COVER EVALUATION FOR LARGE
HYBRID MICROCIRCUITS

Published September 1976

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PDO 6989231
Final Report

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COVER EVALUATION FOR LARGE HYBRID MICROCIRCUITS

BDX-613-1500 (Rev.), UNCLASSIFIED Final Report, Published
September 1976

Prepared by J. H. Williams, D/842, under PDO 6989231

Diallyl phthalate (DAP) was evaluated as a cover material for large HMCs but found unsuitable because DAP covers do not remain sealed to substrates during temperature cycling. Ceramic covers evaluated for the same application were found to remain sealed during temperature cycling and are recommended for use. The use of thermoplastic resins for sealing covers on HMCs was also evaluated and General Mills' Versalon 1164 was found to be the best general resin for the job because it has a slightly higher temperature requirement for complete softening and sealing.

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A prime contractor for the United
States Energy Research and
Development Administration
Contract Number E(29-1)-613 USERDA

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SUMMARY

Some new hybrid microcircuits (HMC) require a different size cover than those used on previous HMCs. Several potential ceramic cover suppliers took exception to the tolerances for the covers, and either submitted a quote for parts with broader tolerances, or submitted no quote at all. As a result, an alternate cover material was sought. Diallyl phthalate (DAP), a thermosetting plastic, was chosen as a possible material for making molded covers. This report covers an evaluation of molded DAP covers and their suitability for use on HMCs. The evaluation was performed between March and August of 1975 and included leak-testing to determine seal integrity as well as temperature cycling to reveal any thermal expansion problems between the ceramic and DAP parts.

Results indicate that DAP covers do not remain sealed to substrates during temperature cycling. For this reason, DAP is not considered a satisfactory material for use in making HMC covers. Ceramic covers with broader tolerances than previously specified were then evaluated in the same manner as the DAP covers and were found to remain sealed during temperature cycling.

This project also included an evaluation of several different types of thermoplastic resins for possible use in sealing covers on HMCs. The method presently used involves an epoxy preform placed between the cover and the HMC. The entire assembly is held together by a clamp while it is being cured in an oven. This produces a good seal, but when a package must be opened to change or repair a circuit, great difficulty is encountered in removing the cover. A thermosetting resin ensures easier removal of the cover since resin softens at a much lower temperature than epoxy. Thermosetting resins are also easier than epoxy to handle and store since no refrigeration is required, and easier to seal since no curing time is required.

The evaluation involved sealing several packages with three different types of thermosetting nylon resins: Milvex 1000, Versalon 1164, and Versalon 1300. All packages were gross leak tested and each type of resin was tested for lap shear strength. Versalon 1164 has a slightly higher temperature requirement for complete softening and sealing, and for this reason is probably the most desirable of the three. Although removal of the cover was comparatively easy, great care was required to keep the resin from stringing across and falling onto the circuit.

DISCUSSION

SCOPE AND PURPOSE

The purpose of this work was to determine the feasibility of using diallyl phthalate (DAP) covers for hybrid microcircuits and to evaluate an adhesive that will permit removal and replacement of covers for troubleshooting purposes. This work was done between March and August 1975.

PRIOR WORK

An assembly contains 0.88 by 1.8 inch (22.4 by 45.7 mm) hybrid microcircuits--larger than other HMCs manufactured by Bendix Kansas City. Plans called for ceramic covers, but it was found that none of the vendors would manufacture ceramic covers to the required ± 5 mil (0.13 mm) tolerance. The decision was then made to evaluate DAP covers for this application since the DAP covers are available in the specified tolerance.

ACTIVITY

Several DAP covers were epoxy bonded to substrates for testing. Three different types of substrates were used in the evaluation: plain ceramic, ceramic with chrome-gold metallization on one side, and ceramic with chrome-gold metallization on both sides. The purpose of the plain ceramic was to test the bondability of the epoxy to ceramic as well as the DAP cover. The chrome-gold substrate was used to test the bondability of the epoxy to gold. The third substrate was metallized on both sides so a Kovar heat sink could be soldered to one side and the DAP cover could be bonded to the other side. Figure 1 shows a typical cover, preform, and substrate.

An epoxy preform (Ablefilm 517B) is placed on the substrate and the cover is then placed over the preform. The preform is supplied in a 14-mil-thick (0.36 mm) frozen sheet and has been punched out in the proper preform size by the manufacturer. It must be stored at -40°F (-40°C) until needed to prevent any curing of the adhesive. After the substrate, preform, and cover are assembled, the entire package is clamped together and placed in an oven for curing at 165°F (74°C) for 3 hours as recommended by Bendix Materials Engineering. The only variable is the force applied during epoxy cure. The dimensions of all substrates and covers were 0.88 by 1.8 inches (22.4 by 45.7 mm). The preforms were 50 mils (1.27 mm) wide and 14 mils (0.36 mm) thick. Before bonding, all substrates and covers were cleaned as follows:

Figure 1. Typical HMC, Preform, and Cover

- Ultrasonically in trichloroethylene for 1 minute, and
- Sprayed with TE-35 (Freon) for 20 to 30 seconds and allowed to air dry.

It was thought that the greatest stress for the epoxy bond might occur during the temperature cycling of packages attached to heat sinks because of differences in thermal expansion coefficients for the materials. The heatsink-mounted substrates were intended to verify or refute this theory.

The DAP covers were bonded to nine samples of each substrate using three bonding pressures (1, 2, and 3 psi [6.9, 13.8, and 20.7 kPa]). After the epoxy had cured, each package was subjected to a gross leak test consisting of immersing the package in Fluorinert which has been heated to 125°C. If a leak existed in the package, it produced a stream of bubbles in the Fluorinert. Circuits that exhibited a leak were patched with liquid epoxy and retested.

After all the circuits had passed the leak test, they were temperature cycled ten times from -40°C to +125°C and back and held at each temperature extreme for 20 minutes. The leak test was then repeated to find any leaks that occurred during temperature cycling.

As can be seen in Tables 1 through 3, there do not appear to be any significant differences among the three bonding pressures used. The percentage of failures after temperature cycling, particularly in the case of the substrates with Kovar heatsinks, indicates that DAP is not a suitable material to use for HMC covers.

Following the DAP cover evaluation, large ceramic covers with ± 0.028 inch (0.71 mm) tolerance were bonded to substrates and tested in the same manner as the DAP covers. Nine covers were sealed to chrome-gold metallized substrates to which leads had been soldered. Nine more covers were sealed to chrome-gold metallized substrates that had been soldered to Kovar heatsinks. The results of the tests are summarized in Tables 4 and 5.

The results show that ceramic lidded circuits will survive the same temperature shocks that caused the DAP-lidded circuits to leak. For this reason, the ceramic covers are recommended for use on the large HMCs.

The second effort of the project was the evaluation of several thermoplastic resins to determine their suitability for use in bonding covers to HMCs. Thermoplastic resins have several distinct advantages over epoxy for use as a sealant.

- HMC packages may be sealed in 10 minutes without any need for curing time. The epoxy presently used requires a cure cycle of 3 hours at 165°F (74°C).
- Preforms do not require any refrigeration. Epoxy preforms now being used must be kept at -40°F (-40°C) until ready for use.
- If rework is required on the circuit, delidding can be performed at a temperature of approximately 300°F (149°C). An epoxy seal requires higher temperatures for longer times.

There are, however, three disadvantages to thermoplastic resins.

- Tensile and shear strengths may not be adequate at elevated temperatures.
- Outgassing properties could be objectionable.
- Removal of the cover might require extra care to keep thermoplastic resin off the circuit.

Three samples of resins were obtained from General Mills: Milvex 1000, Versalon 1164, and Versalon 1300. They were pressed into sheets 10-mils (0.26 mm) thick and then cut into preforms 50-mils (1.27 mm) wide as shown in Figure 2. The best sealing temperature was determined experimentally for each resin.

Table 1. Data on 0.88 by 1.8 Inch (22.4 by 45.7 mm)
Ceramic Substrates With DAP Covers and
14-Mil-Thick (0.36 mm) Epoxy Preforms Cured
at 165°F (74°C) for 3 Hours

Pressure	Package	First Gross Leak	After Patch Second Gross Leak	Gross Leak After Temperature Cycling
1 psi (6.9 kPa)	1	OK		OK
	2	OK		FAILED
	3	OK		FAILED
2 psi (13.8 kPa)	1	OK		OK
	2	OK		OK
	3	OK		FAILED
3 psi (20.7 kPa)	1	OK		FAILED
	2	OK		FAILED
	3	OK		FAILED

Table 2. Data on 0.88 by 1.8 Inch (22.4 by 45.7 mm)
Gold-Metallized Substrates With 7-Mil (0.18 mm)
Soldered Leads, DAP Covers, and 14-Mil-Thick
(0.36 mm) Epoxy Preforms Cured at 165°F (74°C)
for 3 Hours

Pressure	Package	First Gross Leak	After Patch Second Gross Leak	Gross Leak After Temperature Cycling
1 psi (6.9 kPa)	1	FAILED	OK	OK
	2	OK		FAILED
	3	OK		FAILED
2 psi (13.8 kPa)	1	FAILED	OK	OK
	2	OK		OK
	3	OK		FAILED
3 psi (20.7 kPa)	1	OK		FAILED
	2	FAILED	OK	OK
	3	OK		FAILED

Table 3. Data on 0.88 by 1.8 Inch (22.4 by 45.7 mm)
Gold-Metallized Substrates Soldered to Heatsinks
With DAP Covers and 14-Mil-Thick (0.36 mm) Epoxy
Preforms Cured at 165°F (74°C) for 3 Hours

Pressure	Package	First Gross Leak	After Patch Second Gross Leak	Gross Leak After Temperature Cycling
1 psi (6.9 kPa)	1	OK		FAILED
	2	OK		FAILED
	3	OK		FAILED
2 psi (13.8 kPa)	1	FAILED	OK	FAILED
	2	OK		FAILED
	3	OK		FAILED
3 psi (20.7 kPa)	1	OK		FAILED
	2	OK		FAILED
	3	OK		FAILED

Table 4. Data on 0.88 by 1.8 Inch (22.4 by 45.7 mm)
Gold-Metallized Substrates With 7-Mil (0.18 mm)
Soldered Leads, Ceramic Covers, and 14-Mil-Thick
(0.36 mm) Epoxy Preforms Cured at 165°F (74°C)
for 3 Hours

Pressure	Package	First Gross Leak	After Patch Second Gross Leak	Gross Leak After Temperature Cycling
1 psi (6.9 kPa)	1	OK		OK
	2	OK		OK
	3	FAILED	OK	OK
2 psi (13.8 kPa)	1	FAILED	OK	OK
	2	OK		OK
	3	OK		OK
3 psi (20.7 kPa)	1	OK		OK
	2	OK		OK
	3	OK		OK

Table 5. Data on 0.88 by 1.8 Inch (22.4 by 45.7 mm)
Gold-Metallized Substrates Soldered to Heatsinks,
With Ceramic Covers and 14-Mil-Thick (0.36 mm)
Epoxy Preforms Cured at 165°F (74°C) for 3 Hours

Pressure	Package	First Gross Leak	After Patch Second Gross Leak	Gross Leak After Temperature Cycling
1 psi (6.9 kPa)	1	OK		OK
	2	OK		OK
	3	OK		OK
2 psi (13.8 kPa)	1	OK		OK
	2	OK		OK
	3	OK		OK
3 psi (20.7 kPa)	1	OK		OK
	2	OK		OK
	3	OK		OK

A lap-shear strength test was performed on ceramic substrates that had been bonded together with the resin. The results are shown in Figure 3. The strength is sufficient to keep the cover in place at higher temperatures if the force applied to the side of the package is not too great.

Each type of resin was used to seal five packages. After sealing, each package was subjected to a gross-leak test. Those packages that failed the first gross-leak test were reheated to see if the leak could be eliminated. The results are given in Table 6. All packages that had failed the first leak test passed the second test after reheating.

A few covers were removed and then replaced to see if the same cover and preform could be used several times. Although this method did work, it is still advisable to clean off any remaining preform material and use a new preform for resealing. This procedure is much easier with the thermoplastic resins than it is with the epoxy preforms.

Figure 2. Thermoplastic Preform Dimensions

ACCOMPLISHMENTS

The results of the DAP evaluation indicate that the DAP covers will not remain sealed to the substrate during temperature cycling and that another material such as ceramic, should be used. The ceramic covers that were evaluated did remain sealed to the substrate during temperature cycling and are recommended for lidding large HMCs. The thermoplastic resins evaluated did make an effective seal, both in terms of bond strength and freedom from leaks.

Figure 3. Lap Shear Strength Versus Temperature

Table 6. Evaluation of Thermoplastic Resins

Resin	Sealing Temperature	Package	First Gross Leak Test	Second Gross Leak Test
Milvex 1000	221°F (105°C)	1	OK	
		2	FAILED	OK
		3	OK	
		4	FAILED	OK
		5	OK	
Versalon 1300	221°F (105°C)	1	FAILED	OK
		2	OK	
		3	OK	
		4	FAILED	OK
		5	OK	
Versalon 1164	320°F (160°C)	1	OK	
		2	OK	
		3	OK	
		4	FAILED	OK
		5	OK	

Packages were sealed with 2 pounds (9 N) force for 4 minutes and had 10-mil-thick (0.26 mm) preforms (1.27 mm) wide and 7-mil (0.18 mm) leads on two sides.

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