TSM-DS Manufactured with Various Prepregs

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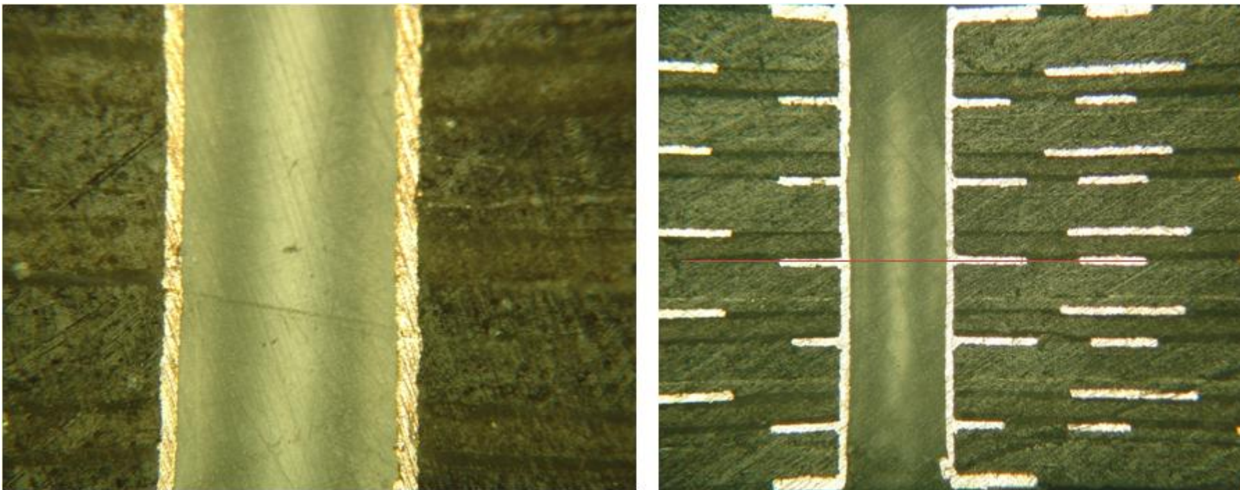
Preparation of Printed Circuit Boards

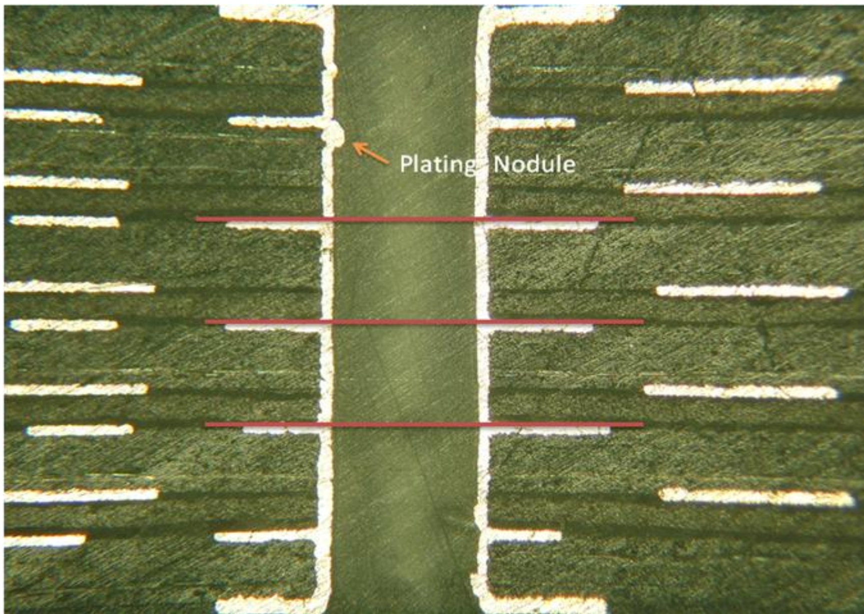
Multilayers using 10 mil cores of TSM-DS were manufactured with 4 different bonding materials including: Speedboard C, fastRise27, Dupont FEP, and Aclar PCTFE (HT1.5 bondfilm, Arlon 6700, RO3001). Lamination was conducted independently using the following conditions: fastRise27 (3 hours at 420◦F/216◦C), Speedboard C (3 hours at 420◦F/216◦C), FEP (3 hours at 550◦F/288◦C), PCTFE (446◦F/230◦C). All of the inner layer cores were etched at the same time. All of the laminated pwbs were drilled using the same parameters: 0.022" phenolic, 62.4K rpm, 10 in/min, chipload = 0.16 mil, retract rate 100 in/min, dwell 0.07 seconds between hits, 0.028" drill bits, and 0.093" phenolic backup. Seven 10 mil TSM-DS 1 oz copper clad cores were bonded together with the respective prepregs (FR27-0050-40, Speedboard C 0.0035", 2 mil FEP, 2 pies 1.5 mil PCTFE film). Prior to plating, the drilled through holes were treated for 30 minutes at 1000 watts with 100% hydrogen gas. The outerlayers were print and etched.

TSM-DS/fastRise27:

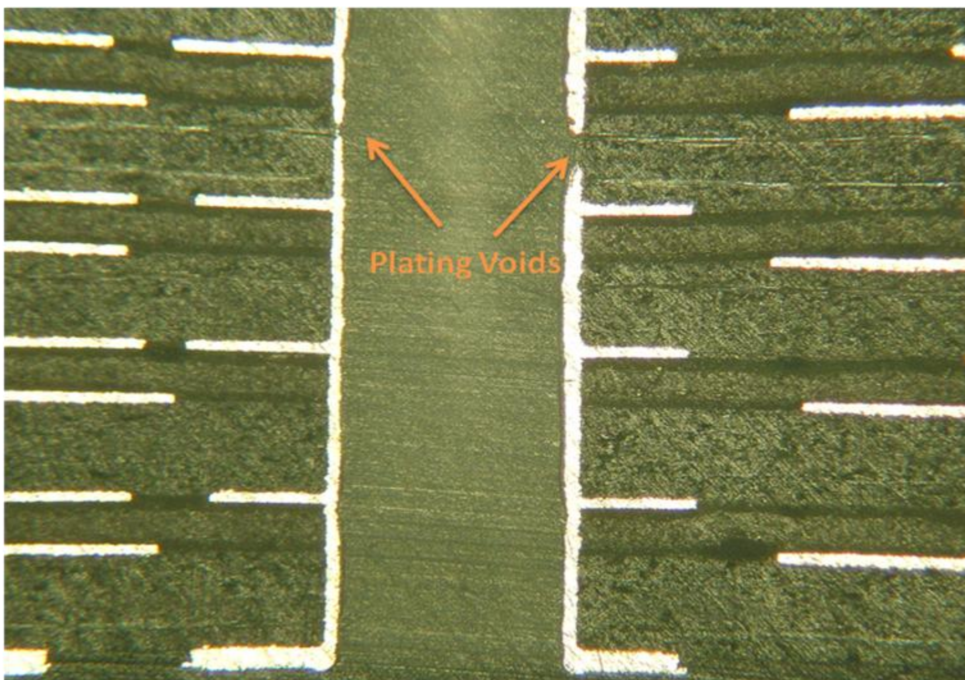
In general the plated through holes for these pwbs looked good. Defects were generally only at the entry material which suggested that the entry material was not optimal.



One key point to notice in the TSM/FR27 combination is that the pads are perpendicular to the barrel. This suggests that the prepreg layer is fairly stiff such that the drill cuts through the prepreg with some resistance such that the pad does not deflect. The TSM-DS/fastRise27 combination did have the occasional plating nodule that seemed to mostly be associated with the entry side of the pwb.

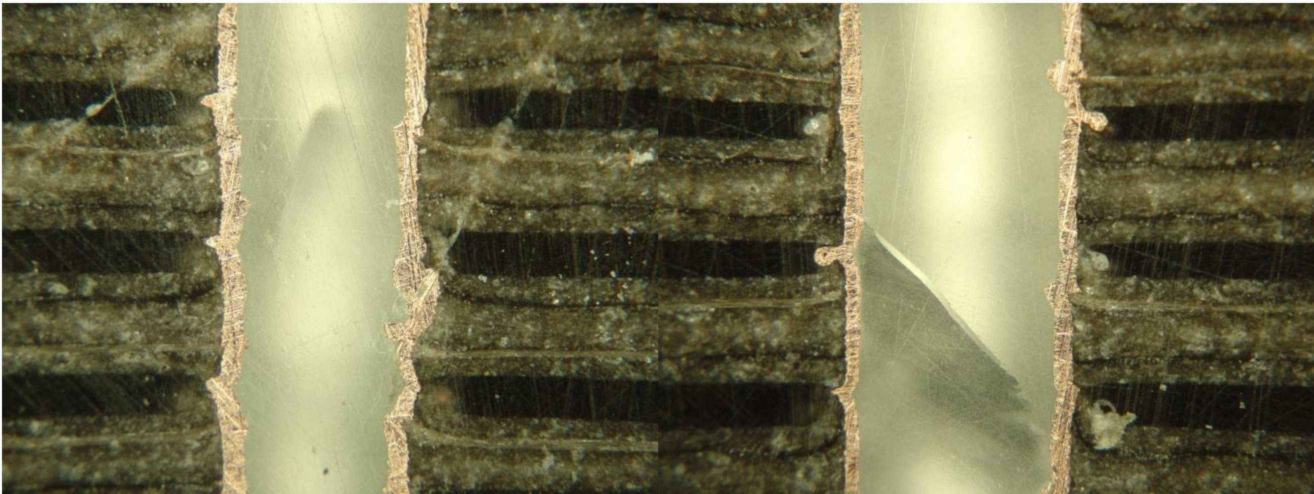


In general the plating of the fastRise27/TSM-DS pwbs was good. A few sections were found where the plating chemistry failed to plate the center of the drilled hole. The fact that the plating voids were only found on the TSM-DS areas suggests that the fastRise27 prepreg is relatively easier to plate than the TSM-DS.

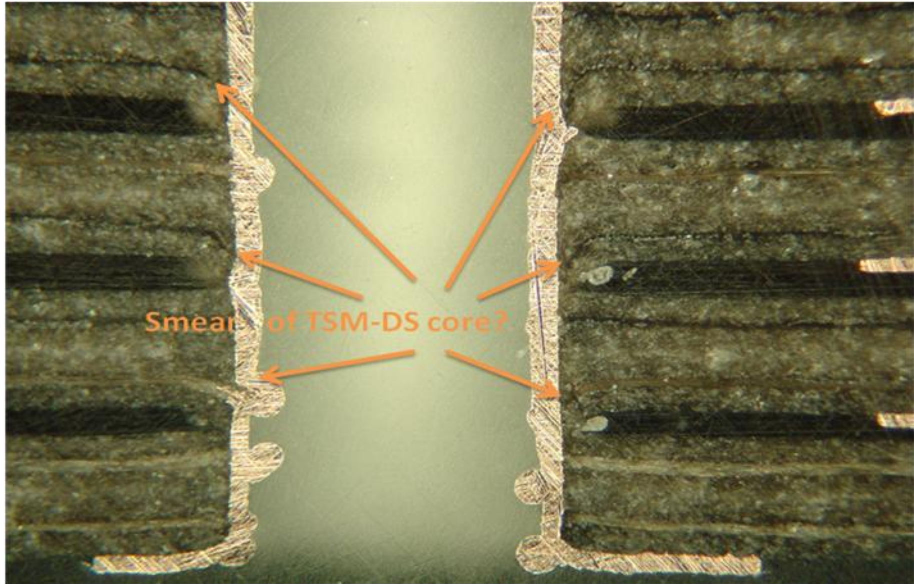


TSM-DS/HT1.5 bond film (Arlon6700/RO3001), Polychlorotrifluoroethylene):

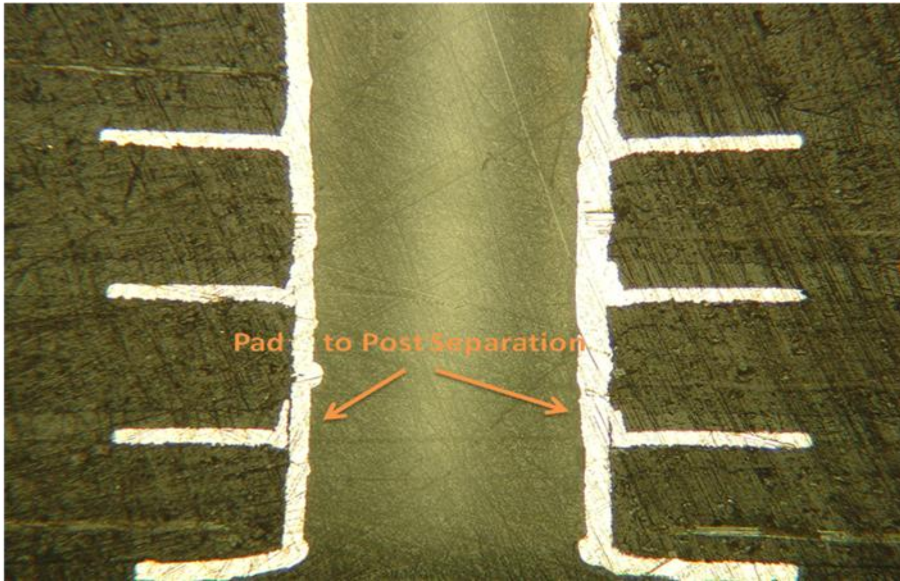
The TSM-DS/HT1.5 thermoplastic bond film demonstrated very rough holes. The film itself looked like small sections were torn at the edges leading to infiltration of plating chemistry.



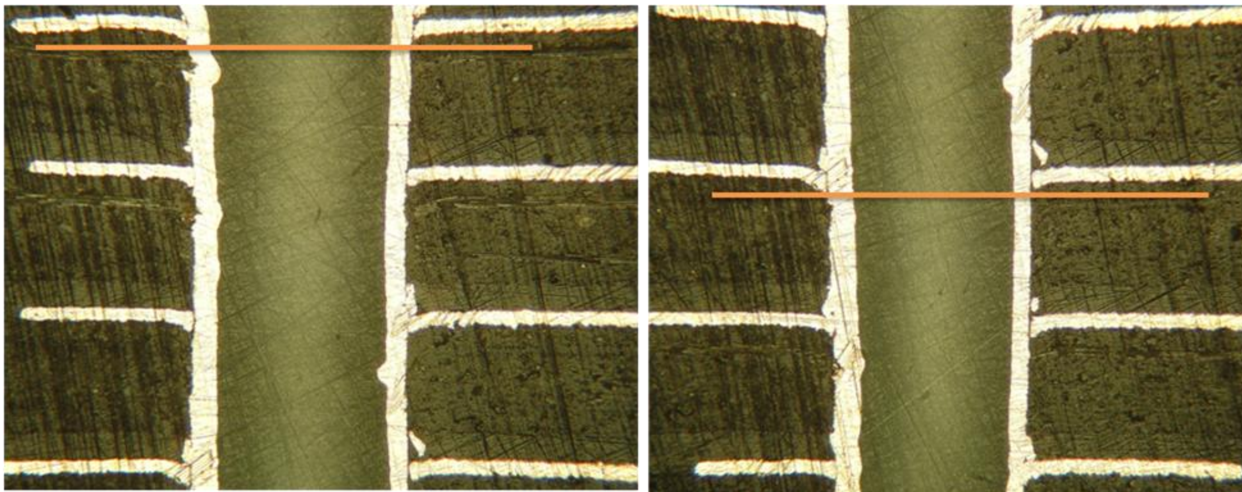
This migration of plating along the film lines might also be a result of the thermoplastic film melting during drilling causing some of it to deposit on the drill bit leaving behind a voided area where plating chemistry could enter. Some areas in the crosssections look like the core material has actually smeared across the thermoplastic film.



The smear of the TSM-DS core is probably related to the fact that the thermoplastic film melts and the TSM-DS core deflects. A more serious issue is the pad to post interconnect. Opens could be readily observed on the TSM-DS/HT1.5 bonding film interconnects.

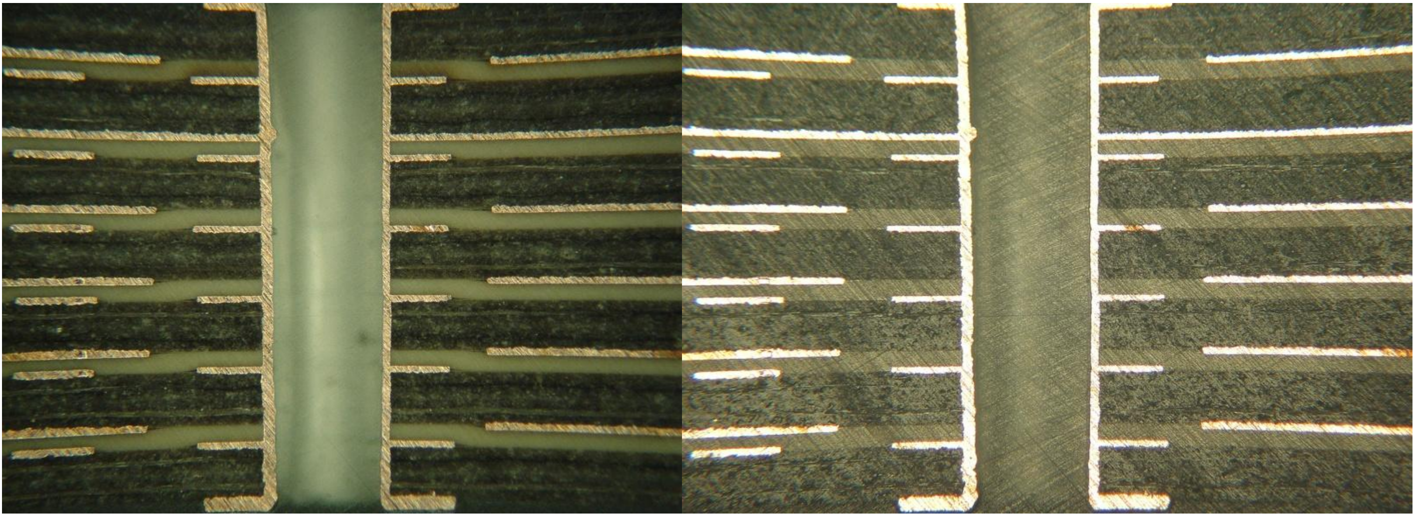


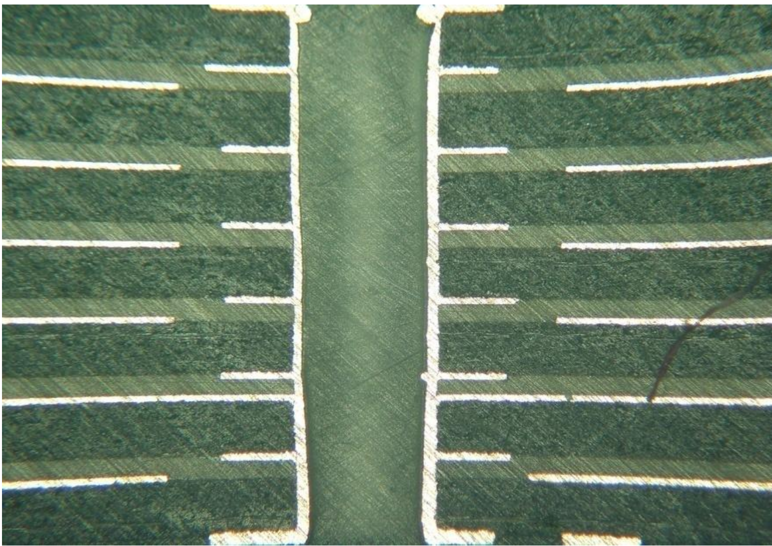
One could make the argument that the drilling parameters could be optimized for a given prepreg. However, the four stackups with TSM-DS/prepg contain 70-80% TSM-DS. The prepreg is actually a minority in these stackups. With the TSM-DS being constant in all stackups, the thermoplastic bond ply HT1.5 (Arlon 6700/RO3001) clearly had the highest probability of leading to opens as it appears that the thermoplastic melts during drilling. There also seems to be a deflection of the pad that leaves behind a leg that doesn't always plate to the barrel of the hole.



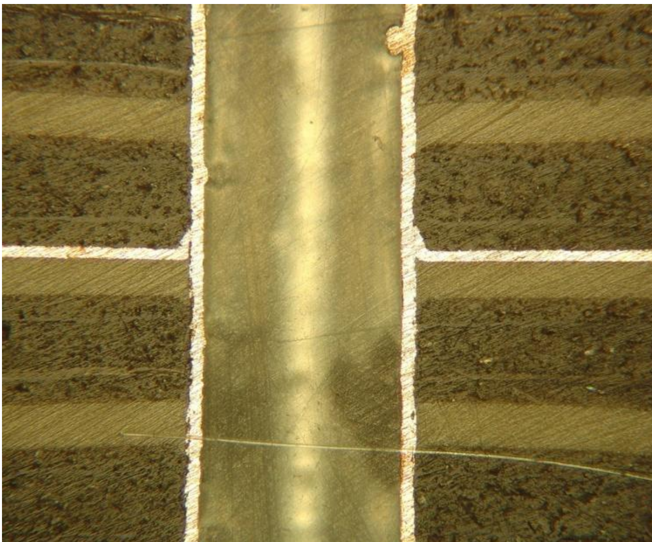
TSM-DS/Speedboard C:

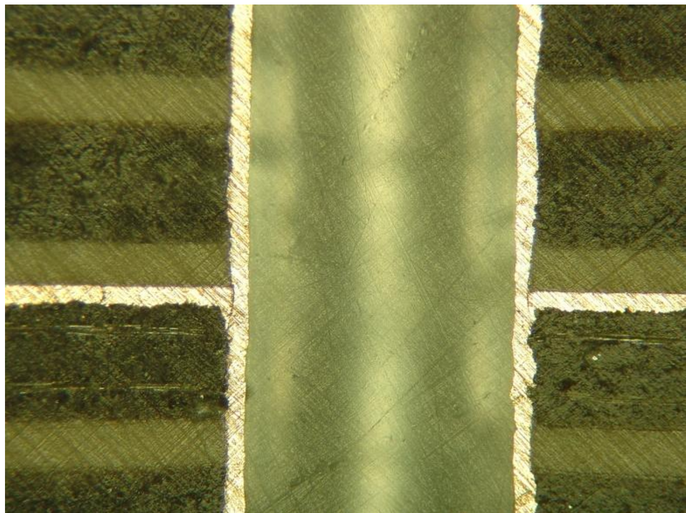
In general The TSM-DS/Speedboard C pwbs had good hole wall quality. There was the occasional plating nodule but the nodules were infrequent in nature. The plated through holes with lots of pads looked the cleanest.



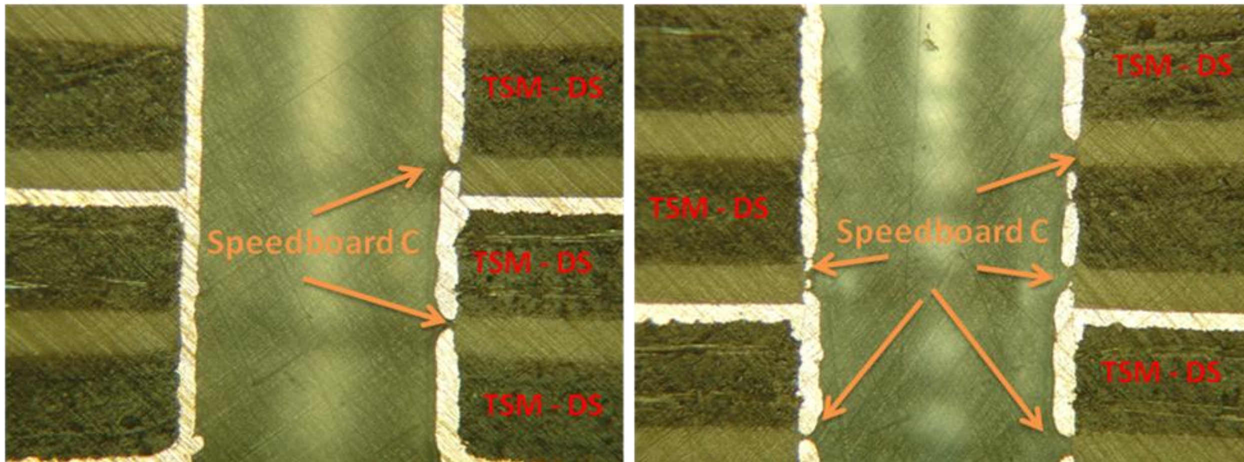


The TSM-DS/Speedboard C only showed what might be more serious defects in holes with one or two pads or ground planes. The plated through holes with heavy populations of pads probably has the effect of scrubbing the drill bits. As shown below, plated through holes with less copper planes showed in some cases what looks to be post to pad separation.





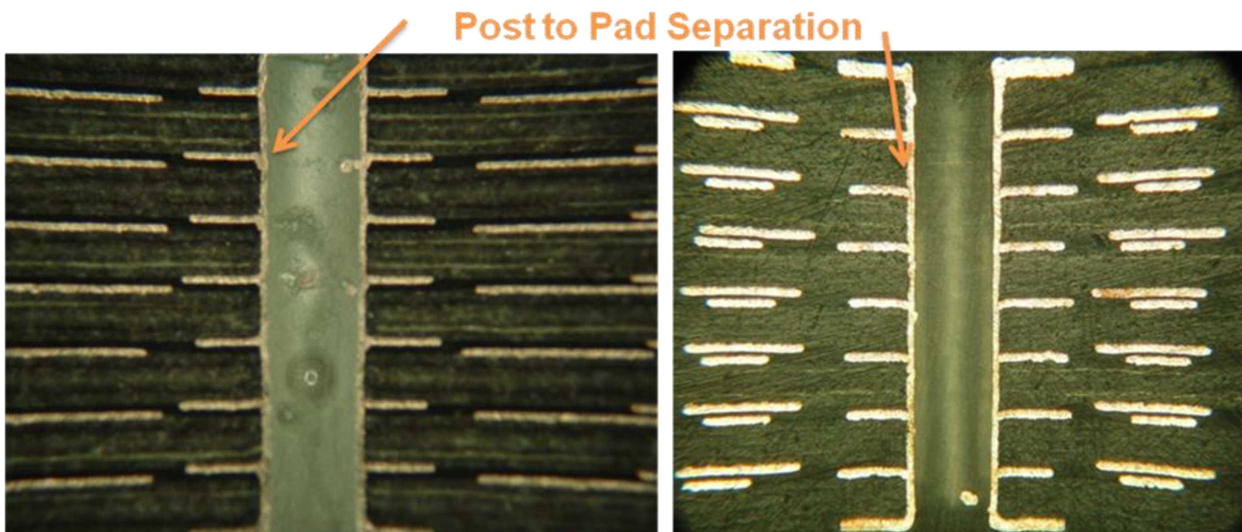
One cannot rule out however that the proper optimization of drilling conditions might be able to eliminate this apparent defect that only seems to appear in the areas having a low density of pads. One further defect that was noted in the TSM-DS/SpeedboardC stackup was the presence of voided areas. While the voided areas can probably be remedied by optimized plasma conditions, the locations of voids does suggest which materials are more prone to voids.



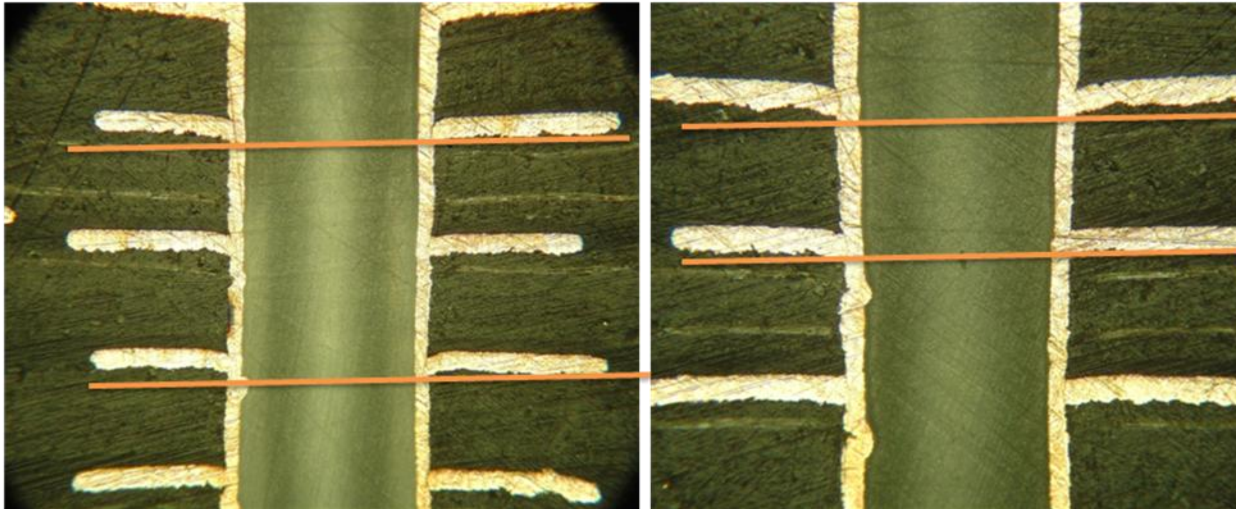
Voided areas were almost exclusively found on the Speedboard C areas. This only suggests that the TSM-Ds is easier to plate than the Speedboard C. Proper plasma conditions should be capable of generating reproducible and good quality plating through all the plated through holes. It should be noted that in the rare case of voiding on the TSM/fastRise27 stackup, the occasional void was on the TSM-DS…..suggesting that both TSM-DS and fastRise27 are easier to plate than SpeedboardC.

TSM-DS/FEP (Polyfluorinated ethylene-propylene from Dupont):

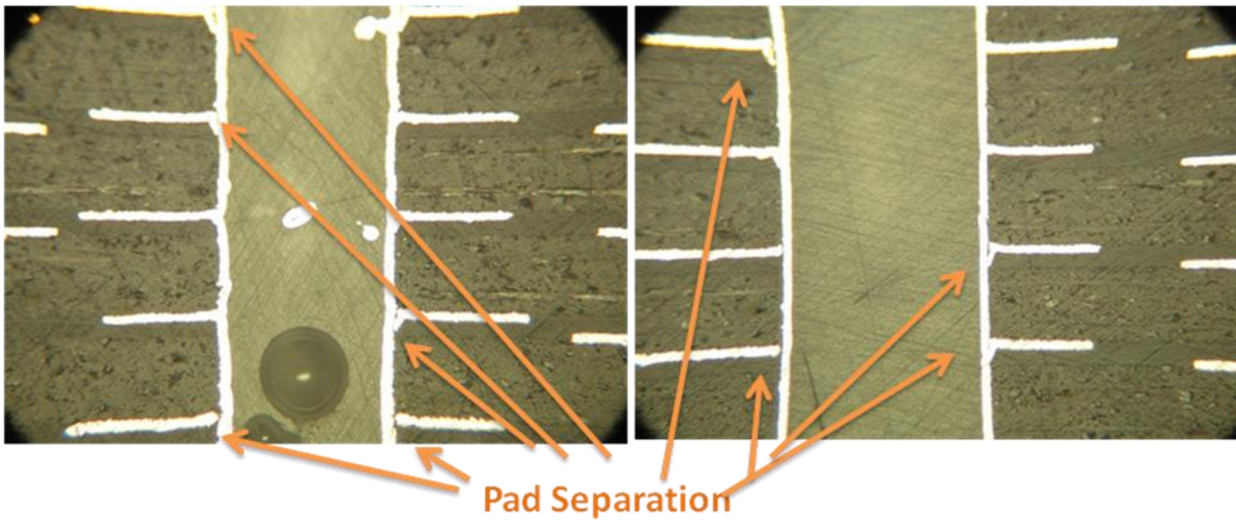
The TSM-DS/FEP stackup drilled in a fashion consistent with the other thermoplastic film (PCTFE: HT1.5 bond ply, Arlon6700, RO3001). There were some areas with no obvious pad to post separation and there were areas of severe pad to post separation. There were serious nodules on drilling entry and there were random nodules in the middle of the pth. Again, entry nodule problem is more likely related to the entry material used during drilling and a thick phenolic material with a combination of drill dwell between hits and the optimum bit geometry could probably fix this issues. Some amount of nodules on entry was found across all the prepregs so this is more likely related to the drill setup rather than a particular prepreg. Like the other thermoplastic film PCTFE (HT1.5bond ply, Arlon6700, RO3001), it was easy to find defects.

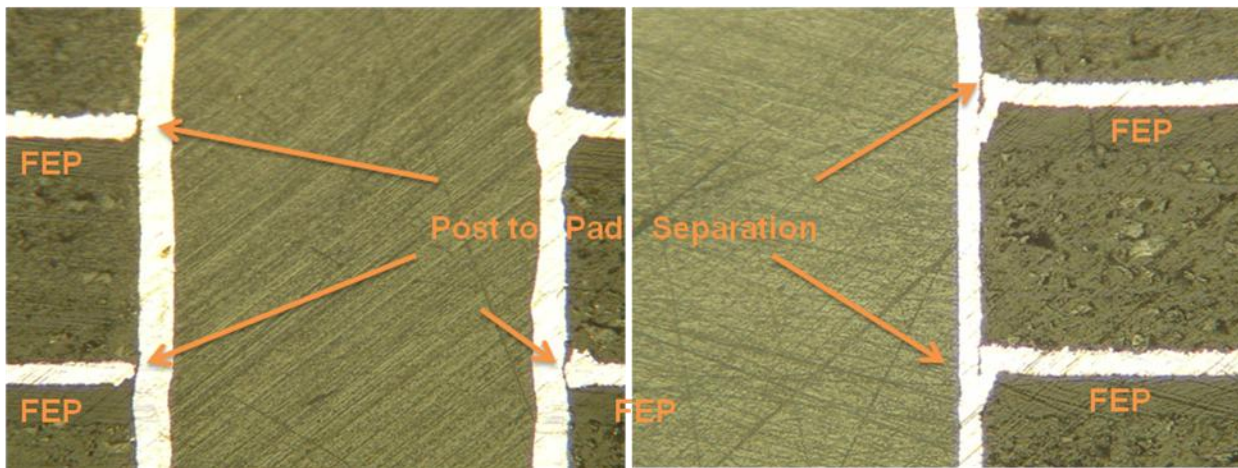


Post to pad interconnect looked inconsistent across all cross sections observed. Like the PCTFE bonding film, the TSM-DS/FEP stackup seemed to suffer from a lack of planarity of the pads from layer to layer. It is postulated that as the drill bit heated the pwb, the FEP softened to the point where there was some deflection of the pads as the drill bit drilled into the pwb. This can be seen in the following pictures.



Pad to post separation varied from hole to hole. There were some clean holes and there were some plated through holes where half the pads or more had a pad to barrel interconnect defect.





In summary, the thermoplastic films (PCTFE/FEP) suffer from similar defects. Drill bits work best when drilling into hard substrates such that the substrate material is reduced to particulates and removed through the drill bit's flutes. The thermoplastic films probably melt during drilling such that "drilling" is more like tearing, cutting, and stretching. Because the thermoplastic films probably melt during drilling, some swimming of the pad occurs resulting in deflection and uneven drilling into the pad. Film is likely smeared across the interconnect leaving the obvious opens. Speedboard C and fastRise27 both having thermosetting chemistries…though they contain some PTFE thermoplastic. The barrels were perpendicular to the pads suggesting that these prepregs hold the pads rigid during drilling. Post to pad defects were only seen on the SpeedboardC/TSM-DS stackup in areas with few pads. The fastRise27/TSM-DS stackup was free of any pad to barrel interconnect defects. However, like all the rest of the stackups, the TSM-DS/fastRise27 did have some level of sporadic plating nodules.