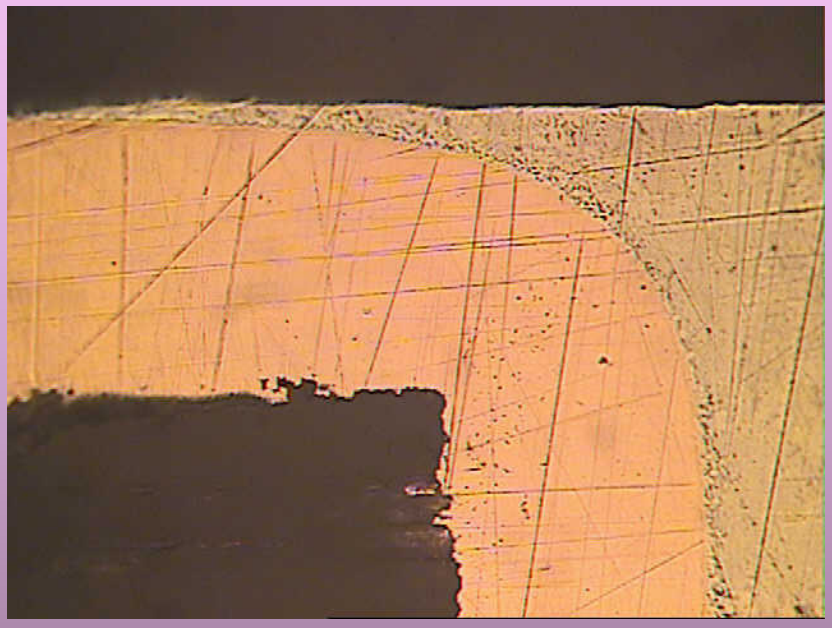
Ver. 1

XTREME RELIABILITY PRINTED CIRCUITS



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Chapter One

Introduction to Reliability

The reliability of the printed circuit has increased and decreased, over time, as technology has intervened and driven the chip packages temperatures up and the size of the via and line width down. One problem which has never been corrected or improved upon, is thermal cycling fatigue of the vias. As the temperature of the circuit cycles up and down over time, the expansion and contraction difference of both the copper and the Fr4 causes the vias to crack and creates either opens or intermittent. The temperature swings and more importantly, the maximum temperature that a circuit sees on each cycle, will determine how many cycles it can survive before the vias crack. Many factors such as number of layers, Tg of the material, the speed of the temperature swing, copper plating ductility, and most of all, the number of assembly cycles, all affect the basic number of cycles that a printed circuit board will survive.

Think of the electronics in the tail of a commercial jet, exposed to -55º F at altitude and probably 150º F, when sitting at the gate, in the sun, engines running, at Phoenix International Airport. Imagine how extreme the temperature and environmental conditions are under the hood of today's vehicles.

As electronics is required to power, control and run our lives, more of that control is of a critical nature. Electronic devices on aircraft, backup inverters for operating rooms, motor drives for elevators and thousands of other applications require the printed circuit to have an inherent survivability. I define survivability as exposure to internal and external forces that would normally destroy or cause a malfunction. Example: a short on a nonessential feature of an aircraft that may destroy a critical power distribution printed circuit before the fuse blows. This reference may well apply to a short in an on board gambling machine causing the aircraft to crash. In order to improve the basic printed circuit board reliability, I embarked on a multiyear survivability study of the internal physics into the working of the via during thermal temperature cycling, which is explained here.

My findings may surprise you and most definitely, cause you to rethink your present methods of design and manufacturing.
…….

The capabilities are virtually the same as a normal board with the only exception being the unavailability of a very fine pitch of .5 mm. The line limit is 4/4 with the same number of multilayers as normal.

For stage one and some stage two, normal printed circuit board CAD data with no special requirements or designs are required. This means your existing art work and CAD data are probably usable. Solder mask and final finish are unaffected by the Xtreme reliability process and all normal variations are available with Xtreme reliability circuits.

Any printed circuit laminate can be used with the Xtreme reliability process: Fr4, Polyimide, BT epoxy, aluminum core, and low CTE materials, Teflon and speed board. All will give much higher reliability numbers when used with Xtreme reliability processing.

Through many experiments, I found a method of manufacturing printed circuits which featured a reduced failure rate. Over the years, I refined this process and a new innovative high reliability printed circuit was created.

Typically, an Fr4 6 layer circuit with 175 Tg material, will start to exhibit signs of cracking at 240 to 400 thermal cycles. Each temperature cycle with the Hats thermal cycling testing computer starts at -45° C and extends to 145° C. The machine monitors the resistance of a string of vias. If the resistance of the string changes by more than 10%, the via is considered to have failed. Tests have shown when a via reaches 10% change, the crack is well established and will shortly fail.

It would appear that the lower temperature is not really important. The highest temperature is more critical, as it is related to the Tg of the material. Each time the temperature swings near the Tg, the Fr4 laminate expansion rate increases dramatically. The copper in the vias has a relatively steady expansion change rate with temperature changes. The expansion rate difference between the two causes the Fr4 to expand in the

Z axis at a faster rate than the copper. The repeated expansion difference slowly tears the copper apart through metal stress fractures.

Xtreme high reliability circuits will significantly improve the overall life cycle span of your product. The cost to replace and repair damaged electronic goods caused by cracked vias is staggering. One major European telecom manufacturer reported spending $220 million to replace all the outdoor pole mounted circuit boards in one line alone. The fault was traced to thermal cycle damaged vias, caused by excessive outdoor temperature swings in a sealed black box up a pole.

Your company no longer has to experience cracked vias and erratic failures. Xtreme high reliability printed circuits can give you the reliably that your customers' products require. If you manufacture medical, space, aeronautical, transportation or any product that cannot fail, you need the advanced protection of high reliability circuits.

Special high temperature Xtreme high reliability boards can be manufactured which will withstand 200˚C for extended time without via or hole cracking problems. They are used for down the hole and extreme applications such as space and aircraft electronics. The only limit of the temperature is the mechanical/survival properties of the laminate itself, i.e. Td.

Tg is not an important effect with Xtreme reliability as the copper via is now stronger than the laminate expansion. So Td, the temperature to degradation or the top usable temperature is now important.

- Xtreme reliability can be manufactured with any laminate, or type of board.

- No difference in Gerber or design is needed.

- Does not affect any parameters such as dielectric rating, CAF ability, impedance or fine lines.

- Has been extensively tested, as well as shown by a certified independent laboratory to significantly improve reliability.

- Extends lower temperature usability to -173°C or lower.

- Extends upper usable temperature a significant amount above Tg.

- Priced above normal Fr4 printed circuits.

- Available in quick turn, prototypes as well as production orders.

- Does not affect UL rating or military rating.

- Significantly improves radiation ratings in nuclear hardening.

Chapter Two

Reliability Testing of Xtreme Circuits

Outside independent qualified tests show the new Xtreme reliability product exceeded 2000 thermal cycles from -40°C to145ºC. Additional in house testing qualified the Xtreme reliability circuit withstood 30 solder cycles at 550º F or three times the lead free T288 test.

The following samples were prepared by the engineering staff for solder float testing.

Sample 1	.062 d/s	Xtreme Reliability	175 Tg	FR406 Isola Laminate
Sample 2	.093 d/s	Xtreme Reliability	175 Tg	FR406 Isola Laminate
Sample 3	.062 6 layer	Xtreme Reliability	175 Tg	FR406 Isola Laminate
Sample 4	.062 10 layer	Xtreme Reliability	175 Tg	FR406 Isola Laminate
Sample 5	.062 6 layer	Normal Technology	175 Tg	FR406 Isola Laminate
Sample 6	.062 d/s	Xtreme Reliability	135 Tg	FR402 Isola Laminate
Sample 7	.062 d/s	Normal Technology	135 Tg	FR402 Isola Laminate

Figure 3: The flowing chart relates to the testing performed and the results.

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7
5 solder floats	**passed**	**passed**	**passed**	**passed**	**passed**	**passed**	**passed**
10 solder floats	**passed**	**passed**	**passed**	**passed**	**failed**	**passed**	**failed**
15 solder floats	**passed**	**passed**	**passed**	**passed**	**failed**	**passed**	**failed**
20 solder floats	**passed**	**passed**	**passed**	**passed**	**failed**	**passed**	**failed**
25 solder floats	**passed**	**failed**	**passed**	**passed**	**failed**	**failed**	**failed**
30 solder floats	**passed**	**failed**	**passed**	**passed**	**failed**	**failed**	**failed**

The solder float test utilized the flowing testing parameters:
A standard 12 hole military coupon was used for all solder stress tests. Solder float samples (6) was routed from the appropriate board, The solder temperature was verified by use of a calibrated IR probe and a calibrated digital temperature probe. The solder pot temperature was confirmed at 550°F.

Each sample was fluxed and placed upon the solder to float and removed after 10 seconds. Each sample was placed on a marked sheet as to the number of cycles completed. Each cycle was five minutes long allowing for complete cool down of the sample before the next hot solder float.

After each set of 5 cycles, the sample was potted and polished to reveal the center of the holes and micro-etched to improve identification of possible cracks in the copper.

A determination of any visible crack either along the barrel, at interconnects or at the copper plated knee, resulted in a failed declaration.

After the solder float test, it was evident that the Xtreme reliability technology improved substantially the number of solder stress test floats in all of the applications. There is a relationship between the number of solder float cycles that a circuit can survive and how long the circuit will survive thermal cycles in the product life, as well as the number of assembly cycles.

Thermal Cycle Verification

To test the high reliability technology in a prolonged thermal cycling cycle, a series of test samples were prepared from a coupon generated and supplied by Hats testing service. The following board samples, four of each, were manufactured and sent to Hats for long term thermal qualification.

Sample 1	.062 d/s	Normal technology	1	135 Tg	FR402 Isola Laminate
Sample 2	062 d/s	Normal * technology	2	135 Tg	FR402 Isola Laminate
Sample 3	062 d/s	Xtreme Reliability	3	135 Tg	FR402 Isola Laminate
Sample 4	.093 d/s	Normal technology	1	175 Tg	FR406 Isola Laminate
Sample 5	093 d/s	Normal * technology	2	175 Tg	FR406 Isola Laminate
Sample 6	093 d/s	Xtreme Reliability	3	175 Tg	FR406 Isola Laminate
Sample 7	062 6 layer	Normal technology	1	175 Tg	FR406 Isola Laminate
Sample 8	062 6 layer	Normal * technology	2	175 Tg	FR406 Isola Laminate
Sample 9	062 6 layer	Xtreme Reliability	3	175 Tg	FR406 Isola Laminate

Normal technology represents a typical manufacturing method used by most shops. Normal * technology was a test of different parts of the Xtreme reliability technology.

Typically, a normally manufactured 6 layer Fr4 printed circuit when subject to Hats thermal testing cycles only lasts 120 to 240 cycles before the via holes crack or open.

To qualify the new Xtreme reliability product, 36 samples of mixed construction and control normal boards were sent to Cat IRTS testing service for prolonged thermal cycling on a HATS tester. The samples were pre-conditioned at IRTS with IPC PCQR2 assembly cycle standard of 6 simulated solder assembly cycles and then put on thermal test. After 13 days and 2000 cycles later, the Fr4 6 layer boards passed.

Testing Services courtesy IRTS, manufacturer of the HATS(tm) Tester. Information about the HATS(tm) Tester can be found at www.HATS-Tester.com

The assembly simulation was performed on an APS convection reflow oven as follows:

* 2 minute heat-up to 183ºC
* 1 minute dwell between 183°C and 215ºC
* 3 to 7 minute cool-down (dependent on coupon thickness)

Even the Xtreme reliability low Tg 135ºC Fr4 samples survived 1600 to 1800 cycles, far beyond the normal 120 cycles typical in the industry. A solder float test was initiated in which samples of Xtreme reliability boards were subjected to repeated solder immersions. The Xtreme reliability circuits survived over 30 cycles for 10 seconds at 550ºF, without any evidence of hole cracking, proving it a very robust board.

The difference between my Xtreme reliability circuits and normal boards is ???

Purchase the xtream reliability technology e-book to find out the secret.