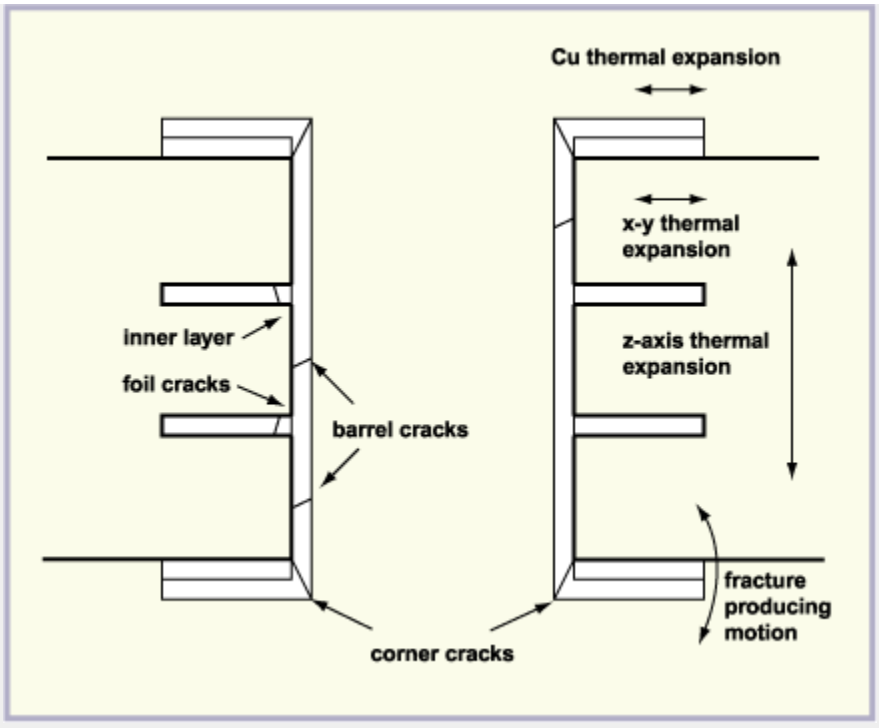
Board Failures

Many of the failures in the printed circuit board are related to corrosion, delamination, electromigration and other effects of moisture which are considered elsewhere. There are, however, some other causes for failure during *application*, as distinct from those problems that are manifest during fabrication and assembly. Chief among these is the result of differences in temperature coefficient between the materials of which the board is made; copper has a CTE of around 15 ppm/°C, whereas most resins have substantially higher values in X and Y axes, and higher again in the Z axis, especially once the glass transition temperature has been exceeded.

The most obvious result of differences in CTE is when the board warps. The non-flat surface can give problems during manufacture and result in stresses on components when the board is flattened during assembly, as was indicated earlier in the unit. However, warping is generally a problem that is evident either on receipt of the board or after soldering (especially reflow soldering). Although having long-term reliability implications if stresses are induced because of warping, a warped board is in itself not necessarily unreliable.

However, potential unreliability due to differences in CTE is much more severe when we look at individual holes rather than the complete board. As indicated in Figure 1, there are a number of ways in which the through-hole metallising can fail. These are conceptually very similar to those experienced with a tubular rivet, and there are many similarities, except of course in scale!

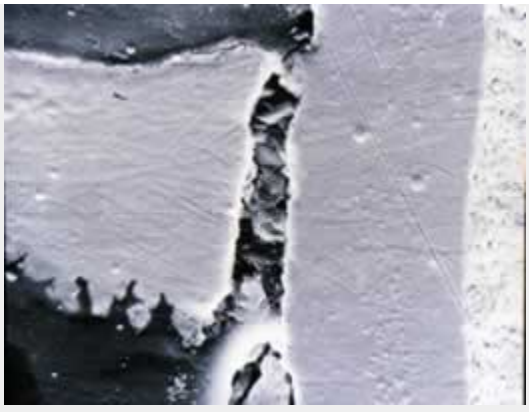
Figure 1: Schematic cross-section of a plated through-hole in a 4-layer PCB showing typical locations of failures due to thermal stress



Illustrated in photographs are typical examples of corner cracking and inner layer cracks. Notice particularly that corner cracking starts from the stress point in the inside, rather than the outside, and can be relatively harmless in appearance. However, given that cracks tend to propagate, intermittencies and open-circuits can be created in a number of places within the through-hole structure.

Cracking on corner of PTH

Multi-layer junction failure

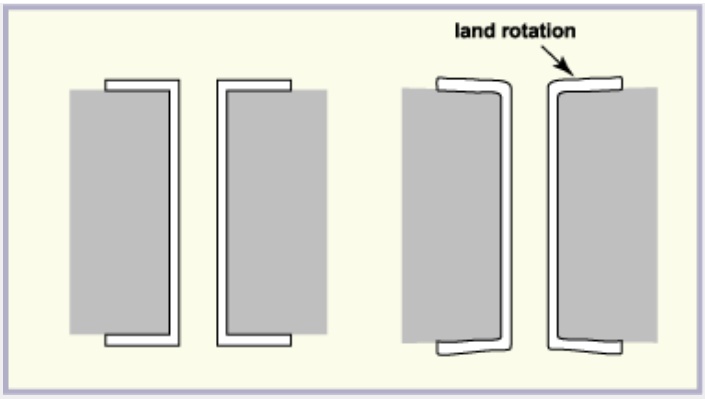


Note that these effects are the result of non-elastic behaviour in the materials. As you would expect, when the through-hole is heated, the

epoxy expands faster than the copper, setting up a tensile stress in the copper and a compressive stress in the epoxy. In the cooling cycle, the reverse happens, with the epoxy shrinking faster than the copper generating tensile stress in the epoxy and compressive stress in copper.

If the performance of the materials were truly elastic, then there would be no problem. However, after repeated cycling, the epoxy grows, with the result that the board is thicker than in its original condition. This results in what is referred to as the ‘rotation’ of the copper land observed at the outer boundary of the through-hole, as shown in Figure 2.

Figure 2: Effect of thermal ratcheting in a plated through-hole structure



Because the stress exceeds the yield strength of copper, given sufficient temperature cycling, the cumulative strain will cause a crack in the copper barrel. This effect, referred to as ‘ratcheting’ is also seen in solder joints subjected to cyclical stresses.

Source : http://www.ami.ac.uk/courses/topics/0165_bf/index.html