Precision Flux Deposition Techniques for Semiconductor Applications

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Abstract

Precise control of flux deposition is critical to semiconductor packaging applications including chip scale packages, ball grid arrays, column grid arrays, and flip chips. The flux must be applied in a defined pattern and film thickness to maximize both quality and throughput. Automated, contactless techniques are increasingly being utilized to replace the less controllable dipping and pin transfer techniques for flux application. Some new contactless flux application methods include flux jetting and ultrasonic atomized spray.

In recent years, the scale of components used in the electronics industry has grown increasingly smaller. A controlled application of flux is key to the soldering of these components, especially for a no-clean process. Flux needs to be applied only to the target area in the proper amount to facilitate soldering. If excess flux is applied, post soldering flux residue will result. Flux residue can cause reliability problems in the field as well as can cause delamination or voids in the underfill. Commonly used brushing or dipping techniques do not provide sufficient control over flux deposition, which results in excess flux residue. Additionally, these methods are slow, cumbersome and generally not suitable for high-volume production. Furthermore, post-soldering cleaning of flux residue is very difficult because die size of these components is increasing while the bump pitch is decreasing. Therefore, an automated, controlled technique for flux application is required to process these components in high volumes so that post-soldering cleaning is not required and the problems associated with excess flux residue are eliminated.

An automated contactless method for flux application has been developed that utilizes a "nozzle-less" ultrasonic spray head coupled with a precision X-Y-Z motion control platform. This technique is an extension of a method currently used in the wave –soldering process called Inline Selective Fluxing (ISF) that utilizes an ultrasonic spray head and a programmable positioning system to apply flux in a defined pattern and film thickness to areas of a printed circuit board assembly.[1.] The ultrasonic spray head uses ultrasonic energy to break a liquid into small drops to form the spray but the liquid does not pass through the device. Liquid is applied externally to a solid, vibrating rectangular surface, vibrating at an ultrasonic frequency (>20kHz). The spray pattern produced is rectangular and is focused with directed air streams. The benefits of "nozzle-free" ultrasonic technology are widely recognized in the wave soldering process as a method to improve quality and reduce costs.[2. 3.] For this application, spray pattern widths as low as 1 mm are achievable using a new configuration of the same basic ultrasonic technology. The liquid flow rate to the spray head is controlled with a precision liquid delivery system. The spray can also be activated and deactivated instantaneously to achieve the required flux deposition to the target areas.

This paper considers a particular advancement in precision fluxing using Ultra-Spray technology with the integrated fluid delivery applicator and precision X-Y-Z motion control platform.

Precision Flux Application System

The precision flux application system consists of 1) an Ultra-Spray ultrasonic head with integrated fluid delivery applicator; 2) a precision liquid delivery system and 3) a precision X-Y-Z motion control platform. An overview of each of these subsystems is provided below.

Ultra-Spray Head with Integrated Fluid Delivery

The Ultra-Spray head consists of an ultrasonic transducer with a spray forming head and an integrated fluid applicator with air and liquid supply passageways and an ultrasonic power generator.

The ultrasonic transducer consists of an ultrasonic converter that converts high frequency electrical energy into high frequency mechanical energy. The converter has a resonant frequency. The spray forming head is coupled to the converter and is resonant at the same resonant frequency of the converter. The spray forming head has a spray-forming tip and concentrates the vibrations of the converter at the spray-forming tip. Figure 1 illustrates the major components of the Ultra-Spray head with the integrated fluid delivery applicator.

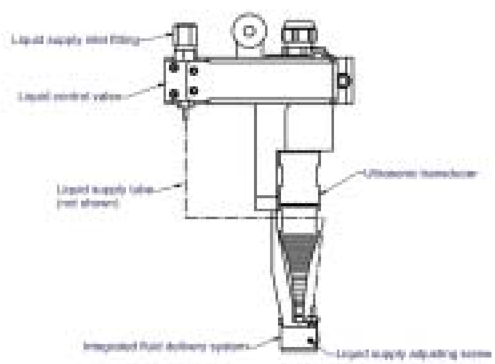

Figure 1 Ultra-Spray – Ultrasonic Spray Head Assembly

The integrated fluid applicator contains separate passageways for liquid and air, a liquid output surface, an air output annulus and an air-shaping ring. The fluid applicator has separate ports for air and liquid. The air inlet port is connected to a ring shaped annulus. The inlet port of liquid is connected to the output surface of the applicator. The air-shaping ring attaches to the bottom of the fluid applicator to enclose the air annulus to form an air passageway to supply air to the holes in the air-shaping ring. The angle of the holes in the air-shaping ring can be set to achieve a specific "focal point" of the liquid spray, thus producing the desired spray pattern size.

Figure 2 illustrates the detail of the integrated fluid delivery applicator.

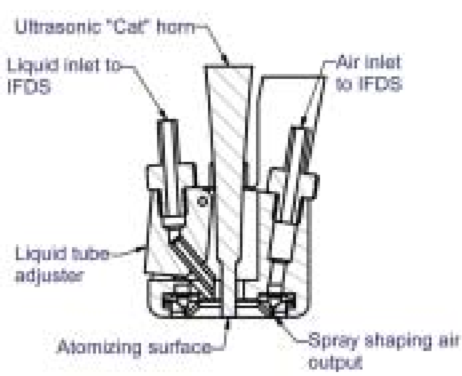

Figure 2 Detail of Integrated Fluid Delivery Applicator

The spray forming end of the Ultra-Spray head contains the necessary elements to produce the desired spray pattern: 1) the atomizing surface of the spray forming head, 2) the liquid applicator output surface and 3) the air delivery ring. These elements are arranged in a manner that allows the spraying forming end to be contained within a small area. Figure 3 illustrates the detail of the spray-forming end of the integrated fluid applicator.

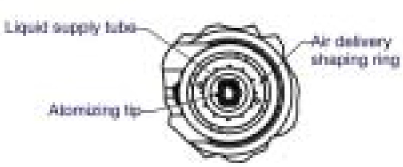

Figure 3 Detail of Air Ring on Integrated Fluid Delivery Applicator

The ultrasonic generator provides the power required by the converter by supplying a constant sinusoidal voltage at the operating frequency of the converter. The power generator tracks the power demand of the transducer by adjusting the operating frequency and power factor required by temperature and "load" changes. Load changes occur when more or less liquid is being sprayed from the atomizing tip. A microprocessor is used to monitor these dynamic conditions then adjusts generator "frequency tuning" to maintain optimum transducer operation. If an overload condition occurs the power generator is turned off and indicates a fault condition on its display. The output power of the generator can be adjusted to control the available ultrasonic energy at the atomizing surface of the spray head.

Precision Liquid Delivery System

Since the liquid is applied externally to the vibrating spray forming tip, precise amounts of liquid can be applied and dispersed as a spray to the substrate providing precise control, coating deposition and pattern. Precise control of the liquid flow rate, flow activation and flow deactivation is critical to achieving this result. Accordingly, the liquid delivery system is designed to meet the specific deposition requirements.

For coating applications of smaller, defined areas, a "micro volume" liquid delivery system consisting of a fast acting micro dispensing valve and a pressurized cartridge is suitable. This type liquid delivery system "dispenses" controlled volumes of liquid to the spray-forming tip of the spray head and the flow can be activated and deactivated virtually instantaneously. The combination of the precision liquid delivery, ultrasonic atomization, and focused airflow produces heretofore, unachievable control over spray pattern and coating deposition.

For coating applications of relatively larger areas and lines, a liquid delivery system consisting of a pressurized reservoir, solenoid valve and a precision orifice is suitable. The precision orifice meters the liquid flow rate to the spray head in proportion to the pressure in the reservoir. The solenoid valve is used to activate and deactivate the flow top the spray head.

Precision Motion and Control Platform

As shown in the wave-soldering process, the use of a precision motion and positioning system for the spray head is critical to achieving control over the flux coverage needed to approach the zero defect soldering goal.[4.] This application requires a precision, programmable X-Y-Z motion control system to provide coordinated control over spray head motion, airflow, liquid flow rate and flow activation/deactivation. The motion and control platform is capable of positioning the spray head with a resolution of 0.025 mm (0.001"), a repeatability of ± 0.025mm (0.001") and an accuracy of ± 0.05 mm (0.002"). The speed of the spray head can be adjusted between 25 to 500 mm/sec (1 to 20 in/sec). All coating functions are independently programmable to achieve the desired coating deposition and pattern.

Conclusion

The scale of components used in the electronics assembly industry is growing increasingly smaller. As a result, new more precise techniques for flux deposition are required especially in "no-clean" processes. A new precision flux application system that includes an advanced ultrasonic spray technology combined with a "micro volume" liquid delivery system and a precision X-Y-Z motion and control system provides the capabilities to meet these challenges.

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