Optimization of Indium Bump Morphology for Improved Flip Chip Devices

Flip chips have applications in cell phones and other small electronic devices.

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Flip-chip hybridization, also known as bump bonding, is a packaging technique for microelectronic devices that directly connects an active element or detector to a substrate readout face-to-face, eliminating the need for wire bonding. In order to make conductive links between the two parts, a solder material is used between the bond pads on each side. Solder bumps, composed of indium metal, are typically deposited by thermal evaporation onto the active regions of the device and substrate. While indium bump technology has been a part of the electronic interconnect process field for many years and has been extensively employed in the infrared imager industry, obtaining a reliable, high-yield process for high-density patterns of bumps can be quite difficult.

Under the right conditions, a moderate hydrogen plasma exposure can raise the temperature of the indium bump to the point where it can flow. This flow can result in a desirable shape where indium will efficiently wet the metal contact pad to provide good electrical contact to the underlying readout or imager circuit. However, it is extremely important to carefully control this process as the intensity of the hydrogen plasma treatment dramatically affects the indium bump morphology.

To ensure the fine-tuning of this reflow process, it is necessary to have real-time feedback on the status of the bumps. With an appropriately placed viewport in a plasma chamber, one can image a small field (a square of approximately 5 millimeters on each side) of the bumps (10-20 microns in size) during the hydrogen plasma reflow process. By monitoring the shape of the bumps in real time using a video camera mounted to a telescoping 12× magnifying zoom lens and associated optical elements, an engineer can precisely determine when the reflow of the bumps has occurred, and can shut off the plasma before evaporation or de-wetting takes place.

This reflow process has been demonstrated to yield streak-free imagers, and repair misaligned or otherwise damaged indium bumps. It has also been demonstrated to yield non-resistive indium bump contacts in hybridized imagers having large arrays of information processing contacts. Without the reflow process, some 15 percent of the indium contacts were affected by unwanted resistance from oxidized or otherwise damaged indium bumps.

This technology has broad applications to all types of hybridized sensors and is not limited to space applications. Bump-bonding technology, in general, is useful in applications where a reduction in the packaging size of a completed device is advantageous. Because wire bonds are unnecessary in bump-bonded devices, the flip chips can sit directly on their corresponding circuit boards, resulting in a reduction of carrier area and height.

This work was done by Todd J. Jones, Shouleh Nikzad, Thomas J. Cunningham, Edward Blazejewski, Matthew R. Dickie, Michael E. Hoenk, and Harold F. Greer of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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