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FINAL REPORT

# CONTAMINATION CONTROL IN HYBRID MICROCIRCUIT MODULES

NAS8-32437

Submitted to

George C. Marshall Space Flight Center

National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama 35812

Submitted by:

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## Introduction

The influence of chemical and particulate contamination upon the reliability and service life of hybrid microelectronic systems is well known and numerous attempts have been made to reduce their deleterious effects. Much of the present cost in such systems is a direct cost of clean environment assembly conditions required for their assembly. The manufacturers of commercial systems have recently initiated assembly of systems using several passivating surface coatings. Several coating systems used include the parylene and Dow Corning silicone (DC90-711) as representative of the systems employed. These passivating coatings have obvious potential for decreasing the degradation caused by particulate contaminants in hybrid systems. These coatings also have the possible deleterious effect of trapping chemical contaminants which may have possible long term degrading influences upon the performance of the system.

## Objective

The primary objective of this program was to evaluate the influence of two representative coating systems upon the reliability of a representative hybrid microcircuit.



## Experimental Outline

The evaluation was conducted upon a group of thirty hybrid microcircuits which form a part of the gyro-rebalance loop system. These circuits were fabricated and assembled at MSFC and furnished to

Vanderbilt for use in these development studies.

1. These systems were subdivided into three lots which served as (a) controls, (b) coating with parylene, and (c) coating with DC90-711.

2. The efficacy of the passivated systems to resisting contamination effects was determined by subjecting all three types of samples to the following environmental tests:

| | | |
|---|---|---|
| A. | Leak Test* | MIL-STD 883A (Fine and Gross) |
| B. | PIND Test | |
| C. | Electrical Test* | |
| D. | Stabilization Bake | 24 hours at 150°C |
| E. | Thermal Cycling | MIL-STD-883A (-65° to +150°C 100 cycles) |
| F. | Thermal Shock | MIL-STD-883A (0°C to 100°C) |
| G. | Mechanical Shock | MIL-STD-883A-Condition B |
| H. | Acceleration | MIL-STD-883A-Condition A |
| I. | High Temperature Storage | 168 hours at 125°C |
| J. | Final Electrical | |
| K. | External Visual | |

*Leak tests and electrical tests to be performed after each major environmental event.

The sequence of testing actually employed is shown in Figure 1.

# EXPERIMENTAL PROCEDURE

## A. Leak Testing

The leak testing was conducted in accord with MIL-STD 883 for both coarse and fine leaks. These tests were conducted in conventional commercial equipment at MSFC.

## B. PIND Test

The parcticle impact noise detection was conducted using the apparatus available at MSFC with two different operators. The technique requires a pretesting mechanical shock to "loosen" particles and this may be the origin of some observed operator differences. Both operators did not always agree upon the result of the PIND test, but the chief operator was able to reproduce his observations.

## C. Electrical Function Test

The electrical function tests were conducted at VAnderbilt and MSFC. The replication of this test led to some disagreement in results which were rationalized before proceeding to the subsequent treatment. Generally speaking, these disparities were the result of external contact problems.

## D. Stabilization Bake

This treatment was accomplished in an air atmosphere at a temperature of 150$^{o}$C ($\pm$ 2$^{o}$C) for a time of 24 hours.

## E. Thermal Cycling

The thermal cycling was conducted in a Thermodynamic Engineering Model 220102 apparatus using a mineral oil for the +150°C side and a Freon -113 as the -65°C fluid. The samples were enclosed in a copper canister and were mechanically moved between the baths and ambient temperature according to Mil Std 883A-1010.1 test condition C. The samples were subjected to 10 thermal cycles.

## F. Thermal Shock

The thermal shock was carried out using the Thermodynamic Engineering apparatus using water as the cold and hot fluid. The samples were held at 100°C for five minutes and rapidly transferred to the 0°C bath. This cycles was repeated for 15 times on each sample. The samples were held in a coarse mesh screen basket during these treatments.

## G. High Temperature Storage

The high temperature storage was accomplished in an air atmosphere for 168 hours at 125°C (±2°C).

## H. Constant Acceleration

The acceleration treatments were conducted in accord with MIL Std 883-A Method 2001.1. The apparatus in which this work was conducted was located at MSFC. A specially designed test fixture was constructed to hold the samples for this experiment. The samples were accelerated along the axis X1, X2, Y2, Y1, Z1, and Z2 for one minute at test Condition A which specifies a stress level of 5,000 g.

## I. Mechanical Shock

The mechanical shock trestments were conducted in a special fixture which was calabrated at MSFC. The fixture gave a 1,500 g shock with a 0.5 msec duration. This shock was applied to all samples on the positive and negative directions along the X,Y, and Z axes.

## Experimental Results

The results of all the tests conducted are summarized on the attached figure. These results reflect the PIND and electrical failures as observed after the treatment noted in the column. It was somewhat surprising to find that the uncoated control samples were substantially more prone to electrical failure than either of the coated sys tems. All of the electrical failures observed were those in the uncoated control samples. In the case of the electrical failures noted in the control samples, the PIND test indicated problems before failure in only two of eight subsequent electrical failures. This would not appear to be a very efficient predictor of impending electrical failures.

In the case of the parylene coating system many PIND failures were observed, but no subsequent electrical failures were noted. This result again suggests that the PIND is not a reliable predictor of failure. The high incidence of anomalous PIND failures is probably a result of loose particles of parylene coating in the packages. This problem is an inevitable result of masking the sealing surfaces during the coating process and some loose coating material results from removal of the masking material.

In the case of the silicone coating, no failures of either PIND or electrical tests were observed.

# PIND & ELECTRICAL RESULTS AFTER NOTED TREATMENT

| SAMPLE | STAB. BAKE | TEMP. CYCLE | TEMP. SHOCK | HI. T. STORAGE | ACCELERATION | MECH. SHOCK |
|---|---|---|---|---|---|---|
| Control 1 | | | | | | |
| 2 | | | | | ✖ ● | ✖ ● |
| 3 | | ✖ | | | ✖ ● | ✖ ● |
| 4 | | | | | | |
| 5 | | | | | | ● |
| 6 | | | | | | ● |
| 7 | | | | | | |
| 8 | | | | | | ● |
| 9 | | ● (repaired) | | | ● | ✖ ● |
| 10 | | | ✖ | | | |
| | | | | | | |
| Parylene 1 | | | | | ✖ | |
| 2 | | | ✖ | | ✖ | |
| 3 | | | | | | |
| 4 | | | ✖ | | ✖ | |
| 5 | Many PIND | failures no | | | | |
| 6 | electrical | failures | | | ✖ | ✖ |
| 7 | | | ✖ | | | |
| 8 | | | | | | |
| 9 | | | | | ✖ | |
| 10 | | | ✖ | | ✖ | ✖ |
| | | | | | | |
| Silicone 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | No failures | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |

✖ PIND Reject ● Electrical failure

## Conclusions

The results of the present program which are based upon a limited sample size indicate that the coating process enhances the reliability of the hybrid microelectronic system. The efficacy of the PIND technique for predicting electrical failures is poorly demonstrated by the present technique. This may be a difficulty associated with the coating process but even the uncoated system failed to demonstrate the usefulness of the PIND technique.

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|---|---|---|---|---|---|---|
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| 2 | | | | | × ● | × ● |
| 3 | | × | | | × ● | × ● |
| 4 | | | | | | |
| 5 | | | | | | ● |
| 6 | | | | | | ● |
| 7 | | | | | | |
| 8 | | | | | | ● |
| 9 | | ● (repaired) | | | ● | × ● |
| 10 | | | × | | | |
| | | | | | | |
| Parylene 1 | | | | | × | |
| 2 | | | × | | × | |
| 3 | | | | | | |
| 4 | | | × | | × | |
| 5 | Many PIND electrical | failures no failures | | | | |
| 6 | | | | | × | × |
| 7 | | | × | | | |
| 8 | | | | | | |
| 9 | | | | | × | |
| 10 | | | × | | × | × |
| | | | | | | |
| Silicone 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | No failures | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |

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