Application Note AN11

Handling and Assembly of Bridgelux LED Arrays

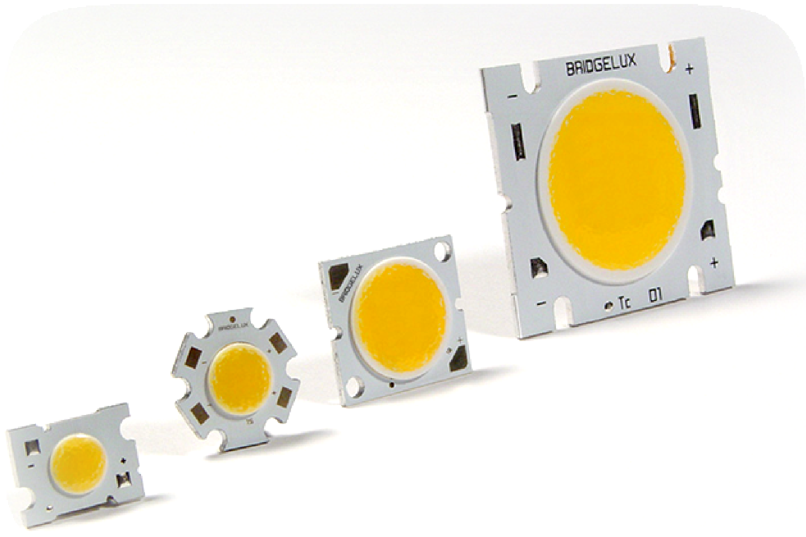
Sept 9, 2011

Introduction

The Bridgelux family of LED Array products delivers high performance, compact and cost-effective solid-state lighting solutions to serve the general lighting market. These products combine the higher efficiency, lifetime, and reliability benefits of LEDs with the light output levels of many conventional lighting sources.

Optimizing performance and reliability of a lighting system using Bridgelux LED Arrays requires careful selection of electronic drivers and consideration of thermal management solutions (see Application Notes AN10 – Effective Thermal Management of Bridgelux LED Arrays and AN12 – Electrical Drive Considerations for Bridgelux LED Arrays). It is equally important to use safe handling and appropriate manufacturing procedures, processes and chemicals during the assembly of the Bridgelux LED Array into the lighting system.

This application note provides recommendations for mechanical and electrical assembly of Bridgelux LED Arrays into lighting systems. Guidelines for chemical exposure and handling of the LED Arrays are included to avoid damaging the LED Arrays during the assembly process. Recommended assembly procedures to ensure a reliable electrical connection to the LED driver and a mechanically robust, thermally efficient contact between the LED Array and underlying heat sink are also provided.



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Assembly Overview

A lighting system using a Bridgelux LED Array requires:

1. A robust mechanical connection between the LED Array and the heat sink or lighting fixture body.
2. A thermally conductive path from the case (or back) of the LED Array to the heat sink or lighting fixture body.
3. An electrical connection between the solder pads on the LED Array and the power supply or electronic driver used to power the LED Array.

A reference drawing of a lighting system assembly using a Bridgelux LED Array is shown in Figure 1. Components of the assembly include wires, solder, screws, lock washers, flat washers, heat sink, and a thermal interface material in addition to the LED Array. For some applications, secondary optics such as reflectors, collimators or other lens systems may also be required to direct the light.

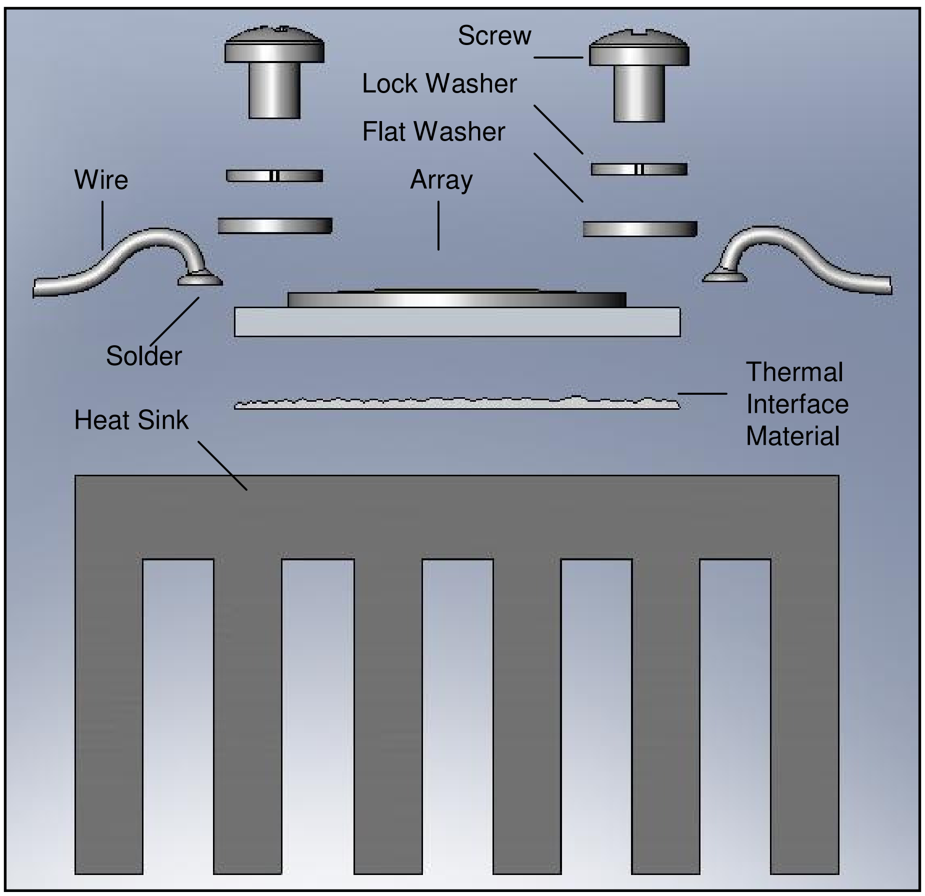

Figure 1: Reference assembly drawing

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Chemical compatibility

Optimizing performance and reliability of a lighting system using Bridgelux LED Arrays requires safe handling and use of appropriate manufacturing procedures and materials during the assembly of the Bridgelux LED Array into the lighting system. Careful consideration must be given to the materials and chemicals used when processing the Bridgelux LED Arrays and to materials that are incorporated into a luminaire. This section provides a list of commonly used chemicals that should be avoided or carefully managed during processing of Bridgelux LED Arrays and during their subsequent use.

Silicone encapsulation is commonly used by most High Brightness LED manufacturers, including Bridgelux. The silicone encapsulation is permeable to gas molecules. The gas molecules, including volatile organic compounds (VOC's), halogen and sulfur compounds, can interact with silicone and other components that comprise the LED Array and cause degradation in performance of the LED array. The possibility and extent of degradation is dependent on the type of chemical, the concentration of the chemical, the temperature during exposure and the length of time of exposure to the chemical. Additional considerations should be given to IP rated or "sealed" luminares that create "air tight environments" around the LED Array which can trap potentially damaging gas molecules from manufacturing processes or subsequent out-gassing of materials used in the luminare which can then result in long term exposure of the LED Array to the contaminant.

The source of the gas molecules can be out-gassing from polymeric materials such as glues, gaskets, paints and/or under-cured materials. Materials used inside a luminare with a potential to outgas should be characterized as part of the luminare design to understand the environment that will be surrounding the LED array during the luminare lifetime. The silicone encapsulation is also vulnerable to non-polar fluids and solvents commonly used during the manufacturing process of the luminare such as cleaning, oil assisted drilling and any processes that would allow the LED Array to come into contact with the fluids or solvents. Care should be taken such that the LED Array is protected from such chemicals to avoid ingress of small non-polar molecules into the encapsulation silicone.

Common chemicals that are known to be harmful to Bridgelux LED Arrays are listed in Table 1 below. Note that the chemicals listed in Table 1 may be found in various states – liquid, gas, and/or solid. All physical states of these chemicals can be harmful to the Bridgelux LED Arrays but those that are in a gaseous state, such as volatile organic compounds (VOCs), can readily permeate the lens material of the array and damage the array internally and/or externally.

Table 1: Commonly used chemicals that will cause harm to Bridgelux LED Arrays.

Classification	Chemical Name	Found In Some
Acids	Hydrochloric Acid Sulfuric Acid Nitric Acid Phosphoric acid	Cleaners, cutting fluids
Organic acids	Acetic acid	RTV silicones, cutting fluids, degreasers, adhesives
Bases	Sodium Hydroxide Potassium hydroxide Amines	Detergents, cleaners
Organic Solvents	Ethers such as glycol ether Ketones such as MEK, MIBK Aldehydes such as formaldehyde	Cleaners, mineral spirits, petroleum, paint, gasoline
Aromatic solvents	Xylene Toluene	Cleaners

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	Benzene	
Low Molecular Weight Organics (VOC's)	Acetates Acrylates Aldehydes Dienes,	Superglue, Loctite adhesives, threadlockers and activators, common glues, conformal coatings
Petroleum Oils	Liquid hydrocarbons	Machine oil, lubricants
Non-petroleum Oils	Siloxanes, fatty acids	Silicone oil, lard, linseed oil, castor oil
Oxidizers/Reducers	Sulfur compounds	gaskets, paints, sealants, petroleum byproducts
Halogen compounds	Cl, F,or Br containing organic and inorganic compounds	solder fluxes/pastes, flame retardants

Because it is impossible to determine all of the chemicals that may be detrimental to the performance of the LED Arrays the list of chemicals above may not be exhaustive. It is the responsibility of the luminare manufacturer to ensure that any and all materials used in the luminare design or manufacturing process do not cause damage to the LED Array.

For additional information on chemicals that are potentially hazardous to LEDs please refer to the following industry resource:

Lighting Industry Federation Technical Statement No.49 http://www.lif.co.uk/

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Handling Bridgelux LED Arrays

CAUTION: CONTACT WITH OPTICAL AREA

Do not touch the optical area of the LED Array. Avoid any contact with the optical area. Applying stress to the yellow phosphor resin area can result in damage to the LED Array.

Optics and reflectors must not be mounted in contact with the yellow phosphor resin area or the white ring that surrounds the yellow phosphor area. Using the white ring to secure optics can result in damage to the LED Array as it is not designed to act as a mechanical locating feature. Optical devices may be mounted on the top surface of the LED Array substrate outside of the white ring maximum OD as specified in the product data sheet. Use the mechanical features of the LED Array substrate edges and/or mounting holes to locate and secure the optical device as needed.

Bridgelux LED Arrays are packaged for volume shipment in tubes with plastic stoppers at each end. Low volume sample shipments may be packaged using other methods. To manually remove the LED Arrays from the tubes rotate the tube such that the parts face upward. The yellow resin side of the LED Array should point up, towards the ceiling, and not down towards the work surface. Remove the stopper at one end of the tube, place the open end of the tube on a clean flat surface, and lift the opposite end. The LED Arrays should begin to slide down and out of the low end of the tube. If the LED Arrays do not slide freely, apply either a slight pressure to the top and bottom of the tube (such as between two fingers) or apply a small vibration to the tube to facilitate movement. Figure 2 illustrates removing the Bridgelux LED Arrays from the shipping tube.

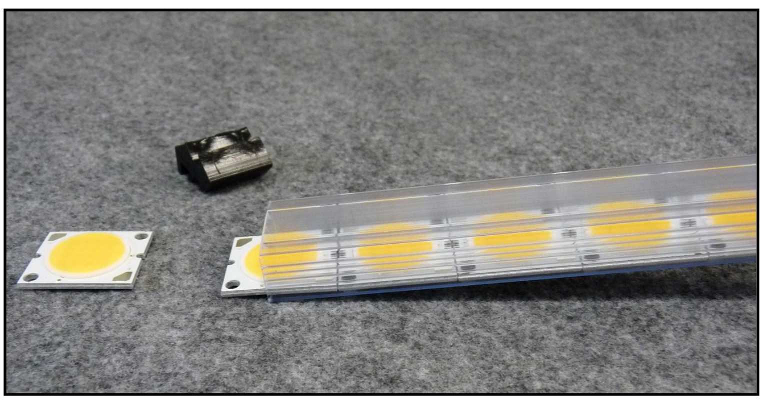

Figure 2: LED Arrays, resin side up, sliding out of the shipment tube

Handle the parts with care. It is recommended to wear finger cots or plastic gloves to prevent dirt or other contaminants from adhering to the LED Array (see Figure 3). Bridgelux LED Arrays are optical devices. Please ensure that nothing comes into contact with the yellow resin area, as this may adversely affect performance.

Parts may also be handled with tweezers. If handling the LED Arrays with tweezers, select tweezers with rounded tips and grip the LED Array by the edges away from the solder pads (see Figure 4). Although use of a clean room is not required, the environment in which the LED Arrays are assembled should be clean, avoiding dust and particles, which may adhere to the resin area of the LED Array.

Bridgelux LED Arrays have passed ESD testing to levels which do not require special handling for most assembly processes. However, to prevent inadvertent damage, Bridgelux recommends using appropriate ESD grounding procedures while handling the LED Arrays.

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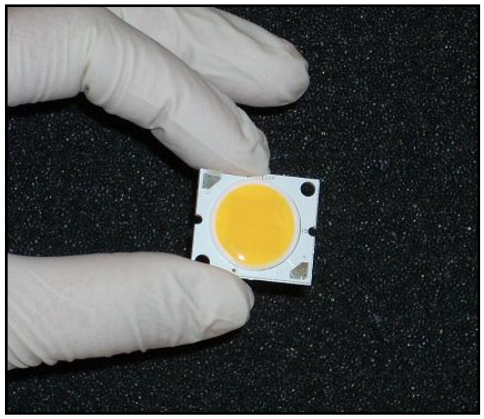

Figure 3: Proper handling of the Bridgelux
LED Array using fingers

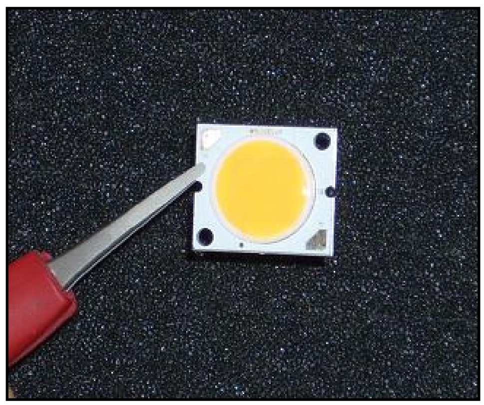

Figure 4: Proper handling of the Bridgelux
LED Array using tweezers

If debris contacts the resin, gently remove it using the tip of a cotton swap soaked in isopropyl alcohol (commonly called rubbing alcohol).

If pick-and-place equipment is used for automated assembly, the vacuum collet should be designed so as to avoid contact on the resin area and the white ring surrounding the resin area.

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Wire Connection

PRE-WIRED

To further enhance ease of manufacturing with the RS and rectangle ES Arrays, an option to order the arrays with wires pre-attached is available. This option simplifies manufacturing by eliminating the need for a soldering process at the luminare manufacturer's facility. Pre-wired arrays can be specified by appending the –Wxx suffix to the array part number as indicated below.

Please refer to Product Datasheet DS18 for additional information on this option.

Table 2: Wire Specification and Ratings

Part Number[1]	Conductor Size	Conductor Type	Length (L) (Figure 5)	Insulation Color	Insulation Temp Rating	Insulation Voltage Rating	UL Rating[2]	RoHS Compliant
- W01	18 AWG (0.82 sq mm)	Tinned stranded copper	165 ±5 mm (6 inches)	Red (positive wire) Black (negative wire)	125ºC	300V	VW-1	Yes
- W03	18 AWG (0.82 sq mm)	Tinned stranded copper	460 ±5 mm (18 inches)	Red (positive wire) Black (negative wire)	125ºC	300V	VW-1	Yes

1. Standard array part numbers with a – WXX extension. Example: To purchase the BXRA-W0802-00000 array with wires, the specified part number would be BXRA-W0802-00000-W01. Consult your Bridgelux sales representative for further information.
2. Flammability rating tested according to UL-758.
3. Specifications apply to both the red (positive) wire and the black (negative) wire.

Table 3: Wire Termination

Part Number	Wire Termination at Free End (Dimension S in Figure 5)	Array Type	Wire Orientation
-W01	Stripped 12 mm (0.5 inch) typical from end Exposed conductor soldered	RS Array	Parallel Orientation
		ES Array	In-line Orientation
- W03	Stripped 12 mm (0.5 inch) typical from end Exposed conductor soldered	RS Array	Parallel Orientation
		ES Array	In-line Orientation

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Figure 5: Wire Length (not to scale)

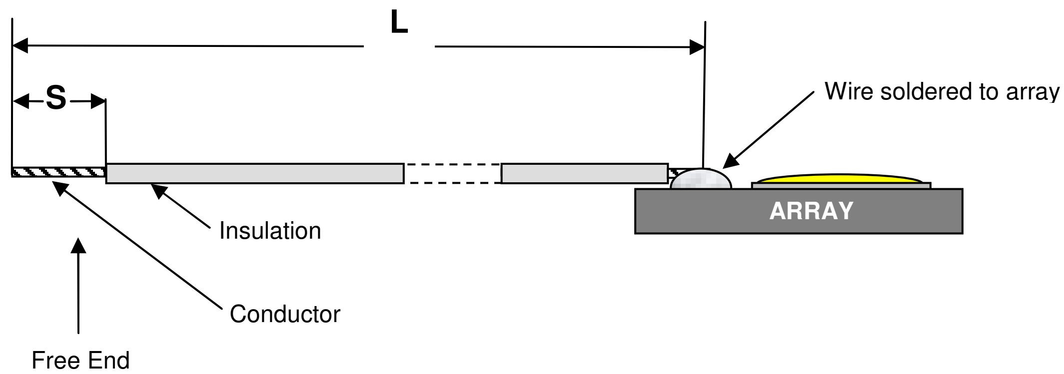


Figure 6: RS Array: Parallel Wire Orientation

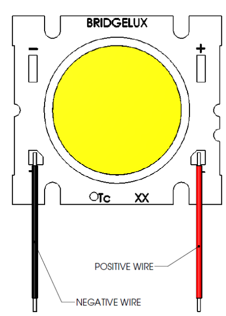
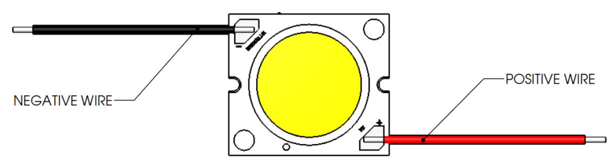


Figure 7: ES Array: In-line Wire Orientation



Notes for figure 6 and 7:

1. Solder pads are labeled "+" and "-"to denote positive and negative, respectively.
2. Note wire orientation for wire attachment to RS Array and ES Array
3. Drawings are not to scale.

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SOLDERING PROCESS

Required Materials

1. Soldering Iron

Bridgelux recommends the use of a soldering iron with a temperature controlled flat shaped tip, similar to the Weller WTCPT (60 Watt Temperature Controlled Soldering Station). Many similar soldering systems are commercially available.

2. Flux

Flux, a chemical cleaning agent, is typically used to remove oxidation from the metals to be joined prior to soldering. When using tin based solders use the rosin recommended by the manufacturer. Some fluxes are water soluble or self cleaning. The use of a water soluble or self cleaning flux facilitates the removal of excess flux after the soldering process, and is therefore recommended. If a non water soluble or non self cleaning flux is used, excess flux may be removed from the solder pad area using small amounts of isopropyl alcohol and a lint free cotton swab.

Solder flux is typically applied using a flux applicator. The flux applicator may be a bottle with a thin needle tip, a thin brush, or a flux pen with a fine tip.

3. Stranded Copper Wire

The correct wire gauge for each application is design dependant. The customer is responsible for selecting the wire gauge that meets all codes and regulatory requirements. Other considerations for selecting a suitable wire include the allowable voltage drop across the wire, temperature requirements, insulating material requirements, and flexibility requirements to facilitate wire routing in the lighting system.

Wires should be cut to size and stripped to remove a few millimeters of insulating material at the ends. Many commercially available tools are available to perform this task. Care must be taken to prevent bare wires from touching the aluminum substrate of the Bridgelux LED Array in order to prevent inadvertent current paths (leading to shorting), and therefore excess insulation removal should be avoided.

4. Solder

Bridgelux recommends using lead free solders, such as SnAg, with high flux content. Typically solder wires with a small diameter, such as a 0.040 inch or 1mm, are easier to use. The final selection of a suitable solder is design dependent. Selection considerations include reliability requirements (such as thermal fatigue and corrosion), melting temperature, strength, reactivity with other components, and wettability. Table 4 lists a sampling of solders and their melting temperatures. For environmental reasons, lead free solders are becoming more widely used.

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Table 4: Solder and associated melting points

Solder	Melting Point	RoHS Compliant
63/37 Sn/Pb (Eutectic)	183℃	NO
SnAg	217 to 220℃	YES
$SnBi_{58}$	138℃	YES
$SnIn_{52}$	118℃	YES

5. Temperature Controlled Hot Plate

Due to the extremely low thermal resistance of the Bridgelux LED Arrays, heat will quickly dissipate from the solder pad during soldering, resulting in a longer solder process time. The soldering time can be reduced by either placing the LED Array on a non-thermally conductive surface to minimize thermal dissipation or by placing it on a temperature controlled hot plate. If used, the temperature controlled hot plate should be capable of reaching 150℃.

6. Flux Cleaner

If there is a need to clean the LED Arrays to remove excess solder flux, Bridgelux recommends using IPA (Isopropyl Alcohol) or deionized water and a clean cotton swab.

Recommended Soldering Process

In addition to the process recommendations that follow, all safety and operation guidelines provided by the soldering station manufacturer should be strictly followed at all times.

1. Pre-tin the tip of the soldering iron and the tip of the wires with a small amount of solder. As noted in the Product Data Sheets in the Absolute Maximum Ratings section, the temperature of the tip of the soldering iron should not exceed 350℃.

2. Clean the LED Array solder pads. If the solder pads are heavily oxidized due to improper storage, rub the oxidized pad with a pencil eraser to remove oxidation. Use IPA to remove non-polar compounds and other contamination.

3. If not already provided with pre-tinned solder pads, pre-tin the LED Array solder pads. A production change was implemented in late 2009 to add solder pre-tinning to the solder pads of all LED Arrays, but products produced prior to this change will not include pre-tinned solder pads. To pre-tin the solder pads use the following process:

    A. Place the LED Array on a hot plate whose temperature is set to 150℃.

    B. Apply a small amount of flux onto the solder pads of the LED Array (see Figure 8). Flux should be applied only to the solder pads and should not touch other parts of the LED Array, especially the light emitting region (resin area).

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C. Hold the soldering iron tip on the solder pad, allowing the pad to reach the temperature at which the solder wets and flows.

D. Apply solder to the solder pad and solder tip, allowing sufficient time for the solder to wet. The solder should form a domed shape on the solder pad.

E. Allow the pre-tinned solder pad to cool.

F. Remove excess flux from the solder pad using IPA, allow the pad to dry.

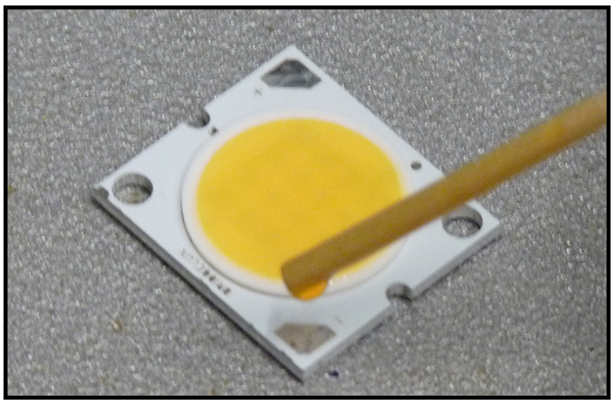

Figure 8: Dispensing flux onto Bridgelux LED Array solder pad

4. Solder the pre-tinned wires onto solder pads using the process below.

   A. Pre-tin the tip of the soldering iron.

   B. Place the pre-tinned LED Array on a hot plate whose temperature is set to 150°C.

   C. Place the pre-tinned wire tip on the pre-tinned solder pad.

   D. Place the hot tip of the soldering iron on top of the wire tip. Bring the solder wire to the area just below the solder tip (see Figure 9). Only a small amount of solder is necessary to form a joint. After the solder melts and while holding the wire in place, quickly remove the soldering iron to prevent the formation of icicles. Signs of an overheated solder joint include solder spike formations and burnt flux residue. If these signs are observed, consider reducing the solder time or the soldering iron temperature. The process of soldering wires to the LED Array should take just a few seconds. The maximum time that the soldering tip should contact the LED Array solder pad and wire is 3.5 seconds.

   E. Allow the solder joint to cool.

   F. Remove excess flux from the LED Array using IPA, allow to dry.

   G. A pull test on the wire can be used to ensure the integrity of the solder joint.

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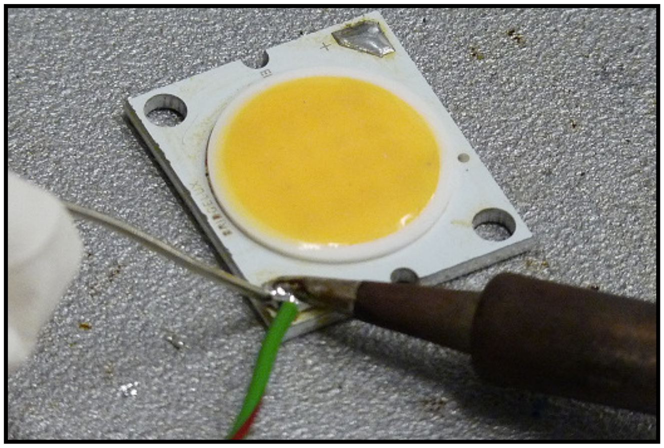

Figure 9: Soldering a pre-tinned wire to a pre-tinned solder pad

Note that two sets of anode and cathode solder pads are provided on the RS Array Series products. It is not necessary to provide electrical connections to both sets of solder pads. Either set of solder pads (6.35 x 2.03 mm rectangular pads or 3.50 mm tapered square pads) may be used depending on application specific design requirements.

REFLOW SOLDERING

Please refer to application note AN15 – Reflow Soldering of Bridgelux LED Arrays for details on soldering wires using a reflow solder process.

Heat Sink and Thermal Interface Materials

Heat sink design and thermal interface materials selection is described in detail in Application Note AN10, Effective Thermal Management of Bridgelux LED Arrays, and will not be discussed further in this application note. Please consult AN10 for further information.

Bridgelux recommends that heat sink surfaces are specified to maintain a flatness tolerance of 0.1 mm and a surface roughness tolerance of RMS $\sqrt{16}$.

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Mechanical Assembly

Screw Size

Bridgelux LED Arrays are provided with holes or slots to facilitate mounting the LED Arrays using screws. Table 5 lists screw or slot diameter, required mounting screw size, and maximum screw head diameter for all products.

A wide variety of screws are commercially available to meet design requirements. Examples include screws with floating threads, screws with self locking threads, screws with self locking and floating threads, miniature screws, flush screws and low profile screws.

When selecting a screw, consider screws that have a low profile screw head. A low profile screw head has the advantage of blocking less of the light emitted from the LED Array. Additionally, if a secondary optic is to be used in the application, a low profile screw head allows more room for the optical components.

Please refer to the mechanical drawings included in the Bridgelux LED Array Product Data Sheets for additional information regarding the location of the slots and holes.

Screw Location and Quantity

For all products except for the RS Array Series, Bridgelux recommends using two screws to mount the LED Array to the heat sink. Using only one screw may result in poor thermal conductivity between the LED Array and the heat sink. For the RS Array Series (BXRA-C4500, BXRA-N3500 and BXRA-W3000 products) Bridgelux recommends using four screws to mount the LED Array to the heat sink.

For Hexagonal Star LED Arrays, the recommended screw locations are illustrated in Figure 10. The recommended screw locations for all other products are the 3.2 mm diameter holes or the 3.2 mm wide slots indicated in the mechanical drawings section of the relevant Product Data Sheet.

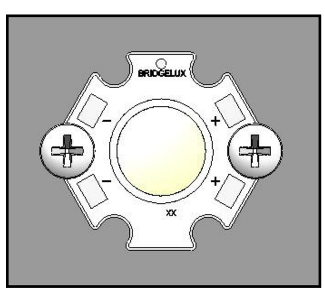

Figure 10: Recommended screw locations for hexagonal star LED Arrays

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Screw Location Tolerance

Bridgelux recommends two tapped holes for mounting screws for all products except for the RS Array Series. The center to center spacing for these two tapped holes is shown in Table 5.

For the RS Array Series, Bridgelux recommends four tapped holes for mounting screws. The center to center spacing for these tapped holes is shown in Figure 11.

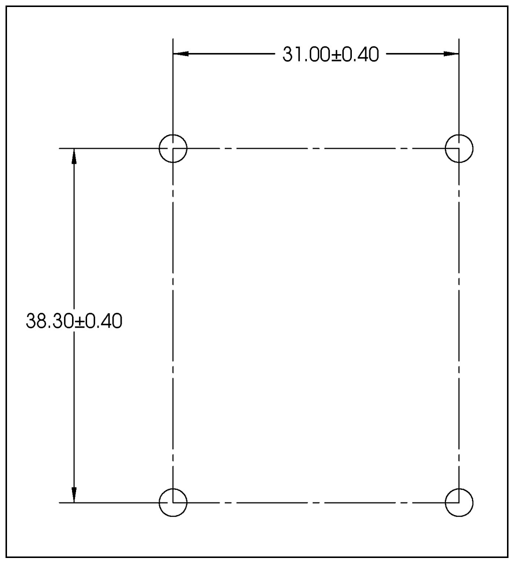

Figure 11: Center to center spacing for mounting screws for RS Array Series

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Screw Torque

When mounting the LED Array to a heat sink, ensure that the proper torque is applied to the screws. For all Bridgelux LED Arrays, the maximum torque that may be applied to mounting screws is 4 in-lbs (45 Newton-centimeters). Excessive torque may result in damage to the LED Array. It is the responsibility of the customer to review manufacturer recommended maximum torque values for selected screws to ensure those values are not exceeded. After assembly the bottom of the screw head should be parallel to the top surface of the LED Array.

Flat Washers

Flat washers may be used to protect the LED Array from damage resulting from excess torque and to provide a wider distribution of the load applied by the screw. Flat washers, however, do not prevent fasteners from loosening in vibration environments.

Bridgelux recommends using soft non-electrically conductive flat washers on all products. The use of these washers reduces the risk of shorts which may be caused by contacting the solder pads or traces on the LED Array. The maximum outer diameter (OD) of washers that may be used with the Bridgelux LED Arrays is shown in Table 5.

Lock Washers, Self-Locking Fasteners, and Thread Sealants

To prevent loosening of screws during vibration or thermal cycling Bridgelux recommends using lock washers, self-locking fasteners, or thread sealants.

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Table 5: Screw sizes, washer sizes, and mounting hole tolerances

Array Series (nominal dimensions)	**Slot or Screw Hole Diameter**	**Required Mounting Screw Size**	**Maximum Screw Head Diameter [1]**
LS Series (13.8 x 18.0 mm) 	3.15 mm	M2.5 or #4	5.5 mm
ES Series (Star) (20.0 mm dia) 	3.15 mm	M2.5 or #4	5.5 mm
ES Series (Rectangle) (25.8 x 28.8 mm) 	3.15 mm	M2.5 or #4	5.5 mm
RS Series (50.3 x 49.5 mm) 	3.15 mm	M2.5, M3 or #4	5.5 mm

Notes:

1. Using larger diameter screw heads may lead to physical interference with components that make up the LED Array (which is not acceptable) or may jeopardize the integrity of the electrical circuit by creating alternate paths for current flow.
2. Typical screw head diameters range from 5.2 to 6.0 mm. Select a screw with a diameter that does not interfere with other components, such as a lens or a reflector.

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Design Resources

Included below is a partial list of available design resources that may be used to handle and assemble Bridgelux LED Arrays into a lamp or luminaire. This is by no means an exhaustive and complete list, nor a recommended list of Bridgelux approved or qualified suppliers. It is the responsibility of the customer to fully qualify and validate luminaire design components and assembly processes to meet all code and regulatory requirements.

Wire Gauge Maximum Current Limits

www.powerstream.com/Wire_Size

Mounting Screws, Washers, Lock Washers, and Self Locking Fasteners

www.longloklocking.com/products_overview

www.nord-lock.com

www.nylok.com

Pick and Place Tools

www.micro-mechanics.com

www.smallprecisiontools.com

Soldering Processes and Procedures

IPC J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies

IPC/EIA J-STD-002 Solderability Tests for Component Leads, Terminals and Wires

J-STD-004 Requirements for Soldering Fluxes

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It is the responsibility of the customer to ensure that the design meets all necessary requirements and safety certifications for its intended use.

About Bridgelux

Bridgelux is a leading developer and manufacturer of technologies and solutions transforming the $40 billion global lighting industry into a $100 billion market opportunity. Based in Livermore, California, Bridgelux is a pioneer in solid-state lighting (SSL), expanding the market for light-emitting diode (LED) technologies by driving down the cost of LED lighting systems. Bridgelux's patented light source technology replaces traditional technologies (such as incandescent, halogen, fluorescent and high intensity discharge lighting) with integrated, solid-state lighting solutions that enable lamp and lighting manufacturers to provide high performance and energy-efficient white light for the rapidly growing interior and exterior lighting markets, including street lights, commercial lighting and consumer applications. With more than 500 patent applications filed or granted worldwide, Bridgelux is the only vertically integrated LED manufacturer and developer of solid-state light sources that designs its solutions specifically for the lighting industry.

For more information about the company, please visit www.bridgelux.com

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