Application Note AN41 - PRELIMINARY

Handling and Assembly of Bridgelux V Series LED Arrays

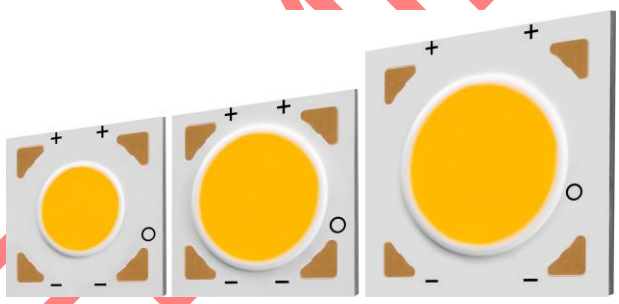
Oct 17, 2013

Introduction

The Bridgelux family of Bridgelux V Series LED Array products delivers high performance, compact, cost-optimized solid-state lighting solutions to serve the general lighting market. These cost-effective light engines extend the technology and performance of the highly successful Bridgelux Vero line. The Bridgelux V Series LED Arrays (Bridgelux V Series) feature high flux density in small source size packages, and is well suited for sub 1000 lumen commercial and residential lighting applications where tight beam control and high quality light are essential.

Optimizing the performance and reliability of a lighting system using Bridgelux V Series requires careful consideration of thermal management solutions, electronic drivers and secondary optics. It is equally important to use safe handling and appropriate manufacturing procedures, processes and chemicals during the assembly of the Bridgelux V Series into the lighting system.

This application note provides recommendations for proper mechanical and electrical assembly of Bridgelux V Series into lighting systems. Guidelines for chemical exposure and handling of the Bridgelux V Series 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 V Series LED Array requires the following:

1. A robust mechanical connection between the Bridgelux V Series and the heat sink or lighting fixture body.
2. A thermally conductive path from the case (back of aluminum substrate) of the Bridgelux V Series to the heat sink or lighting fixture body which in turn has convective or forced airflow with the ambient (cool) air.
3. An electrical connection between the connector port or the solder pads on the Bridgelux V Series and the power supply or electronic driver used to power the Bridgelux V Series.

A reference drawing of a lighting system assembly using a Bridgelux V Series is shown in Figure 1. Components of the assembly include a Bridgelux V Series LED Array, Bridgelux V Series holder, screws with flat washers and spring washers, heat sink, thermal interface material, reflector, and housing.

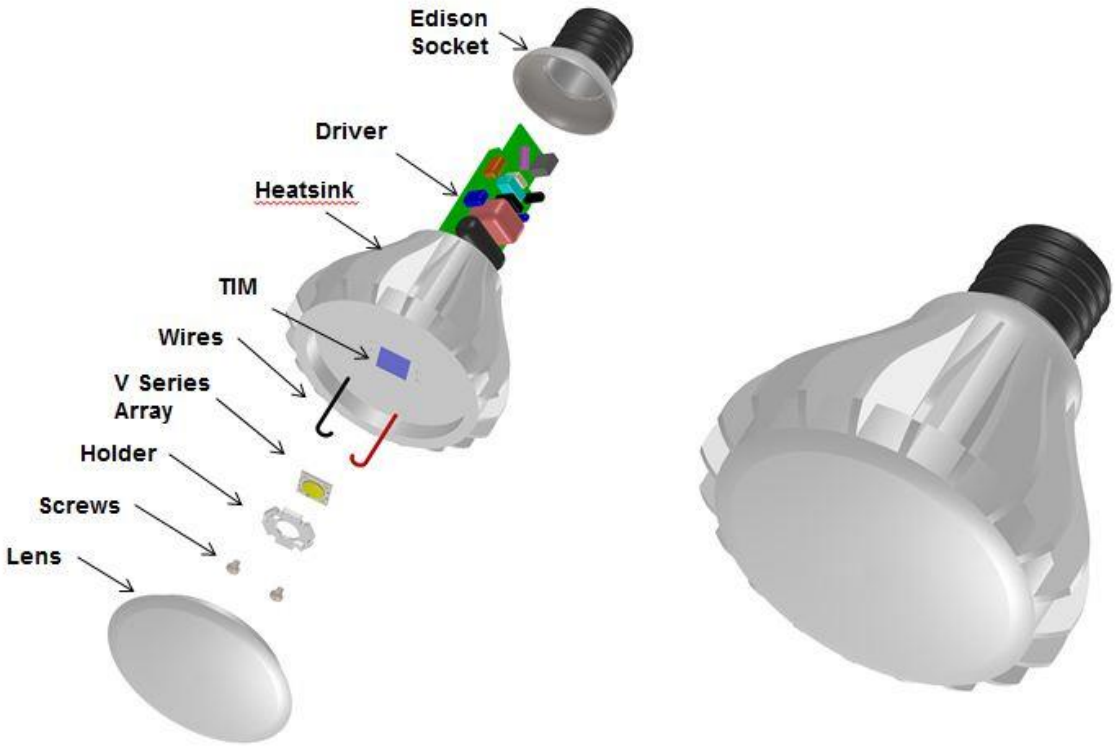

Figure 1: Bridgelux V Series Array System Assembly Drawing

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Chemical Compatibility

Optimizing performance and reliability of a lighting system using Bridgelux V Series LED Arrays requires safe handling and use of appropriate manufacturing procedures and materials during the assembly of the array into the lighting system. Careful consideration must be given to the materials and chemicals used when processing the Bridgelux V Series 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 V Series 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 Bridgelux V Series and cause degradation in performance of the Bridgelux V Series. 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 the array is exposed to the chemical. Additional considerations should be given to IP rated or "sealed" luminaires that create "air tight environments" around the Bridgelux V Series. Luminaires sealed in this fashion can trap potentially damaging gas molecules from manufacturing processes or subsequent out-gassing of materials used in the luminaire which can result in long term exposure of the Bridgelux V Series 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 luminaire with a potential to outgas should be characterized as part of the luminaire design to understand the environment that will be surrounding the Bridgelux V Series during the luminaire lifetime. The silicone encapsulation is also vulnerable to non-polar fluids and solvents commonly used during the manufacturing process of the luminaire such as cleaning, oil assisted drilling, and any processes that would allow the Bridgelux V Series to come into contact with the fluids or solvents. Care should be taken such that the Bridgelux V Series 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 V Series 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 V Series, 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.

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Table 1: Commonly used chemicals that will cause harm to Bridgelux V Series 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 Benzene	Cleaners
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, flameretardants

Because it is impossible to determine all of the chemicals that may be detrimental to the performance of the Bridgelux V Series the list of chemicals above may not be exhaustive. It is the responsibility of the luminaire manufacturer to ensure that any and all materials used in the luminaire design or manufacturing process does not cause damage to the Bridgelux V Series.

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

Lighting Industry Association Technical Statement 13 http://www.thelia.org.uk

Handling Bridgelux V Series LED Arrays

CAUTION: CONTACT WITH OPTICAL AREA

Avoid any contact with the optical area. Do not touch the optical area of the Bridgelux V Series LED Array or apply stress to the yellow phosphor resin area. Contact may cause damage to the LED array.

Optics and reflectors must not be mounted in contact with the yellow phosphor resin area. Optical devices may be mounted on the top surface of the plastic housing of the Bridgelux V Series LED Array. Use the mechanical features of the LED array housing, edges and/or mounting holes to locate and secure optical devices as needed.

Bridgelux V Series LED Arrays are packaged for volume shipment in trays of various sizes. Low volume sample shipments may be packaged using other methods. To manually handle the arrays first remove the cover tray by removing the rubber band that holds the trays together. Next move a single tray with arrays to the edge of a table top. Be sure not to drop or jostle the tray. If necessary, use a weight, such as the cover tray, to counter balance the tray with arrays. Push the array upward from the bottom of the tray through the round holes using a Number 2 pencil with an eraser. Lastly, while wearing clean gloves, hold the array from the corners. Be sure not to touch the light emitting surface (yellow area) of the array as this can damage the array. Figure 2 illustrates a suitable method of removing the Bridgelux V Series from the shipping tray.

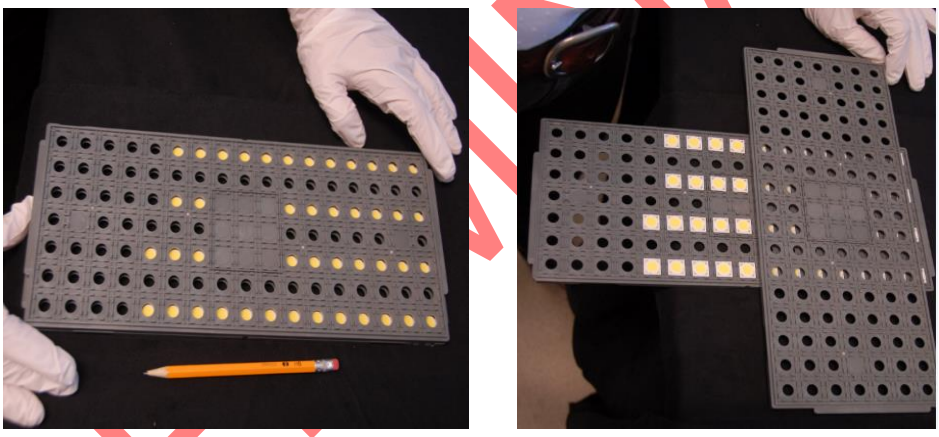
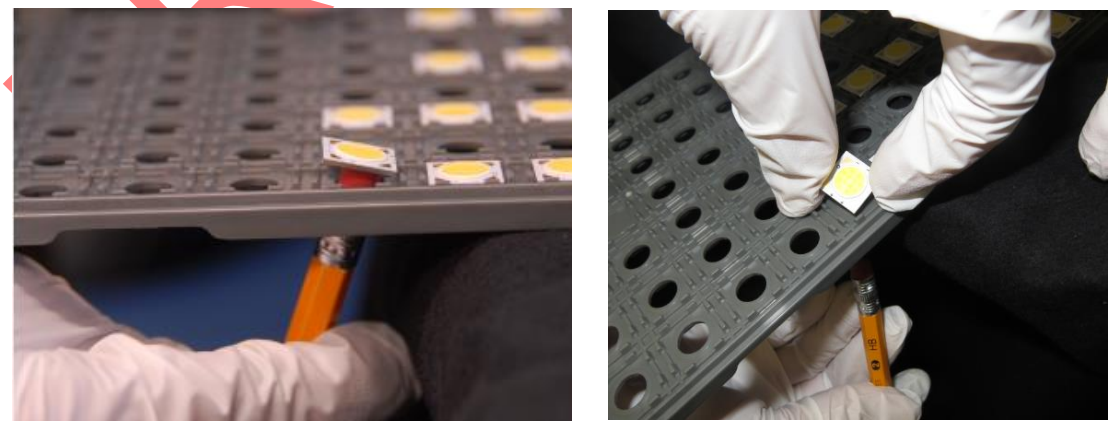


Figure 2: Array removal from the tray: (a) remove tray cover, (b) place tray on the edge of table top surface, (c) use a pencil to push the array up, and (d) grip the array from the corners



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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 Bridgelux V Series (see Figure 3). Bridgelux V Series are optical devices. Please ensure that nothing comes into contact with the yellow resin area, as this may adversely affect performance.

Although use of a clean room is not required, the environment in which the Bridgelux V Series are assembled should be clean, avoiding dust and particles which may adhere to the resin area of the Bridgelux V Series.

Bridgelux V Series 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 Bridgelux V Series.

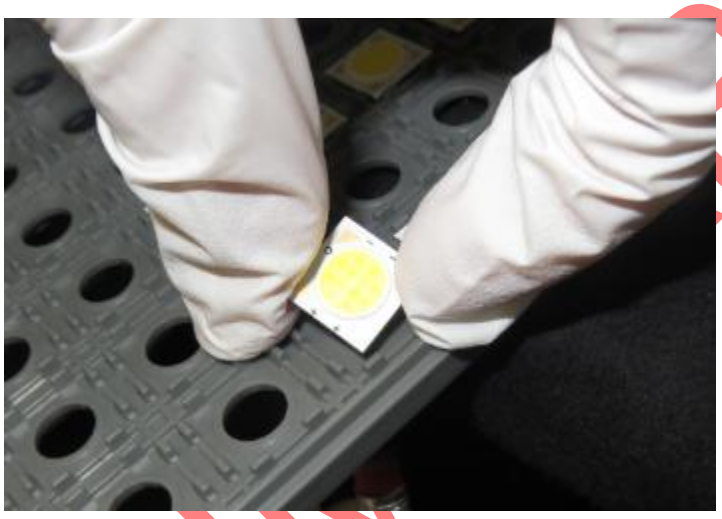

Figure 3: Wear gloves or finger cots when handling Bridgelux V Series LED Arrays. Grip the arrays from the corners. Do not touch the light emitting yellow area.

If debris contacts the resin, gently remove it by rinsing it with isopropyl alcohol (commonly called rubbing alcohol).

If pick-and-place equipment is used for automated assembly, the vacuum collet should be designed to avoid contact with the resin area and the thin white ring surrounding the resin area. Contact with the outer plastic is acceptable

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Soldering Bridgelux V Series LED Arrays

SOLDERING PROCESS

Modern manual soldering iron systems consist of a control unit, soldering pencil and soldering tip. In order to have the capability to produce satisfactory solder joints, the proper equipment and operating conditions for that equipment must be specified. The technique utilized by the operator can cause dramatic variation in the results obtained even with proper equipment. The information provided in this section provides reasonable starting points for developing a suitable manual soldering process for soldering wires on Bridgelux V Series. As with all manual soldering processes, some degree of adaptation, experimentation and optimization may be required to meet the objectives of a particular manufacturer, product design constraints or manufacturing sequence and equipment limitations.

Required Materials

1. Soldering Iron System

Bridgelux recommends the use of a temperature controlled soldering iron of no more than 30 to 40 watt capacity and a temperature control range of at least 250°C to 350°C. Systems having an electronic temperature control are preferred as they generally provide more accurate and constant solder tip temperature.

The soldering iron tip should be a “single flat”, “screwdriver” or “chisel” shape of appropriate size that will fit the solder pad size without overlapping the plastic housing surrounding the solder pad and be within appropriate range of heat capacity matching the Bridgelux V Series substrate thermal capacity. Conical, round or point shaped tips should not be used, due to the limited heat transfer surface that they provide.

Table 2 lists commercially available soldering systems from Weller that have been found satisfactory for soldering Bridgelux V Series and also summarizes recommended tip for the Bridgelux V Series form factors. Many similar soldering systems are commercially available from other manufacturers.

Table 2: Soldering systems and tip size

Model	Wattage	Pencil	Tips
			BRIDGELUX V SERIES Arrays
WD1	40	EC1201A	ETH (tip size 0.79mm width x 0.48mm thickness) used with 22 gauge lead wires

2. Wire

Bridgelux recommends the use of stranded copper wire which has been ‘pre-tinned’ and stripped to the correct length prior to soldering. The correct wire gauge for each application is design dependent. The customer is responsible for selecting the wire gauge that meets all codes and regulatory requirements. The wire gauge will affect the thermal load placed on the soldering system, so a larger diameter wire (smaller gauge numbers) may require a higher soldering iron temperature setting or a longer soldering cycle time then a smaller diameter wire with the same LED array. Suggested wire size, soldering temperatures and soldering times are provided in Table 3.

Table 3: Bridgelux V Series Array wire sizes and soldering temperature/time

Array Type	Suggested wire Gauge	Wire Diameter	Suggested Soldering Temperature	Suggested Soldering Time
Bridgelux V Series Array	22 AWG	0.744 mm	300°C	6 to 10 Secs

Other considerations for selecting a suitable wire include the allowable voltage drop across the length of 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 couple millimeters of insulating material at the ends and be tinned with the same solder alloy as will be used in the soldering process. Many commercially available tools are available to perform this task. Bridgelux recommends that the length of the stripped wire be equal to or within 0.5mm greater than the dimension of the pad that the attached wire will be oriented to. This will minimize the overhang of bare wire over the non-pad area of the array, and possible heat damage to the Bridgelux V Series phosphor area during the soldering process. It is good practice to minimize the amount of exposed wire beyond the soldering pad to minimize the possibility of a short circuit between the lead wires through the aluminum substrate to other parts of a luminaire.

3. Solder Alloy

Bridgelux recommends using lead free solders, such as SnAgCu, with high flux content. The flux core of the solder should be of a “No-Clean” type, with little or no Halide content, such as Kester “275” No-Clean. 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 solder alloy and their melting temperatures. For environmental reasons, lead free solders are becoming more widely used. If a low melting point solder is used, care should be exercised to ensure that the array case operating temperature will not weaken the joint during operation.

Table 4: Solder and associated melting points

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

4. 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

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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. Bridgelux encourages the use of "No-Clean" or Halide-free fluxes such as Kester 959T.

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.

5. Flux Cleaner

If there is a need to clean the Vero Series to remove excess solder flux, Bridgelux recommends using IPA (Isopropyl Alcohol) or de-ionized 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.

As noted in the Product Data Sheets in the Absolute Maximum Ratings section, the temperature of the Vero Series solder pad should not exceed 300°C for more than 10 seconds. The temperature and size of the solder iron tip, as well as the gauge (diameter) of the wire being attached and the soldering technique used will all affect how quickly and to what temperature the solder pad heats. The settings below are suggested starting points for evaluation when the specific equipment mentioned above is used. Other equipment may require different settings or techniques. The manufacturer should evaluate the quality of solder joints obtained before commencing with full production.

1. Select the appropriate solder iron tip for the array to be soldered from Table 4 above. Set the soldering iron temperature to 275 to 300°C.

2. Pre-tin the tip of the soldering iron and the tip of the wires with a small amount of solder (see Figure 4).

   Note: Either a soldering iron or a "solder pot" can be used to pre-tin the wires. If a solder pot is used, it is recommended that the wire first be dipped into a container of liquid flux and then be dipped into the solder pot.

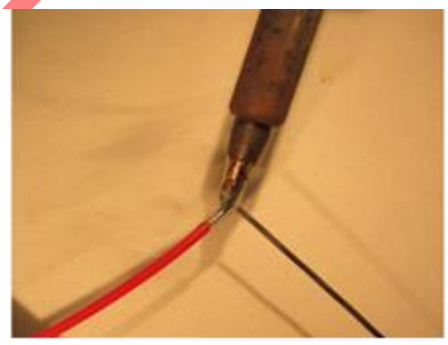

Figure 4a: Pre-tin the wire using a soldering iron

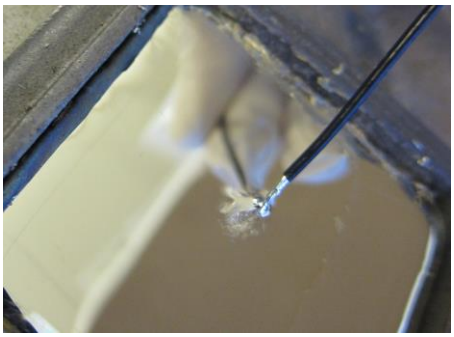

Figure 4b: Pre-tin the wire by dipping the tip of the wire in a solder pot

3. Pre-tin the Vero Series solder pads using the following process:

   A. Hold the soldering iron tip on the solder pad, allowing the pad to reach the temperature at which the solder wets and flows. This can be determined by touching the end of the solder wire to the junction of the soldering iron tip and the pad, and observing that the solder melts to and wets the pad.

   B. Apply solder to the solder pad and solder tip, allowing sufficient time for the solder to wet. The solder should form a small dome shape on the solder pad (see Figure 5).

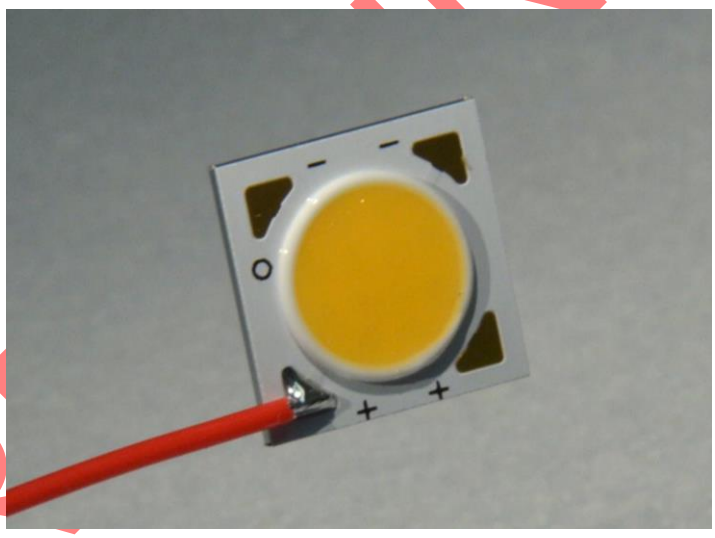

Figure 5: Pre-tin solder pads

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 wire tip on the pre-tinned solder pad.

   C. Place the hot tip of the soldering iron on top of the tinned wire end. Bring the solder wire to the area just below the solder tip (see Figure 6). 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

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the Bridgelux V Series should take just a few seconds. The maximum time that the soldering tip should contact the Bridgelux V Series solder pad and wire is 10 seconds.

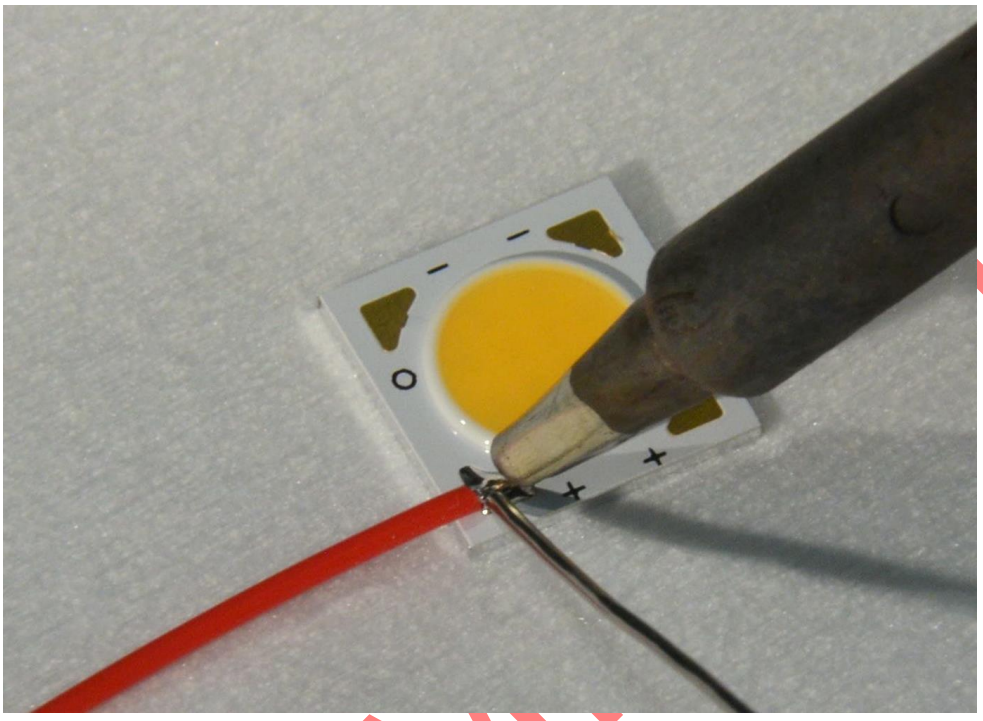

Figure 6: Soldering a pre-tinned wire to a pre-tinned solder pad

D. Allow the solder joint to cool until the molten solder solidifies. Do not move the wire or the array during this time. Figure 7 shows examples of good solder joints.

Figure 7: Good solder joint

E. (Optional) Remove excess flux from the Bridgelux V Series using IPA and allow to dry

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Figure 8 shows examples of bad solder joints or problems associated with soldering.

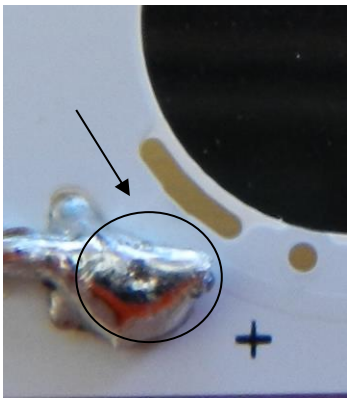

Figure 8a: Cold solder joint due to insufficient heat

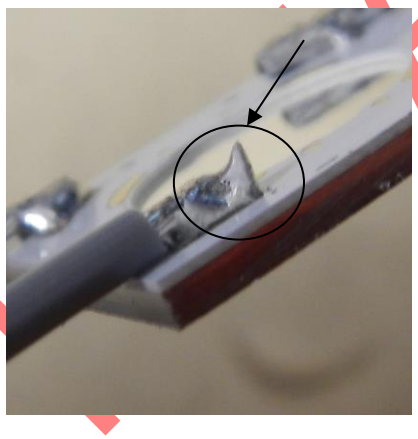

Figure 8b: Icicle due to excess solder and slow tip withdrawal

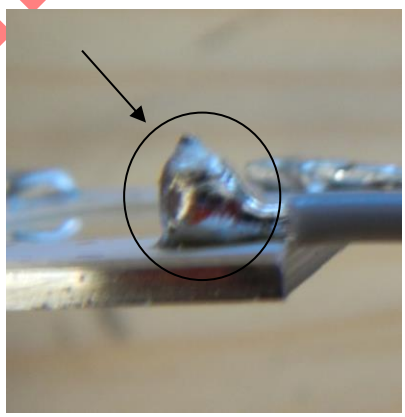

Figure 8c: Too much solder on the joint

Mechanical Assembly and Fasteners

Bridgelux V Series do not have mounting holes or slots like other Bridgelux LED Arrays. However, there are several options for mounting a Bridgelux V Series to a heat sink or luminaire housing mounting surface. Attachment options include mechanical holders, screws, and dispensed or film adhesives, all of which can all be used to secure the Bridgelux V Series. Please review Bridgelux V Series data sheets and 3D CAD files for additional information regarding the Bridgelux V Series size and feature locations

Screws

Screws can be used to secure the V Series to the mounting surface. When using a screw, a method that works well is to position the screw holes on either side of the array as shown in Figure 9. Figure 9a shows the V Series secured with a M2.0 screw and Figure 9b shows the V Series Array secured with a M2.5 screw. Since the V Series do not have screw cutouts, the installation method below will help to ensure the array does not move during the installation process.

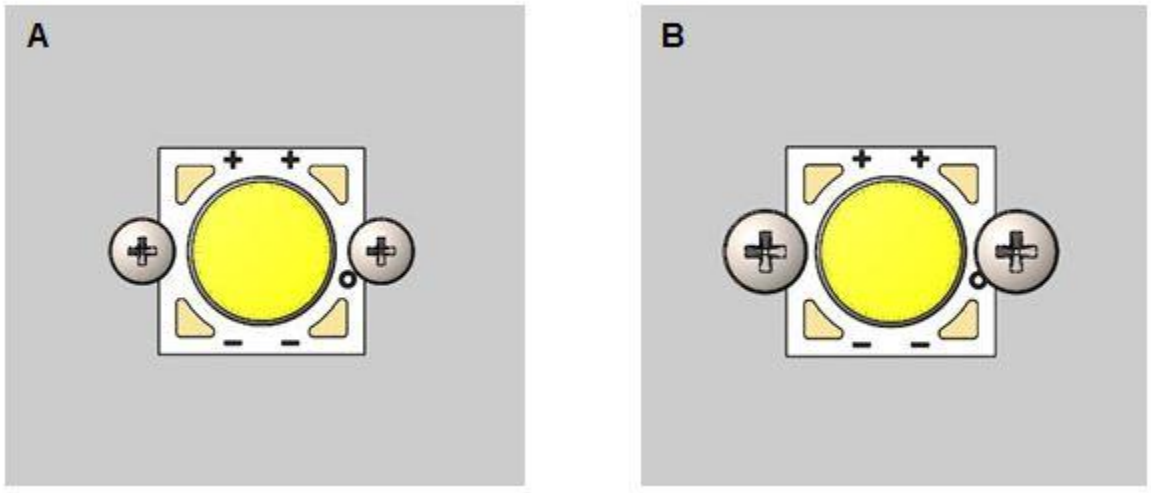

Figure 9: Screws securing Bridgelux V Series Array to Mounting Surface.
Figure 9a shows M2 screws and Figure 9b shows M2.5 screws

For the installation method, refer to figure 10 steps 1 – 4. First, partially install one screw into position, but leave enough space for the Bridgelux V Series to slide underneath the screw head and then slide the V Series under the first screw. Second, install the second screw into position and screw until the head is seated on the surface of the array. Third, screw the first screw until the head is seated on the surface of the array. For the fourth step, use an anti-rotation fixture to ensure the array will not rotate out of position when tightening the screws to the final torque. Screw down both screws to the appropriate torque to hold the Bridgelux V Series in place. When using screws, it is important to pay close attention to the location of the screw head to the soldered wires to ensure there will not be contact which could result in electrical shorting. In some cases, a plastic washer under the screw head or an epoxy coating over the soldered wires may be necessary to ensure electrical isolation.

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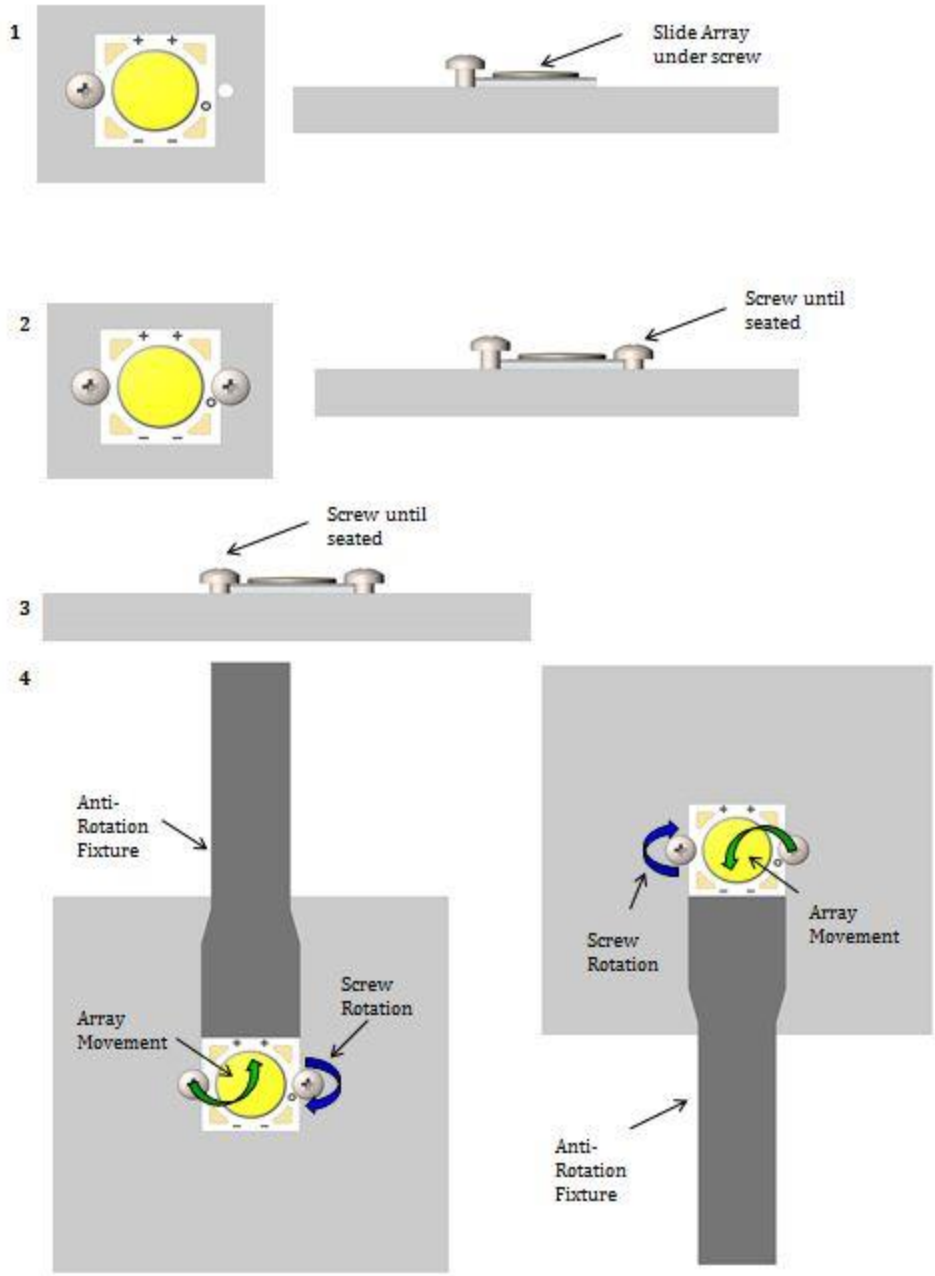

Figure 10: Bridgelux V Series Screw Assembly Steps

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Screw Head Type

Bridgelux recommends using screws with a flat shoulder for mounting Bridgelux V Series, see figure 11 below. A wide variety of commercially available screws types can be used to meet design requirements. Examples include pan head, button head, round head, and truss head screws. Flat head and oval head screws or other screws with an angled surface should not be used.

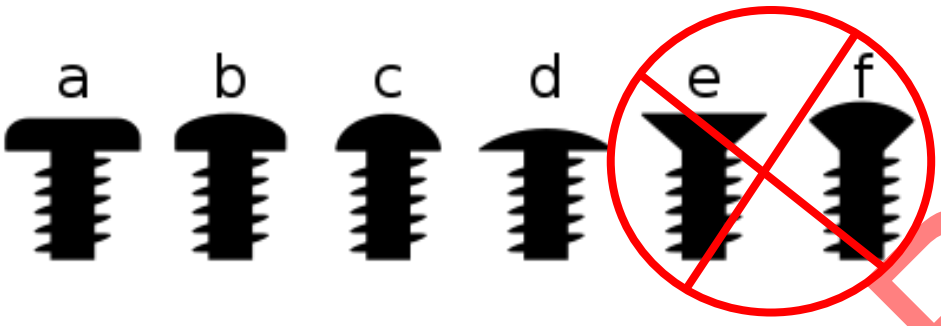

Figure 11: Screw Head Types for Bridgelux V Series LED Arrays

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 Bridgelux V Series. Additionally, if a secondary optic is to be used in the application, a low profile screw head allows more room for the optical components.

Screw Torque

It is critical to ensure the proper torque is applied to the fasteners when mounting the Bridgelux V Series to a heat sink. If too little torque is applied, the thermal path between the Bridgelux V Series and the heat sink will be compromised while excessive torque may result in damage to the Bridgelux V Series. Many variables affect the actual torque required to seat the screw such as thread friction, materials of the heat sink and screw, screw head friction, etc. For example, a machine screw with typical thread friction can be seated with < 1 lbf-in of torque, but it may take much higher torque to seat a thread forming screw. Table 5 below lists the suggested torque values based on the screw size shown and typical friction factors for machine screws in a pre-tapped hole. It is the responsibility of the customer to test and ensure the correct torque values are specified and used during the assembly process.

Flat Washers, Lock Washers, Self-Locking Fasteners, and Thread Sealants

Flat washers may be used to protect the Bridgelux V Series from damage resulting from excess torque and to provide a wider distribution of the force applied by the screw. Flat washers, however, do not prevent fasteners from loosening in vibration environments. To prevent loosening of screws during vibration or thermal cycling Bridgelux recommends using lock washers, self-locking fasteners, or thread locking sealants.

Table 5: Bridgelux V Series LED Array mounting specifications

Array	Suggested Mounting Positions	Nominal Diameter	Suggested Screw Size	Suggested Torque N-cm (lbf-in)
Bridgelux V Series 6, 8	2 (see figure 9)	2.0	M2.0	23 (2)
Bridgelux V Series 10	2 (see figure 9)	2.5	M2.5	34 (3)

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Mechanical Holders

Mechanical holders have been developed by Bridgelux partners and can be used to secure Bridgelux V Series to the mounting surface. The holders are intended to provide mechanical attachment, but in addition may contain features for optical alignment. Various designs are available and some holder designs cover the solder pads and wires completely leaving a flat interface surface, while others leave the solder pads and wires exposed to allow more flexibility depending on the application's needs. See figure 12 below for an example. Contact Bridgelux sales for more information.

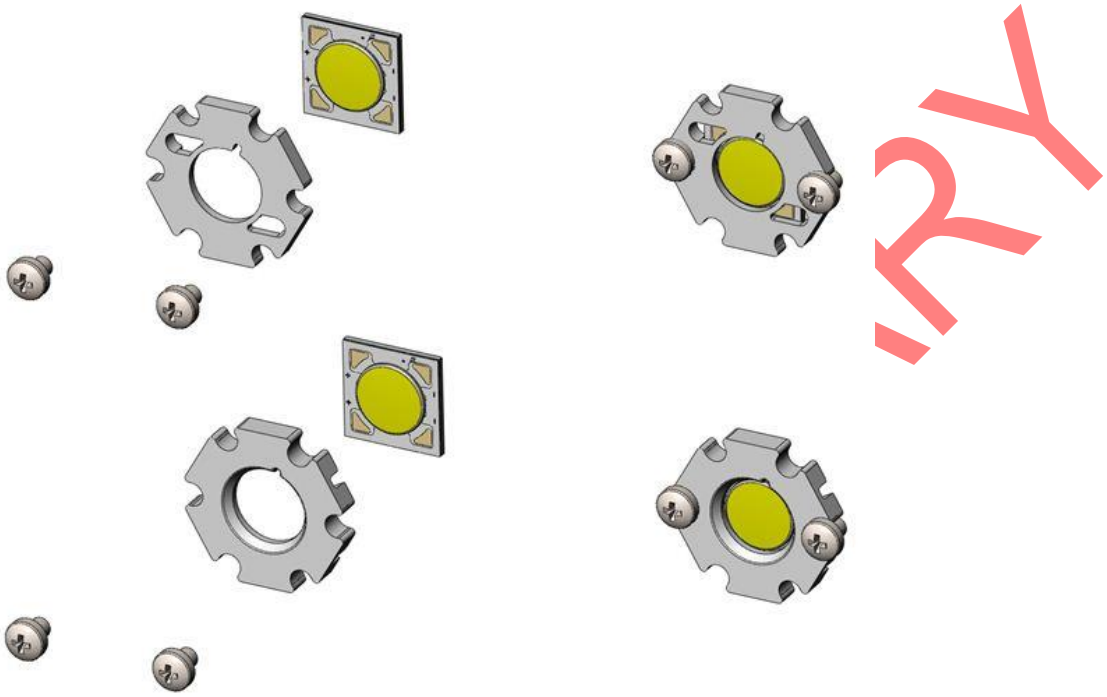

Figure 12: Vero Bridgelux V Series Mechanical Holder Examples

Adhesive Attachment

There are various adhesive products in the market which can be used to secure the Bridgelux V Series to the mounting surface. It is important to note that the adhesive must also provide thermal connection between the Bridgelux V Series and the heat sink, so the adhesive must provide both a structural and a thermal interface function. Dispensed adhesives and film adhesives offer several advantages such as reduced components (no screws or holders), less interference with optics, etc. However, there are additional items to consider when using adhesives. Such items include wetting, % entrapped air, CTE mis-match, long term reliability due to temperature cycling, application consistency, mixing consistency, application time, cure time, curing processes, etc. It is best to work with adhesive suppliers directly to be sure the optimal adhesive product can be selected for the application in terms of thermal performance, mechanical holding performance, cost, manufacturing requirements, etc.

Heat Sink and Thermal Interface Materials

Effective Thermal Management of Bridgelux V Series LED arrays, will be discussed further in another application note.

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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 V Series 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 Capacity

www.powerstream.com/Wire_Size.htm

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

www.longloklocking.com
www.nord-lock.com
www.nylok.com

Soldering and Pick and Place Tools

www.cooperhandtools.com/brands/weller
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 Solder ability Tests for Component Leads, Terminals and Wires
J-STD-004 Requirements for Soldering Fluxes

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Disclaimer

This applications note has been prepared to provide guidance on the application of Bridgelux V Series Arrays in customer applications. Bridgelux provides this information in good faith, but does not assume any responsibility or liability for design deficiencies that might exist in a customer design.

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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 luminaire 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 550 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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