Lead-Free Solder

3-Apr-01

New Technologies - lead free/solder-less interconnects

U.S. and European political movements and Japanese marketing pressures indicate an eventual change in interconnect attachments that use traditional tin/lead solder compositions; however, there is no drop-in metallurgical technology, nor is there a proven technology with affordable, reliable connections or one with less overall adverse environmental impact. Never-the-less, traditional lead-solder processes, throughout the worldwide electronics industry, may be eventually phased out by legislative goals for a totally pollution-free environment.

Lead-free solders have been around for decades, but the low cost of tin/lead alloys and their lower processing temperatures have made them the mainstay in the electronics industry. Evaluations, and limited usage of lead-free solder alloys in small consumer products, indicate the most promising compositions may be those of Sn/Ag/Cu and Sn/Ag/Cu/Sb.

Compositions containing Indium are too expensive for bulk wave usage; Bismuth presents reliability issues in processing as well as with fillet lifting after assembly; And, the reliability of Sn/Cu solder in through-hole applications is suspect. Concerns are the higher temperatures required, i.e. “Lead-free” vapor phase reflow: +255ºC, verses traditional lead solders: +220ºC, and the results of synergistic chemical reactions with the new and different combinations of metals and fluxes involved. Overall, the use of these lead-free solders in critical applications (Military, avionics, medical, emergency communications, etc.) need further assessment of long life reliability and repairability.

The hopeful metallurgical options, Sn/Ag/Cu and Sn/Ag/cu/Sb, require higher processing temperatures (up to +280ºC), and necessitate pre-conditioning bake-out drying to prevent board warping, de-laminations, crazing, and pop-corning of encapsulated components. This requires higher fuel consumption with subsequent increases in waste materials (scrap dross), air pollutants (stack emissions), and also contributes somewhat to global warming. More favorable options may be new and improved recycling processes, changeover to conductive adhesives and, the significant reduction of interface connections by design.

Another problem of concern is the potential growth of tin whiskers in lead-free solders. Tin whiskers are single-crystal growths that follow a spiral pattern above the tin surface and may achieve a length of 0.35 inch (9.0mm) and carry up to 100mA. Pure tin readily produces tin whiskers which can cause shorts; so do some alloys of tin - but not alloys of tin and lead. Unfortunately, there is no good test that will reveal the potential for tin whiskers. The higher power level signals

of the past would simply burn away the whiskers with little effect on the circuit function; however today's finer pitch and smaller power levels are susceptible to serious disruptions or catastrophic failures from tin whiskers. Their existence is suggested by electrical anomalies, but proven only by physically sectioning the part. One potential solution is to plate leads with palladium, but this treatment makes rework or repair of a board extremely difficult because the heat needed to remove the palladium is likely to damage the board and nearby components.

Recycling -The less than 0.5 % of total lead waste ending up in landfills from expended electronic consumer products can be reduced even further through re-cycling of expended product – e.g. re-claiming up to 75% of the solder from the dross. Lead-free product disposal will also require improvement in recycling as landfill leaching of these other compositions will also violate EPA and many municipal regulations.

Conductive adhesives - Polymer solder processes are a potentially viable metallurgical solder replacement; and, these adhesives have an advantage over metallurgical bonding as, they provide strong, durable, electrically and thermally conductive bonds in many non-metallic substrate applications, e.g. ceramics, glass, laminates and molded plastics.

Interconnect reduction - Today's high density packaging requirements promote designs that use MCMs, CSP, and multi-layered substrates that significantly reduce the total number of interconnects, also reducing the amount of solder in end item products.

U.S. legislation of 1990 banning lead in many other products did not include electronic solder. Present legislation in congress to ban all potentially toxic materials by 2008 is meeting strong opposition by the AEA & EIA[1] as there is no scientific finding justifying the ban or indicating a safe environmental impact by replacement materials. Initial European efforts to ban lead from electronic solder have now been scaled down to extend their timetable to 2009, and in some cases, to 2020. Some European countries (i.e. Germany), instead of an all out ban, are imposing recycling measures for discarded equipment. Japan has been the leading proponent of lead free solder, particularly in some of their smaller products (e.g., Panasonic's portable MiniDisc); however, even their all-out ban timetable extends to 2015. Probably, lead free interconnects will eventually prevail – the final chapter as to how when and when is yet to come.

[1] *The American Electronics Association (AEA) and the Electronics Industries Alliance (EIA) has informed Vice President Al Gore regarding their concerns with pending legislation.*