INDIUM CORPORATION®

Issues Causing Head-in-Pillow Defects

APPLICATION NOTE

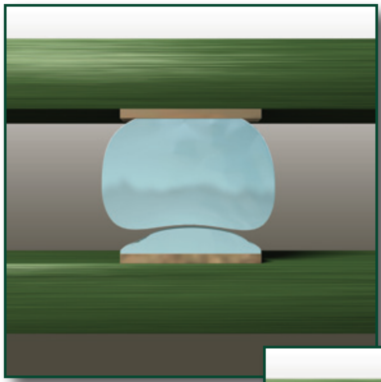
Head-in-pillow (HiP) is the incomplete wetting of the solder joint when attaching a ball-grid array (BGA), chip-scale package (CSP), or even a package-on-package (PoP) component to the printed circuit board. From cross-sections, it actually looks like a head has been pressed into a soft pillow.

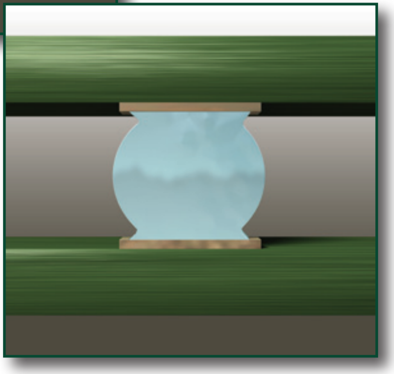
There are two issues that cause head-in-pillow defects: poor wetting and component warpage. They both look the same, but one can identify the difference by the location and occurrences. Random head-in-pillow defects are generally due to poor wetting, whereas edge or center defects are typically caused by component warpage.

HiP defects can be caused by problems in three areas:

Supply Issues
Supply issues entail everything before you put the boards and components on the production line. This may include oxidation, hydroxidation, and silver segregation. Oxidation issues occur when the component bumps and/or board pads have formed a hard-to-solder oxide coating on their surface. This oxidation can be caused by the manufacturing process environment, packaging techniques, and/or shipment and storage conditions. Unsealed or improper packaging, poor air quality, or an excess of oxygen introduced into the manufacturing environment or the storage vessels of the components all contribute to higher surface oxidation. Hydroxidation, a less well-known issue, is when a surface hydroxide is formed. This is usually limited to the component's manufacturing process as it is commonly caused when molten solder spheres are exposed to higher humidity. When hydroxidation does occur, the solder bumps are extremely hard to solder. Another issue is called "silver segregation", which is caused by increased silver content within the solder joint. The actual causes of the silver segregation are still unknown, but it may be caused by the component sphere manufacturing process, particularly the cooling rate.

Process Issues
Process issues entail everything that happens during the actual production process including printing, placement, and reflow. Printing issues, not directly related to the properties of the solder paste, are poor registration, imperfect or improper printer setup, and poor stencil design. Poor registration leads to printing off-pad or pump-out. Printing too fast or too slow will alter the amount of solder that is printed, as well as pulling the solder paste out of the apertures (scooping). Stencil design is probably the most important issue as a bad stencil design can lead to insufficient solder deposits, which may cause the component to not come in contact with the solder paste, as well as not having enough flux to overcome the oxide content on the sphere, board pads, or in the paste itself. The area ratio of the stencil apertures plays a large role in the transfer efficiency of the solder paste.





Component placement is another cause of the head-in-pillow defect. Offset placement, off-plane placement, placement pressure, and down stop, can all have a negative effect if not optimized. If the component doesn't sit down far enough and just floats on the surface of the solder paste, the spheres may not come in contact with the solder paste, dooming the process from the beginning.

The majority of head-in-pillow defects arise during the reflow process. This occurs when warping of the component and/or boards actually lift one edge, opposite edges (the "Pringle effect" or "potato chip"), or the corner or center spheres away from the paste deposit. To prevent this, it is important to read the component manufacturer's recommendations so that the reflow temperatures don't exceed the maximum processing limitations. Another issue during reflow is flux exhaustion. This occurs when the flux loses its activation because the reflow profile is too long.

OVER→

Form No. 98691 R0

www.indium.com askus@indium.com

ASIA: Singapore, Cheongju: +65 6268 8678
CHINA: Suzhou, Shenzhen, Liuzhou: +86 (0)512 628 34900
EUROPE: Milton Keynes, Torino: +44 (0) 1908 580400
USA: Utica, Clinton, Chicago: +1 315 853 4900

Issues Causing Head-in-Pillow Defects

Material Issues

Head-in-pillow defects related to solder paste or flux performance would be classified as materials issues. These include poor transfer efficiency on apertures with the appropriate area ratio, insufficient wetting (fluxing) capacity, a low oxidation barrier, and low activity. The key to overcoming head-in-pillow defects is to get each component sphere to stay in contact with the solder paste. If the solder paste has poor or inconsistent transfer efficiency, there may not be intimate contact between the sphere and the paste. Low area ratios can account for many of the paste transfer issues so it is important to match the appropriate material to the process and stencil design being used. Many times a good solder paste can control even an imperfect process.

The solder paste flux activation, oxidation barrier, stencil life, and tack life also play a significant role in the elimination of the head-in-pillow defects. High flux activation is preferred because this is the working part of the flux. Flux activation removes the oxide content from the solder and component bumps.

Oxidation barriers, such as high rosin content within the flux vehicle, are useful because it protects the solder paste, board metallization, and solder bump from forming new oxides. This means there is more activation to clean the oxide that is already present. Increased rosin content will typically add tack. If the solder paste remains tacky, and the package does warp, the solder paste will stretch to provide a continuum so that the solder and component will remain a single alloy mass upon reflow. There are artificial ways to add an oxidation barrier and additional activation, such as using a nitrogen reflow or flux/paste dipping process. Nitrogen reflow prevents the formation of additional oxides during the reflow process, but does not remove oxides and hydroxides already formed on the components. Flux or solder paste dipping are viable options because this adds activation directly on the component, rather than leaving it to chance on the board. In addition, the extra solder paste that is present from the dipping process will add solder volume, which will help to hold the component and the solder paste together if there is any warpage during the reflow process. Material solutions can typically overcome both the supply and process issues as long as the right material is chosen.