Solder Materials Science Gets Small as Miniaturization Challenges Old Rules

Extreme miniaturization in a high-volume, high-reliability production environment is one of the electronics assembly industry's most significant challenges to date. While many process variables can be impacted, possibly none is affected as much as the solder process. With new tighter pitches and smaller geometries, soldering materials must also maintain lead-free properties as well as high temperature compatibility, humidity resistance, and more.

Particles that Pack a Punch

Traditional Type 3 solder pastes are increasingly less capable of addressing small deposit volume requirements. However, moving to Type 4 paste will not necessarily solve the problem, and it is thus critical that today's Type 4 materials are optimized for extreme miniaturization.

Optimization in this case relates not only to particle size but to distribution as well. While IPC Standard J-STD-006A allows a liberal range of particle sizes, recent testing supports that a smaller upper limit particle size could prevent potential manufacturing issues.

With the current focus on condensing the size and distribution of Type 4 particles, the resulting high surface to volume ratio introduces increased oxidation potential. If left unaddressed, this increased oxidation can contribute to performance issues such as non-coalescence, poor wetting, graping and more.

By condensing particle size distribution, paste release from the stencil is more complete, as large particles can easily become trapped leading to a range of defects. Reducing the upper and lower limits of particle size in new Type 4 materials allows for a far more robust process.

Lead-Free Solder Paste Advances

In addition to requirements for much finer dimensions, overall paste and flux system capability is key and new process issues such as graping continue to emerge. This occurs when solder partially coalesces to resemble a cluster of grapes – a result of extreme miniaturization not easily addressed without the proper soldering materials.

The purpose of flux within the solder paste is to eliminate oxides from metal surfaces, encouraging the formation of a solder joint and offering protection from re-oxidation during reflow. As miniaturization requirements continue to dictate the need for smaller particles sizes, metal surface of the solder increases and necessitates more activity. Typically powder oxidation occurs on surface particles, which places further demands on the flux as the relative amount of solder surface increases. Generally surface oxides have a higher melting temperature, which older generation flux formulations cannot overcome.

However, there are several ways to avoid graping with incorporation of developmental materials and technology. Smooth surface powders feature a tighter distribution range with particle size limit to deliver more even deposits and a reduced metal surface for an ideal deposit surface area volume ratio.

By providing sufficient activity and re-oxidation migration capacity, next-generation solder paste flux formulas can resolve graping as it occurs.

New Approaches for Heterogeneous Component Placement

Further miniaturization dilemmas include efficient placement of large and small components. Stencil technologies are often the limiting factor, as creating a stencil capable of printing large small deposits together is nearly impossible. Because multiple prints are out of the question, dip fluxing is a viable solution.

Generally dip fluxes deliver the necessary activity for robust solder joint formation, but the problem is then how best to protect those joints. Capillary flow underfills are an option only with a gap large enough to allow sufficient flow and coverage. However, this allows significant room for error and alternative methodologies should generally be considered.

Epoxy flux materials combine the action of a flux with the protection of a material to deliver an ideal solution for many reasons. With the dual-functionality of a flux and an underfill, the secondary underfill dispense can be eliminated. The solder joint is formed and the epoxy surrounds and protects each interconnect during the reflow process. When capillary underfilling is an option, traditional materials have exhibited problems including component floating and voiding. However, fluxing underfill remains near or around the solder bump to provide enhanced reliability without floating or void formation.

The Nano Future

With the advancement of miniaturized devices and lead-free soldering processes, temperature concerns and thermal management techniques are more prevalent than ever. As technology continues to evolve, so does materials innovation – even forging ahead in many cases. With solutions including advanced powder technologies and dual function materials, today’s innovations continue to support the smaller, faster and cheaper demands of the modern consumer.

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