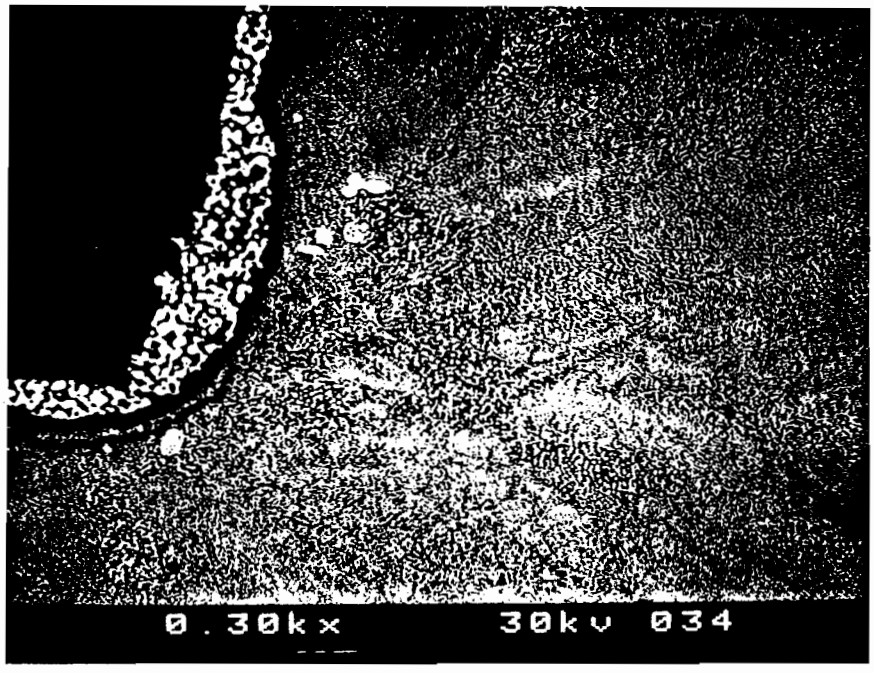

Figure 17

SEM photograph of interface between LCC corner and PMH reflowed solder joint.

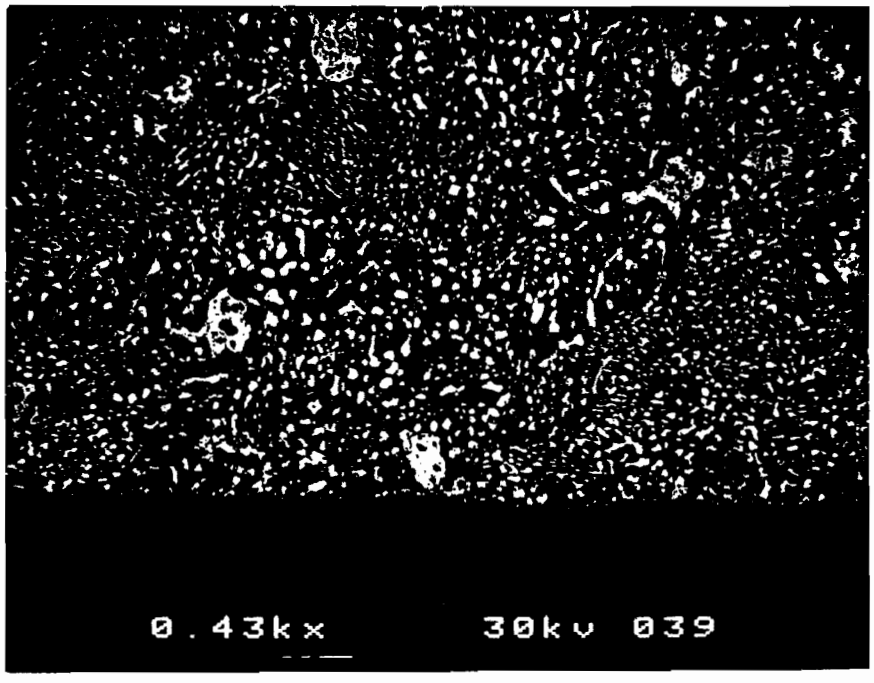

Figure 18

SEM photograph of interface between PWB pad and vapor phase reflowed solder joint.

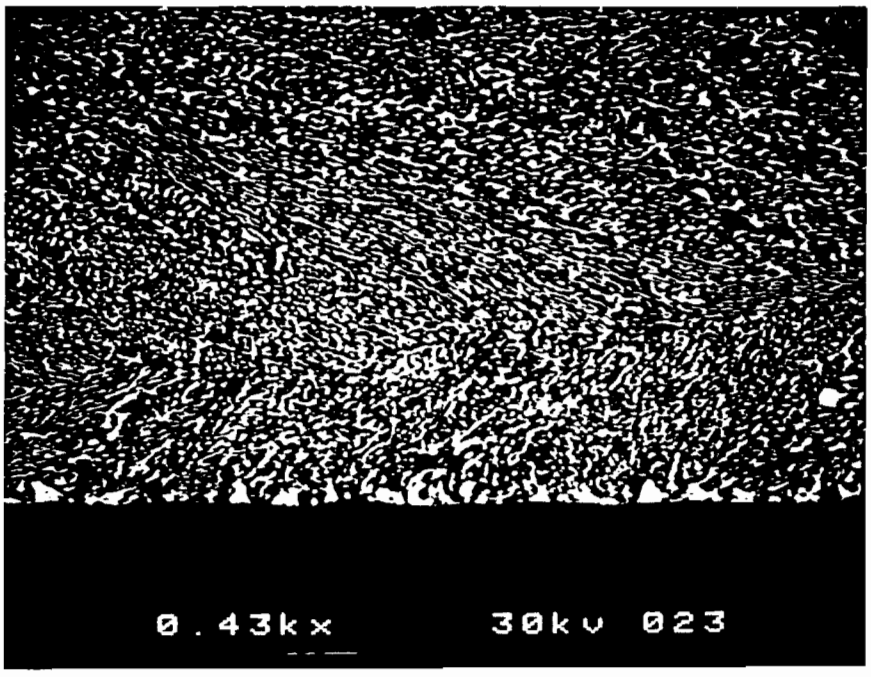

Figure 19

SEM photograph of interface between PWB pad and LASER reflowed solder joint.

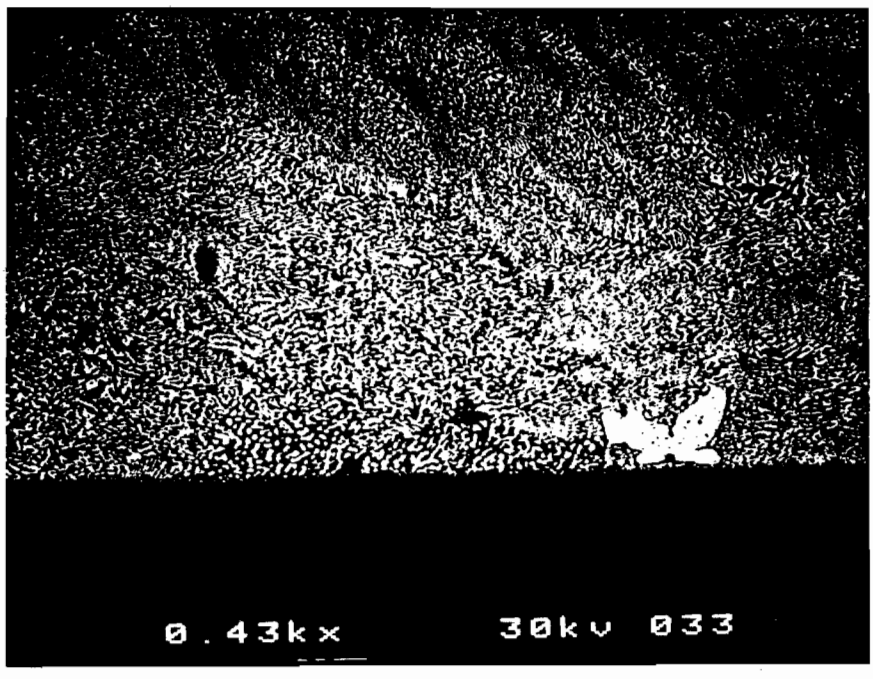

Figure 20

SEM photograph of interface between PWB pad and PMH reflowed solder joint.

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October 26,1987

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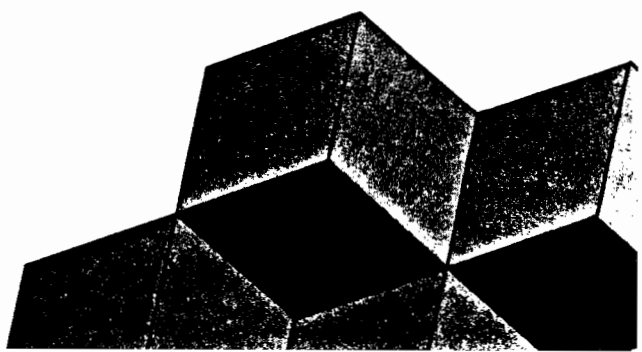
William D. Ashman
Conference Director



CEG
Cahners Exposition Group
Cahners Plaza, 1350 E. Touhy Ave., P.O. Box 5060, Des Plaines, IL 60017-5060
Telephone: 312/299-9311, Int'l Tlx: 82882 CEG CHGO, U.S. Tlx: 256148 CEGCGO DSP

ADDENDUM "A"

For the work, " DISCRETE VLSI PACKAGE REMOVAL/REPLACEMENT
By Scott Dahne and George Hira
"

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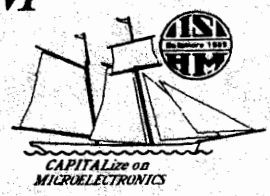
The 18th Annual Hybrid Microelectronics Symposium

Sponsored By Capital Chapter ISHM

Wednesday, May 4, 1988
Holiday Inn, Timonium, Maryland



Schedule of Events

May 3, 1988

Hospitality Suite, Timonium Holiday Inn 6:30-11:00 p.m.

May 4, 1988

Vendor Set-up Starts @ 9:00 a.m.
Vendor Display Hours 2:30-6:00 p.m.

8:00-9:00 Registration
9:00-10:05 Technical papers
10:05-10:15 Coffee Break
10:15-11:20 Technical papers
11:20-11:50 Cocktails
11:50-12:45 Lunch
12:45-1:15 Technical papers
1:20-2:30 Panel Discussion
- 1772 Certification -
2:30-6:00 Vendor Exhibits/Refreshments

Technical Program on Reverse

Cost

ISHM Members - $15.00 Pre-Registered
Non-Members - $20.00 Pre-Registered
Full Time Student Members - $5.00
$5.00 Additional after **April 27**

Deadline: Prepaid reservations are required by April 29,1987. Make checks payable to **Capital Chapter ISHM** and mail to Ms. Platte or Mr. Bryan. Use enclosed Registration Form.

Vendor Announcements

Vendors interested in participating in the Vendor portion of the May Symposium, please call Dick Cope of Microstar (215) 867-0612 immediately to sign up. If you sign up by April 22 you will be included in the **Capital Chapter ISHM Vendor List.**

All Vendors who have signed up and who are planning to sign up, please send advertisement info (brochures, list of companies rep, etc. - limit info to two pages) to Martin Kris for the **Literature Packet** by April 30. Martin is putting together about 175 folders for attendees. *Address:* Tech Reps, 112 South Carolina Ave, Pasadena, Md. 21122 *Phone* (301) 437-5434.

National ISHM Meeting

1988 International Symposium on Microelectronics, October 17-19 in Seattle, WA.

Technical Program

SESSION A **Materials Related Topics**

9:00-9:30 *"Copper Clad Molybdenum for High Performance Electronics Packaging Applications"*
Mr. Sandeep Jain, AMAX Speciality Metals Corp., Cleveland, OH.

9:35-10:05 *"Aluminum Nitride for Use in Electronic Pakaging"*
Written by John B. Blum, Speaker John B. Snook, Spectro-Lambda Inc., Pasadena, MD.

10:15-10:45 *"Light Weight Enclosures for Avionics"*
Mr. Joe Merritt, Litton-Amecom, College Park, MD.

10:50-11:20 *"Controlled Expansion Pakaging"*
Mr. Joe Merritt, Litton-Amecom, College Park, MD.

12:45-1:15 *"Thick Film Vehicles for High Print-Speed Applications"*
Dr. W. F. Howard, Jr. and Stephanie T. Coyne, Heraeus Inc., Cermalloy Div., West Conshohocken, PA.

SESSION B **Process Related Topics**

9:00-9:30 *"Residual Gas Analysis....More Than Just A Moisture Measurement Technique"*
Mr. Donald T. Shuman, Oneida Research Services Inc., Whitesboro, N.Y.

9:35-10:05 *"Labeling & Tracking Electronic Circuit Boards with Bar Coding"*
Mr. Ben Tafoya, Intermec Mid-Atlantic, Laurel, MD.

10:15-10:45 *"Analysis of the Effect of Laser Machining on 96% Alumina Ceramic Substrates and the Advantages of New La-Tite Finish"*
Mr. Michael L. Capp and Mr. Roger R. Luther, Laserage Technology Corp., Waukegan, IL.

10:50-11:20 *"A Rework Methodology for High Density Leaded and Leadless Packages"*
Mr. Scott Dahne and Mr. George Hira, Westinghouse DEC, Baltimore, MD.

12:45-1:15 (TBA)

PANEL DISCUSSION

1:20-2:30 Mil-Std-1772 Certification

Panel Members: Mr. Jim Blanton, DESC
Mr. Bill Eikenberg, Westinghouse DEC, Quality
Mr. Brad Born, Spectrum Micro Devices, Prod. Assurance