Light emitting diode (LED) applications are growing and LEDs are becoming a substitute for light bulbs. They use less power, have longer lifetimes, produce little heat and emit coloured light, plus they are bright, efficient and quick to react. They are widely used in automotive lighting, cameras, consumer products, architectural applications and more. To reach performance and cost targets will require continuous improvements in LED devices and packaging to extract ever-increasing lumens per watt. One way of achieving this is through pulse heat eutectic die attach and wire chain bonding.

There are four levels, or areas, in the manufacture of LEDs. Level 0 is the device itself. Level 1 assembly involves attaching the device to the source of electricity, usually accomplished with die attach and wire bonding. Level 2 assembly is where the package is put into a structure in multiples to create light output for applications like external signage or outdoor lighting. Level 3 is system assembly for the whole system or solution.

LED packages range from a single LED to a complex matrix of LEDs. In a standard array LED, each LED is wire bonded to a substrate pad. LEDs can be addressed individually or tied together, and often the dies are attached with epoxy.

For high-bright LED applications, such as outdoor lighting or rear projection screen lighting, a matrix configuration of LEDs is used (Figure 1). Matrix assemblies are growing in popularity because more lumens per area can be derived from this configuration. However, compared to single die packages, matrix LED packages present challenges for both die attach and wire bonding. For a matrix configuration, the LEDs are placed in tightly packed rows and columns to generate the most light. Packing many LEDs so close together generates heat, so the die attach method that is used has to provide good thermal conductivity or thermal transfer to keep the LEDs as cool as possible. A eutectic method is used because it can transfer the tremendous amount of heat-per-unit-area generated by the diodes, thereby providing the thermal and electrical connections needed to generate a stable transmission of light.

Pulsed-heat controlled eutectic die attach

Critical to the LED assembly process is a void-free eutectic solder interface between the diode and its substrate. It is an extremely temperature-sensitive process, and success requires careful temperature control and consistent heat transfer from the diode. Temperature profile repeatability is critical to the process to allow proper eutectic wetting with low voids without damaging the LEDs. Required temperature profiles depend on the substrate materials, geometry and solder composition.

Proper LED attach can be achieved with a ganged pulsed-heat reflow. During the pulsed-heat cycle, temperatures are ramped from a preheat temperature to the reflow temperature using a servo-controlled ramp profile (as compared to traditional heater stage systems). Once the interface is brought up to the proper eutectic temperature, the heating mechanism must maintain that programmed temperature with minimal overshoot. The reflow temperature is held for a prescribed duration. Then, simultaneously using active thermoelectric pulse heating and cooling gases, the heating mechanism goes through a controlled cooling to minimise damage to the diode and allow the eutectic material to

Figure 1 – A matrix of LEDs assembled together for high lumens
reach metallurgical equilibrium. Pulsed heat profile control allows batch reflow of the LED matrix for reduced overall cycle time and minimum time at temperature for the protection of temperature sensitive LED devices.

**Wire bonding**

A high density LED matrix format requires the LEDs to be interconnected using wires; therefore, once the LEDs are bonded, strings of wire bonds are used to interconnect the LEDs. There are several methods of wire bonding, such as ball bonding and wedge bonding. Recent tests have shown that a new chain bonding technique, using a ball bonder instead of a wedge bonder, achieves the best results.

In standard ball/stitch bonding, a ball is placed, then bonds are placed on top of the stitches to create a string of interconnected LEDs. Chain bonding is a variant on ball/stitch bonding where the stitch is not terminated and another loop-stitch combination is repeated to complete a chain bond wire set (Figure 2). It ends with a loop-end stitch which can be followed by a security ball bump on the end stitch.

This is not new technology, but it has been further developed through materials selection and software tools. Chain bonding enables higher throughput since there is only a need to create free air balls for the first loop in the chain. In addition, there is less light occlusion due to chain bond stitch geometry. Pull tests show that better pull strength is achieved.

**Conclusions**

Placing LEDs in a matrix configuration can result in high lumen LED packages. This configuration creates challenges in assembly because of the high concentration of heat and the need for high density wire bonded connections that must be accurately placed in tight areas, have consistent loop structure and have a connection strong enough to withstand mechanical shock and stresses due to large thermal variations.

Three steps in the assembly process are key. First, high-accuracy die pick-and-place for matrix LED applications to within LED geometric tolerances. Second, using a pulsed-heat controlled batch eutectic reflow die attach process to provide consistent melting and a void-free attach interface. This is necessary for consistent heat transfer from the diode and contributes significantly to temperature stabilisation during LED operation. Third, using a chain bond to provide excellent electrical and mechanical connection of the arrays across the LEDs. Utilising these assembly processes results in high brightness while achieving thermal dissipation and maximum light extraction.

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**Premo**

Tel. +34 951 231 320, Fax. +34 951 231 321
patricia.mancera@grupopremo.com
www.grupopremo.com