What to look for from your board supplier when changing to an alternate surface finish to HASL

Overview: over the last five to eight years the use of HASL alternatives by the OEM's and CM's has increased dramatically, particularly in response to increasing board density and the need for a solderable planar surface that increases their yields at assembly. The chemical industry has responded to meet the needs of the OEM's but unfortunately some of the product offerings and the manner in which they were installed were less than stellar. This paper outlines for the OEM / CM engineer/auditor some of the areas that should be examined in more detail than might otherwise happen. The information outlined should also be used for surface finish engineers at PWB fab houses that might be new to a finish and may possibly save them from some very late nights on a line trying to understand a problem.

For further information:

Gerard O'Brien
Photocircuits Corporation
516 609 1230
gobrien@photocircuits.com

Introduction: The use of HASL alternate finishes continues to increase on a daily basis and with it comes the risk of choosing a finish that may not be ready for the market place, may not be totally understood by the seller (including the chemical supplier to the fab house) and also may not be understood pertaining to its interactions with a complex assembly technique. Add to this the continuing closures of domestic fab houses with the accompanying loss of years of knowledge and their replacement by start up Asian facilities with little to no experience and the probability for a disaster begins to become a definite possibility. Some of the information presented here may be redundant and/or obvious to the battle hardened surface finish engineer but to the novice the total package of information presented may prevent production/quality and reliability issues in the future.

Fig One below is a cheat sheet for the surface finishes currently available to the fab / assembly industry

Surface finish	Solderability	Switches	Wire bonding	Press Fit	Edge connector	Lead Free compatible	COST
HASL	“The standard”	No	No	No	No	Possibly	Low
OSP	Excellent (careful with washoff’s)	No	No	Possibly	No	Yes	Low
ENIG	Excellent (will require profile mod)	Yes	Yes (aluminum wire only)	Yes	Yes plug to install	Yes	High
Immersion Tin	Excellent	No	No	Yes	No	Yes	Low to Medium
Immersion Silver	Excellent (careful with non soldered pads)	Yes	No*	Possibly	No	Yes	Low to medium
Palladium (over Cu)	Excellent (can be a challenge)	Yes	Yes (gold wire only)	Yes	Yes (plug to install)	Yes	High to very high
Nickel Palladium Gold (universal)	Excellent (can be a challenge)	Yes	Yes (both aluminum and gold)	Yes	Yes	Yes	Very high
Electroless Gold	Excellent** (will require profile mod)	Yes (soft touch only)	Yes	No	Yes (plug to install)	Yes	Very high
Nickel Gold (electrolytic)	Excellent* (will require profile mod)	Yes	No	Yes	Yes	Yes	Medium to high
Reflowed Tin/lead	Excellent	No	No	No	No	No	Low

As can be seen the choices available are many plus keep in mind that there are multiple supplies for each and every one of these finishes in addition to each one having its own unique set of challenges. Some of the finishes have been around for many years and are well established while others still remain on the bleeding edge. The following will deal with the most commonly used finishes and some of the pitfalls that are associated with them.

OSP – Organic Solderability Preservatives - these copper selective coatings have been around for quite some time and are definitely one if not the most mature of the alternate finishes. The majority of the coatings are applied by a flood coat system for the higher volume suppliers but “dip and dunk” tank systems are still in existence.

The use of an OSP coating as the name suggests is to preserve the copper from oxidation, and thus maintain its solderability. It is a single function coating – solderability – the deposit being electrically insulating and soft thereby rendering it useless as an edge connector surface or keypad surface. As mentioned above, the deposit is copper specific – it does not adhere to the solder mask or laminate or if there are other metals on the board, i.e. gold, that is not copper. Because of this it is imperative to present to the coating a clean copper surface that will readily react with the chemistry and produce a uniform deposit that will protect and copper and provide a solderable surface with a decent shelf life. In addition the deposit is transparent, some people claim they can tell if it’s on the board but I would not like to bet my salary on it.

Critical characteristics – measurement of the coating is one of the main issues pertaining to the use of OSP’s. Unlike a metallic coating that can be checked by X – Ray Fluorescence (XRF) and is considered a non-destructive test – the measurement technique for OSP requires the dissolving of the coating in an acid media and then using a UV spectra-photometer to determine the deposit thickness. This presents a number of issues not least being:

1) Because it is a “dissolve and measure technique” the area to be tested needs to be significantly large enough to get an accurate result. Unfortunately the coupon size is normally many orders of magnitude larger than a typical solder pad – **CAN YOUR SUPPLIER DEMONSTRATE A CORRELATION BETWEEN THE COUPON AND A REAL WORLD PWB.**
2) Because it is a “one time test” there is no possibility for a retest on the thickness coupon (you can of course re-coat the coupon) –**CAN YOUR SUPPLIER PRESENT GAUGE REPRODUCABILITY / REPEATABILITY (GR&R) DATA ON THE UV VIS PIECE OF EQUIPMENT TO SHOW ACCURACY AND REPEATABILITY OF THE TEST PROTOCOL?**
3) As mentioned above the OSP coating is copper specific and therefore needs clean / residue free copper in order to deposit in a consistent and uniform way - **CAN YOUR SUPPLIER PROVIDE DATA SHOWING A CLEAR UNDERSTANDING OF POTENTIAL SOURCES OF COPPER CONTAMINATION, A CLEAR AND WELL DEFINED PROCESS TO ENSURE “KNOWN GOOD COPPER”, A SENSIBLE AND WELL DOCUMENTED PRECLEAN / MICROETCH CHEMISTRY ANALYSIS AND DUMP SCHEDULE, HOW THEY DEFINED THE AMOUNT OF COPPER TO BE REMOVED IN THE MICROETCH PROCESS?**
4) In any plating process – whether immersion / electroless or electrolytic – there will be a variation in deposit thickness as a function of feature size, number of panels being plated (bath loading), proximity to sparges, eductors, the amount of solution movement etc. The same applies to OSP coatings. For a horizontal coating machine there exists the possibility of side to side variation as well as top to bottom variation in deposit thickness. – **CAN YOUR SUPPLIER PROVIDE YOU WITH DATA SHOWING DEPOSIT DISTRIBUTION MAPPING OF THE LINE AS A FUNCTION OF LOCATION? THE SAME APPLIES FOR “DIP AND DUNK” APPLICATION METHODS.**
5) One of the benefits of using an OSP coating is the improvement in board cleanliness as a function of removing the known bad players that exist in a HASL process and that are very difficult to remove/clean. However, one of the most common mistakes made when specifying and OSP cleanliness level is to require a Solvent Extract Conductivity (SEC) type test. The OSP coating dissolves in the Alcohol /DI water solution that is used as the extract media. As a result the coating produces a strong Ionic signal to the conductivity probe and produces values far in excess of any specification currently in use. There are two solutions to this problem depending on the level of sophistication your board suppliers has or that you demand. The first one is to require a Surface Insulation Resistance (SIR) test – the parameters recommended by either IPC or Telcordia will produce failures if the boards are “dirty” but will easily exceed the requirements if the only source of conductive contamination is the coating itself. The second method is to use the SEC test but to have the supplier pull the

sample just prior to coating – test after the preclean / microetch /rinse step. If the boards are clean then they will easily meet any SEC values currently in use. One other method is sometimes used but is not recommended by the author. A baseline of total Ionic contamination is established by performing SEC testing on a coated PWB. The end user then assembles the PWB and performs electrolytic corrosion testing / life testing on the module. If all the tests meet the requirements of the end user then the board PWB total Ionic's becomes the new accept/reject specification. This is a costly method with a very small snap shot of time and production and may be statistically invalid unless a large enough population is tested. **CAN YOUR SUPPLIER DEMONSTRATE A CLEAR UNDERSTANDING OF THE IMPACT OF CLEANLINESS ON HIS PRODUCT – CAN HE DIFFERENTIATE THE DIFFERENCE BETWEEN SIR AND SEC TESTING, THE DIFFERENCE BETWEEN IONIC / BI-POLAR ORGANIC AND ORGANIC CONTAMINATION.**

6) Last but not least – this deposit is used a solderability preservative –**WHAT DATA DOES YOUR SUPPLIER HAVE ON THE SOLDERABILITY PERFORMANCE OF THE OSP DEPOSIT THAT HE IS USING. DO NOT ACCEPT SALES LITRATURE FROM THE CHEMICAL SUPPLIER, THE PWB SUPPLIER SHOULD HAVE REAL DATA ON SHELF LIFE / STORAGE CONDITIONS RECOMMENDATIONS AS WELL AS BEING ABLE TO ASSIST THE END USER WITH ITS SUCCESSFUL IMPLEMETATION.**

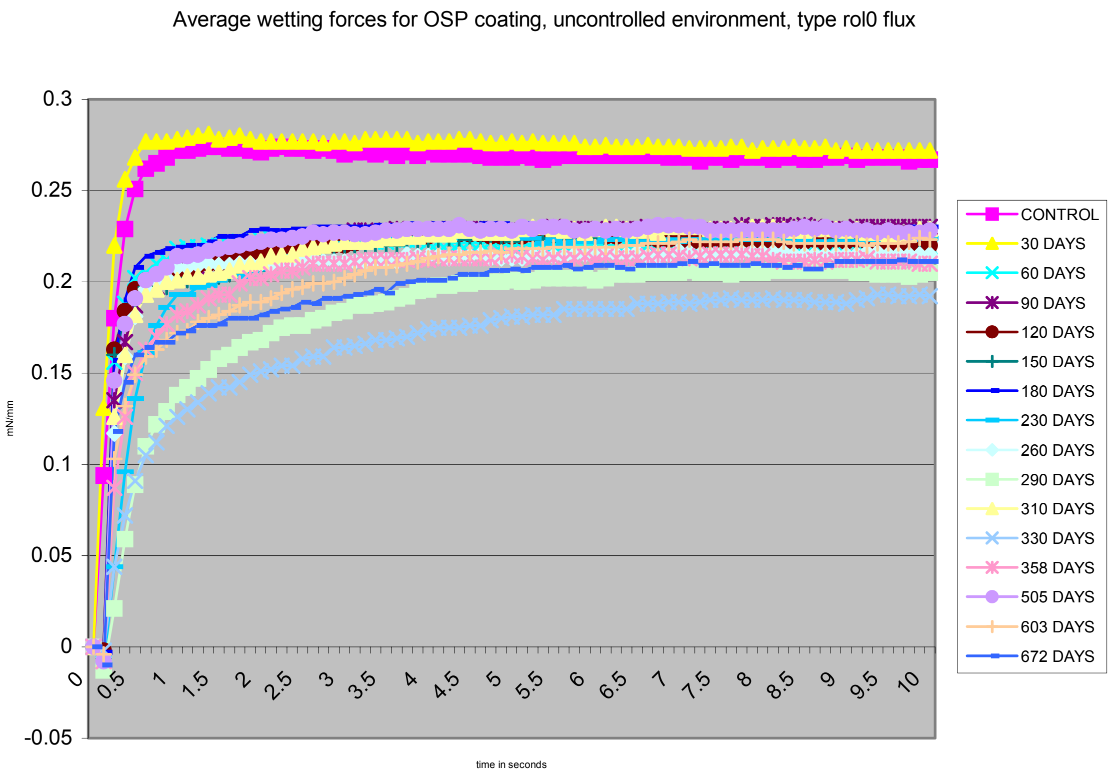

Fig 2: wetting balance data from an OSP coating that was stored in an un-protected environment with no packaging showing excellent solderability post 672 days – if the coating is applied correctly then you should see the same shelf life.

Electroless Nickel Immersion Gold – ENIG: This coating is the next most common alternative to HASL and unfortunately has suffered the most from lack of attention to detail from everyone up and down the food chain. A new IPC specification – 4552 is currently under review that deals specifically with ENIG and how to correctly specify the deposit, it is recommended that the reader obtain a copy of this document if ENIG is a surface finish of choice. ENIG is a wonderful surface finish with multi-functionality at a very inexpensive price. ENIG can be used for solderability, switch pads, wire bond sites (Aluminum wire only), plug to install edge connectors and press fit applications. If applied right ENIG provides a high reliability interface to the rest of the PWB assembly. If applied incorrectly ENIG provides a low reliability surface combined with some of the worst headaches an assembler will ever deal with. The scares that have gone through the industry – black pad – may be attributable to a general misunderstanding of the process on the part of the PWB supplier as well as a lack of attention by the chemical suppliers to the possibility of the fab houses running their product totally out of specification. All the work done by the industry round robin tests to reproduce the "black pad" phenomena have failed, this I believe gives credence to the point that a PWB fab house in an out of control condition is a) responsible for the issue and b) typically the degree of out of control is not reproducible in a round robin study. One point must be stated again and again with regard to ENIG:

THE IMMERSION GOLD IS ONLY THERE TO PROTECT THE UNDERLYING NICKEL.

1) The ENIG process is not a simple process by any definition. The average ENIG process has upwards of twenty one process steps including chemical baths, pre and post dips as well as rinse steps (sometimes overlooked with regard to time of rinsing and quality of the water used). The process also has to deal with the fact that both the Nickel and Gold baths run hot 190°F, which means a lot of solution evaporation and therefore a constantly changing chemical bath. In addition to solution loss there is obviously the metal being consumed as a function of plating as well as metal being lost due to drag out. Some of the chemical baths also have to deal with "metal contamination" from the surface on which they are reacting with i.e. copper contamination in the Palladium bath, Palladium contamination and some copper in the Nickel bath, nickel contamination in the gold bath. To further complicate matters is the fact that stabilizer and other complexing agents that are used to prevent the baths from plating out onto themselves and used to help the reaction take place need to be kept in a specific ratio to one another. **CAN YOUR SUPLIER DEMONSTRATE PROCESS CONTROL TO DEAL WITH THE ABOVE? THE CHEMICAL REPLENISHMENTS OF THE NICKEL BATH SHOULD BE DONE AUTOMATICLLY BY THE USE OF A CONTROLLER – OVER THE SIDE ADDS OF CHEMISTRY WILL ALMOST CERTAINLY GUARANTEE PROBLEMS IN THE FUTURE. CAN THE SUPPLIER DEMONSTRATE A GOOD KNOWLEDGE OF THE CONTROLLER AND THAT IT IS ACCURATE AND CALIBRATED? WHAT SPC DATA CAN THEY SHARE WITH YOU DEMONSTRATING THAT THE BATHS ARE IN CONTROL?**
2) It is typically used as a selective process applied only to areas not covered by solder mask. As a result of this the deposit has to contend with mask and developer residues. The requirement for a robust preclean process cannot be overstated. For the ENIG process to be successful requires that the copper be catalyzed by Palladium. This immersion displacement reaction is considered chemically very benign, any solder mask residues or bleed out will prevent palladium catalyzation of the surface and subsequently be responsible for skip plating. **CAN YOUR SUPPLIER DEMONSTRATE HIS UNDERSTANDING / RATIONAL BEHIND THE CHOICE OF PRECLEAN STEPS USED. A STATEMENT OF "IT'S THE RECOMMENDATION OF THE CHEMICAL SUPPLIER" SHOULD NOT BE ACCEPTED, AS EVERY PWB MANUFACTURER WILL HAVE SOME UNIQUE SOURCE OF CONTAMINATION.**
3) The measurement of the ENIG deposit is also a challenging area. The method to measure ENIG accurately by is XRF however it is not as simple as that. As mentioned above the nickel bath uses a reducing agent, most typically phosphorus but could be a boron containing chemical. The reducing agent will be deposited as a "contamination" with the nickel. Nickel

phosphorous systems used for ENIG will typically co - deposit 4 to 8% of phosphorus. When calibrating the XRF to measure ENIG this factor must be taken into account. The author has had to deal with many questions / queries from customers stating that the deposit supplied was out of spec only to discover the use of electrolytic nickel electrolytic gold standards as the calibration references. Another key point is the use of a gold standard in a thickness that is relevant to ENIG. It is incorrect to calibrate an XRF with a 30 microinch standard as the minimum gold value if you are wishing to measure in the 3 to 5 microinch range. Another key point is the age and capability of the unit being used to measure the ENIG. Older units typically do not have the correct "hardware" – detector / x-ray tube etc to measure accurately thin gold over nickel over copper. **CAN YOUR SUPPLIER DEMONSTRATE A GOOD GR&R CAPABILITY FOR HIS XRF, DOES HE HAVE THE CORRECT ENIG STANDARDS TO CALIBRATE THE MACHINE. IS THE PHOSPHOROUS CONTENT OF THE STANDARDS CONSITANT WITH THE PHOSPHOROUS RANGE OF THE NICKEL BATH?**

4) Once a thickness measurement capability has been verified then a plating distribution examination / understanding can begin. Plating rate studies and deposit thickness variations are key elements to demonstrate a clear and thorough understanding of the process. The typical Nickel bath has a finite number of metal turnovers (amount of metal replaced) before the bath is dumped. This is typically a function of contamination build up which affects both the deposit itself and the plating rate efficiency of the bath. Chemically reduced metal baths are prone to deposit thickness variations as a function of solution movement, bath loading, design of the racks holding the work pieces, temperature gradients in the bath which are further effected / influenced by the age of the chemistry and how much contamination is in the bath. **CAN YOUR SUPPLIER SHOW YOU PLATING RATE STUDIES AS A FUNCTION OF BATH AGE, BATH LOADING. CAN YOUR SUPPLIER SHOW YOU THICKNESS DISTRIBUTION STUDIES AS A FUNCTION OF BATH LIFE?**

5) The primary function of ENIG is as a solderable surface. If applied correctly the deposit will provide shelf life for many years – the author has reported elsewhere successful solderability of ENIG after 899 days in unprotected storage. **WHAT DOES YOUR SUPPLIER KNOW ABOUT ENIG AND SOLDERABILITY? IS HE ABLE TO RECOMMEND PROFILE CHANGES IN ASSEMBLY THAT WILL GUARANTEE THE FORMATION OF Ni_3Sn_4 INTERMETALLIC COMPOUNDS – NECESSARY FOR A RELIABLE SOLDER JOINT. IT MUST ALSO BE STATED HERE THAT THE ASSEMBLY INDUSTRY MUST TAKE SOME RESPONSIBILTY FOR SOME OF THE PREMATURE SOLDERJOINT FAILURES EXPERIENCED WITH ENIG. THE NiSn PHASE DIAGRAM CLEARLY SHOWS THAT A REFLOW PROFILE TYPICALLY USED WITH PEAK TEMPERATURES OF 212 TO 217°C IS INSUFFICIENTLY HOT TO FORM THE NECESSARY IMC COMPOUNDS AND AS A RESULT THE SOLDER JOINTS ARE MORE LIKE GLUE THAN A METALURGICAL BOND.**

IMMERSION SILVER: the use of silver has been growing steadily over the last number of years. It is a deposit that provides excellent solderability protection (packaging considerations necessary)- silver is the most solderable metal, has a very fast dissolution rate in tin and all things being equal is a very acceptable replacement for HASL. However there are some issues that go along with silver. Silver is active metal and if not used with care may produce dendritic growth failures. The older generation electrolytic silvers (100 plus microinches) were very prone to dendritic growth and subsequent module failures. Unfortunately Immersion silver has had to deal with reputation of the electrolytic silver and this has affected its acceptance rate especially by regulatory agencies such as UL. In the current revision of UL796 it even has a section dealing specifically with silver and does not differentiate between the older electrolytic silvers and the modern generation of Immersion silvers. It should be noted that IPC and UL have been working together to prove that the new silvers if applied correctly do not suffer from electrolytic corrosion issues. It is hoped that in the not to distant future that the special testing requirements by UL will be modified or removed altogether.

Immersion silver is a relatively simple and benign process compared to the other alternative finishes but that does not mean it is fool proof or that it does not have it's own set of unique problem

1) The surface preparation of the copper prior to the silver being applied is critical. The dwell time in the silver bath is typically one minute, which does not leave a lot of time for the chemistry to try and overcome any residual mask smear etc that may be on the copper. **CAN YOUR SUPPLIER DEMONSTRATE AN EFFECTIVE PRECLEAN / MICROETCH PROCESS THAT ENSURES THAT ALL RESISDUES FROM PREVIOUS PROCESSES ARE REMOVED AND THAT OXIDATION OF THE COPPER IS REDUCED?**
2) The immersion silver deposit is somewhere between 4 to 16 microinches depending on the supplier of the chemistry – this is a very thin porous deposit and as such accurate measurement of the deposit is a challenge. XRF is used to measure the deposit but similar to ENIG the correct hardware and correct standards are imperative if a valid and repeatable measurement is to be obtained. Older generation equipment may have the incorrect detector / x-ray tube etc to accurately measure such a thin coating. It should be noted that even brand new equipment that may have been purchased for HASL measurement may also be unsuitable –you need to check it. As an XRF is as only good as the standards it's calibrated with – the need to have Immersion Silver standards in the range of interest – 4 microinches is imperative otherwise inaccurate results are guaranteed. **DOES YOUR SUPPLIER HAVE THE CORRECT XRF EQUIPMENT AND STANDARDS, CAN HE DEMONSTRATE AN ACCEPTABLE GR&R FOR MEASURING IMMERSION SILVER.**
3) Now that you can measure the deposit accurately, the issue of deposit consistency can be addressed. As mentioned above the thickness of the silver is between 4 to 16 microinches. The dwell time in the silver bath is short – maybe one minute for a vertical system, could be even less for a horizontal system. Because of the lack of dwell time in the chemistry, the potential exists for plating inconsistency due to solution movement, proximity to sparges as well as dealing with any residuals from the preclean steps. **CAN YOUR SUPPLIER DEMONSTRATE CONSISTANTY OF PLATING DEPOSIT ACROSS THE PANEL AND PANEL TO PANEL? DO THE VALUES ACHIEVED FOR MEAN AND STANDARD DEVIATION GUARANTEE THAT THE MINIMUM SPECIFIED WILL NEVER BE ACHIEVED I.E. –4 SIGMA FROM THE MEAN MUST BE GREATER THAN THE MINIMUM THICKNESS SPECIFIED.**
4) As mentioned above, silver is a very active metal and needs to be handled / stored with care if defects are not going to occur. From a solderability view point the use of neutral pH paper to slip-sheet the panels in process is highly recommended. **MAKE SURE THAT THE SUPPLIER TESTS THE INTERLEAF PAPER FOR SULFUR AND IT'S pH value. A DETAILED SPECIFICATION FOR THE PURCHASING DEPARTMENT COVERING THE PAPER SHOULD EXIST AND BE IN USE – DOES IT? SILVER IS PRONE TO ELECTRO-MIGRATION AND DENDRITIC GROWTH FAILURES. THE SUPPLIER SHOULD BE ABLE TO DEMONSTRATE ITS RESISTANCE TO BOTH OF THESE ISSUES BY THE USE SIR / SEC AND ELECTRO-MIGRATION TESTING. IN ADDITION THE USE OF THE UL FULL COMPLIANCE SYMBOLS REQUIRE EXTENSIVE TESTING UNIQUE TO SILVER. IF THE BOARD WITH SILVER HAS A FULL MOT RATING THEN ASK TO SEE THE UL LETTER, IF IT REQUIRES A FLAME ONLY "94V-0 RATING THEN THE LEVEL OF TESTING IS NEGLIGABLE AND IS NORMALLY DEEMED A PAPERWORK ISSUE – CHECK IT OUT.**

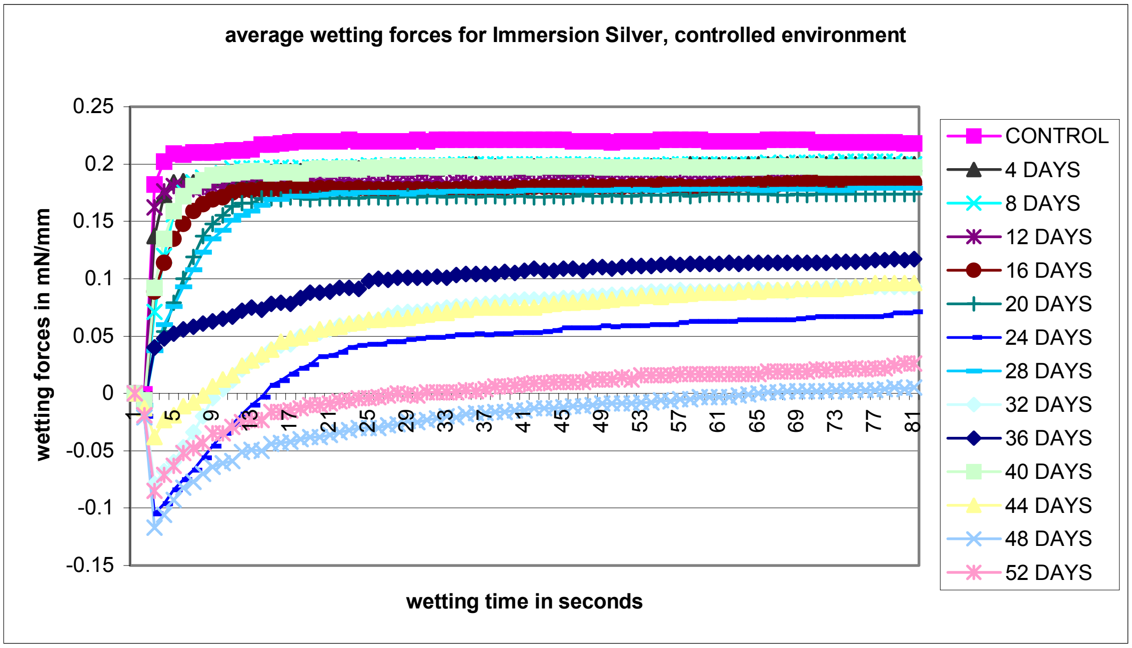

Fig 3: what happens to Immersion silver solderability if not stored correctly – note the number of days.

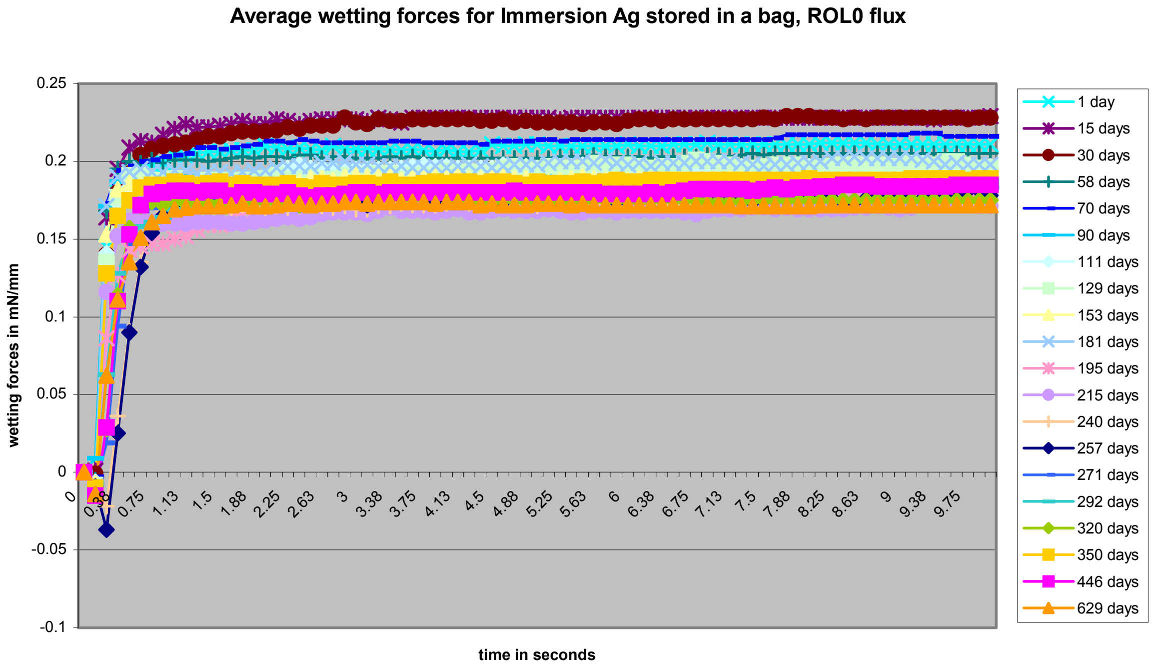

Fig 4: note the dramatic improvement in storage life for Immersion silver if stored correctly

Immersion Tin: The use of immersion tin as a surface finish should be much further along in its use and acceptance but has unfortunately been the victim of many false starts. Immersion Tin has been around for 40 years or so and the use of it as a realistic surface finish has been prevented by its affinity to the underlying copper on the PWB and the resultant copper tin intermetallic compounds that rapidly form, migrate to the surface where they oxidize and render the deposit non solderable.

The trend towards Lead free re-invigorated the immersion tin industry to come up with some novel solutions to retard the IMC migration –please note that all solutions only retard and none actually stop the formation and subsequent migration. By retarding the IMC migration the deposit begins to obtain a useable shelf life – six plus months as opposed to the weeks. Three approaches have been tried with varying degrees of success

1) A co-deposition of an organic compound
2) The use of a defusion barrier layer – Palladium
3) The refinement of the grain structure of the deposit.

1) Each of these three methods has their own unique set of problems etc. For the co-deposition formula the biggest issue is to explain and demonstrate how the system works. The ability of the organic to be deposited uniformly throughout the tin matrix and to be uniformly deposited pad to pad and panel to panel is very difficult in the experience of the author. **IF YOUR TIN SUPPLIER IS USING THIS TYPE OF FORMULATION HAVE HIM EXPLAIN IN DETAIL HOW THE UNIFORMITY OF THE CO-DEPOSIT IS ACHIEVED. CAN HE PROVIDE DATA TO BACK IT UP? THE ANALYSIS OF THE DEPOSIT TO PROVE PRESENCE OF THE ORGANIC WILL REQUIRE SOPHISTICATED ANALYTICAL APPERATUS SUCH AS AUGER OR XPS.**

2) The use of a Palladium defusion layer is now probably quite rare due to the cost swings that the market has seen on the price of this precious metal. However, if your supplier does use this type of Tin formulation the control of the Palladium bath and the preparation of the copper prior to the palladium process are critical. The deposit of palladium is almost as a mono – layer and as such presents measurement capability issues. **DOES YOUR SUPPLIER DEMONSTRATE CONTROL OF THE PALLADIUM BATH AND CAN HE ENSURE THE UNIFORM DEPOSIT OF THIS VERY THIN LAYER OF PALLADIUM**

4) The latest generation of the immersion tin chemistries utilizes a grain refining technique to enhance the shelf life of the product. The copper migrates along the grain boundaries of the tin deposit. The smaller the grain structures the more boundaries per unit area compared to a coarser grained deposit. By increasing the number of grain boundaries the time to travel through the same deposit thickness increases and thus increases the useable shelf life of the product. **CAN THE SUPPLIER OF THE CHEMSITRY USED BY THE SUPPLIER OF THE PWB'S ADEQUATELY DEMONSTRATE GRAIN REFINEMENT IN HIS PRODUCT AND THAT THE SIZE OF THE DEPOSIT DOES NOT CHANGE OVER THE LIFE OF THE BATH?**

5) For immersion tin to deposit onto the surface of the copper requires the use of a catalyst – for tin there is only one catalyst and that's Thiourea. This is a sulfur bearing compound that can under certain conditions breakdown and co-deposit sulfur into the tin deposit. Sulfur contamination will render the deposit non solderable. **IS YOUR SUPPLIER AWARE OF THE POSSIBILITY OF SULFUR CO-DEPOSITION AND THE IMPACT ON PRODUCT SOLDERABILITY?**

WHAT CONTROLS EXIST TO VERIFY THAT THERE IS NO SULFUR CO-DEPOSIT IN THE TIN

6) While the relative temperatures of the chemical baths on the immersion tin line are low, the aggressiveness of the chemistry is high and will readily attack the solder mask on the board, probably even more than ENIG attacks mask. Not all masks are compatible with immersion tin as a result. **DOES YOUR SUPPLIER CLEARLY DEFINE WHICH MASK TYPES ARE SUITABLE, HOW DOES HE PERFORM MASK ADHESION TESTS AND HOW OFTEN. IS THE CORRECT IPC RECOMMENDED TAPE BEING USED?**

7) Because of the aggressive nature of the chemistry there is another potentially latent but never the less very serious defect – entrapped contamination that can result in electro migration defects. The deposit if not rinsed correctly will produce ionic contaminations numbers in the region of 20 plus micrograms / in^2. With a correct rinse schedule this number can be reduced to sub 2 micrograms / in^2. The use of a heated SEC tester is a requirement; the use of the older non-heated ionographs will produce an artificially low value. **DOES YOUR SUPPLIER HAVE A HEATED SOLUTION SEC TESTER. CAN HE DEMOSTRATE BOARD CLEANLINESS IN THE 2 MICROGRAMS /IN^2 RANGE? DOES HE UNDERSTAND THE RELIABILITY IMPLICATIONS OF HIGHER IONIC NUMBERS?**

8) The ability to accurately measure the tin deposit is again a challenge, what would you expect. The deposit as mentioned above is constantly changing as a function of IMC growth and migration. The use of the correct standards to calibrate the XRF cannot be understated. These standards need to have the same density as the deposit; the use of electrolytic standards will produce false readings. Similarly the standards will have a finite life, as they will also be prone to IMC consumption of the tin. **DOES THE SUPPLIER HAVE THE CORRECT XRF STANDARDS AND CAN HE DEMONSTRATE THAT THEY ARE STILL USEFUL AND HAVE NOT BECOME PREDOMINENTLY IMC SPECIES. THE USE OF SERA IS AN ALTERNATIVE METHOD OF MEASURING THE TOTAL TIN IN THE DEPOSIT BUT IS NOT FOUND AT A PWB MANUFACTURER AS COMPARED TO XRF. DOES THE SUPPLIER HAVE SERA DATA OR ACCESS TO SERA?**

9) In addition to IMC growth and migration, the other most common defect that tin will suffer with is oxidation. There are two oxidation states of tin – SnO and $SnO2$. The first state is the most common and is readily reduced by the assembly flux and does not cause any problems. The second state is black in color and is non-solderable. Great care must be taken by the suppliers to ensure that the tin in the bath does not become predominantly $SnO2$, by too much solution movement or too much air sparging for example, and thereby deposit onto the board. **DOES YOUR SUPPLIER UNDERSTAND THE DIFFERENT OXIDATION STATES AND THEIR IMPACT ON PRODUCT PERFORMANCE? CAN HE DEMONSTRATE BATH CONTROL TO MINIMIZE THE POTENTIAL FOR Sn4 PRODUCTION?**

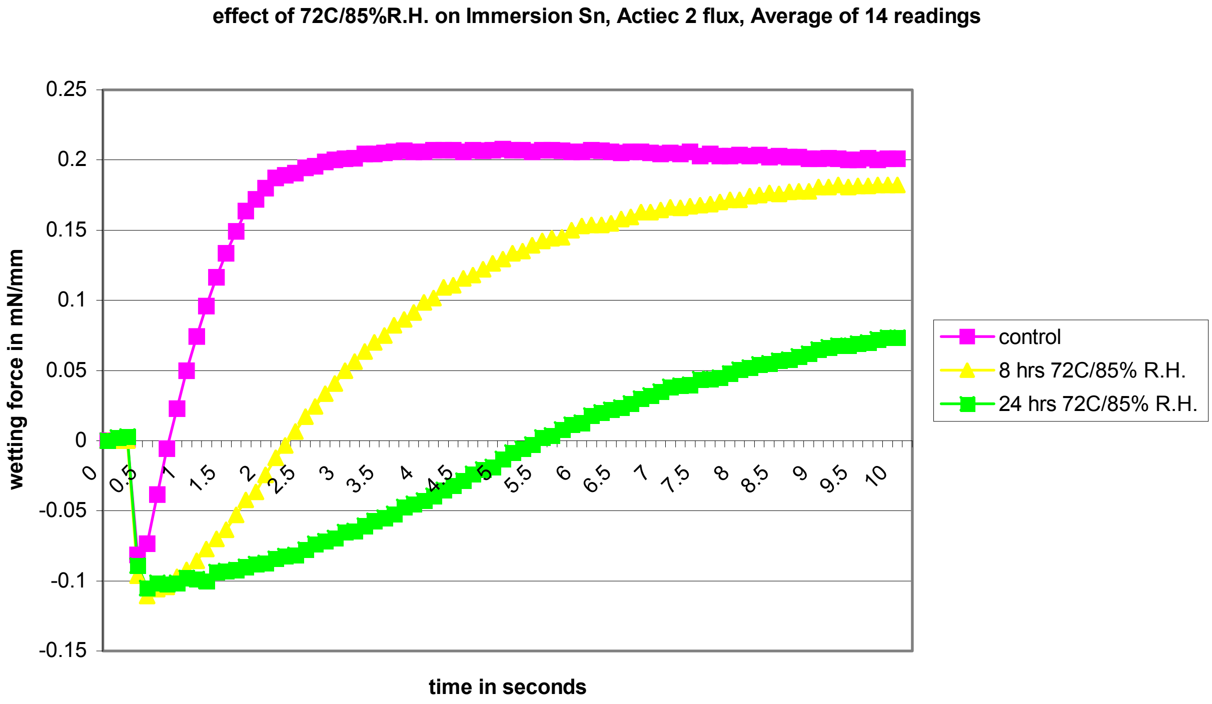

Fig 5: effect of 4 Angstroms of SnO2 on an immersion tin deposit.

10) Of late an old issue with the use of tin as a metallic finish has raised its head to the surface – tin whiskers. The plating industry has always known of the propensity of pure tin to form whiskers especially in the electroplated industry. When the current generation of immersion tin coatings were released, the issue of whisker formation was felt to be a non-issue due to the thinness of the deposit and the fact that it is supposedly a low stress deposit. The usual test of exposing the deposit to 51C for? days failed to produce any whiskers and were therefore deemed to be a whisker free deposit. An accidental examination of the deposit by one of the larger OEM's found evidence of the problem. Simple storage of the boards produces tin whisker growth after only a few days with very clear evidence of the problem post three weeks. This issue has forced the chemical suppliers back to the drawing board with regard to formulation and the thinking on the mechanism for the production of tin whiskers. **DOES YOUR SUPPLIER AND HIS SUPPLIER CLEARLY UNDERSTAND THE MECHANISM OF TIN WHISKERS? HAVE THEY RECENTLY (POST JANUARY 2002) REFORMULATED THEIR CHEMISTRY TO ADDRESS THE ISSUES OF TIN WHISKERS?**

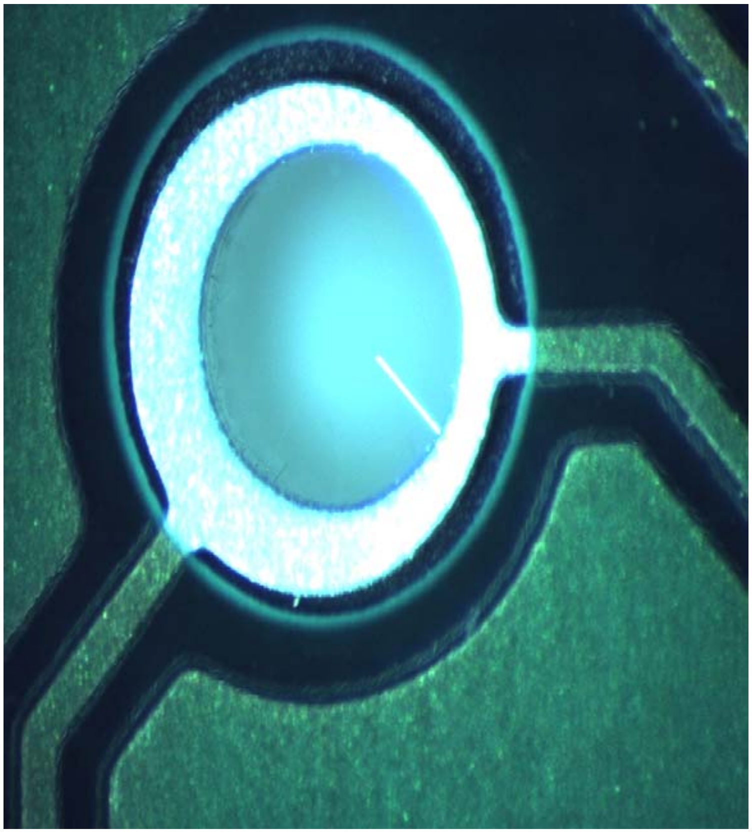

Fig 6: immersion tin whisker in via hole

What surface finish to choose?

As can be seen from the above there are many options to choose from, the question is which one? As from table one above if you need a multifunctional surface the choice is limited by definition and the only concern is the ability of the PWB supplier to satisfy the items outlined above. If the choice is solderability only then the problem of choice becomes more difficult. In an attempt to reduce this difficult choice I offer the following, again based on real life experiences:

1) Choose the finish that your supplier has demonstrated most knowledge and with which the comfort level is greatest.
2) Choose the most cost effective (provided item 1 above is met)
3) Do not forget assembly techniques, in particular post cleaning requirements, if any, as well as the environment that the module will operate in.