

Application Note AN31

Handling and Assembly of Bridgelux Vero Series LED Arrays

May 28, 2013

Introduction

The Bridgelux family of Vero 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 Vero Series LED Arrays requires careful consideration of thermal management solutions, selection of electronic drivers and secondary optics. Application Notes AN30, AN32 and AN36 deal with each of these topics in depth. It is equally important to use safe handling and appropriate manufacturing procedures, processes and chemicals during the assembly of the Bridgelux Vero Series LED Array into the lighting system.

This application note provides recommendations for mechanical and electrical assembly of Bridgelux Vero 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 Vero LED module requires the following:

1. A robust mechanical connection between the Vero LED module and the heat sink or lighting fixture body.
2. A thermally conductive path from the case (back of aluminum substrate) of the Vero LED module to the heat sink or lighting fixture body which in turn has convective or forced airflow with the ambient (cool) air. See also AN30 “Thermal Management for Bridgelux Vero Series LED Arrays”
3. An electrical connection between the connector port or the solder pads on the Vero LED module and the power supply or electronic driver used to power the Vero LED module. See also AN36 “Electrical Drive Considerations for Bridgelux Vero Series LED Arrays”

A reference drawing of a lighting system assembly using a Bridgelux Vero LED module is shown in Figure 1. Components of the assembly include a Vero LED module, wire harness with Molex Pico-EZmate™ connector, screws with flat washers and spring washers, heat sink, thermal interface material, reflector, and housing.

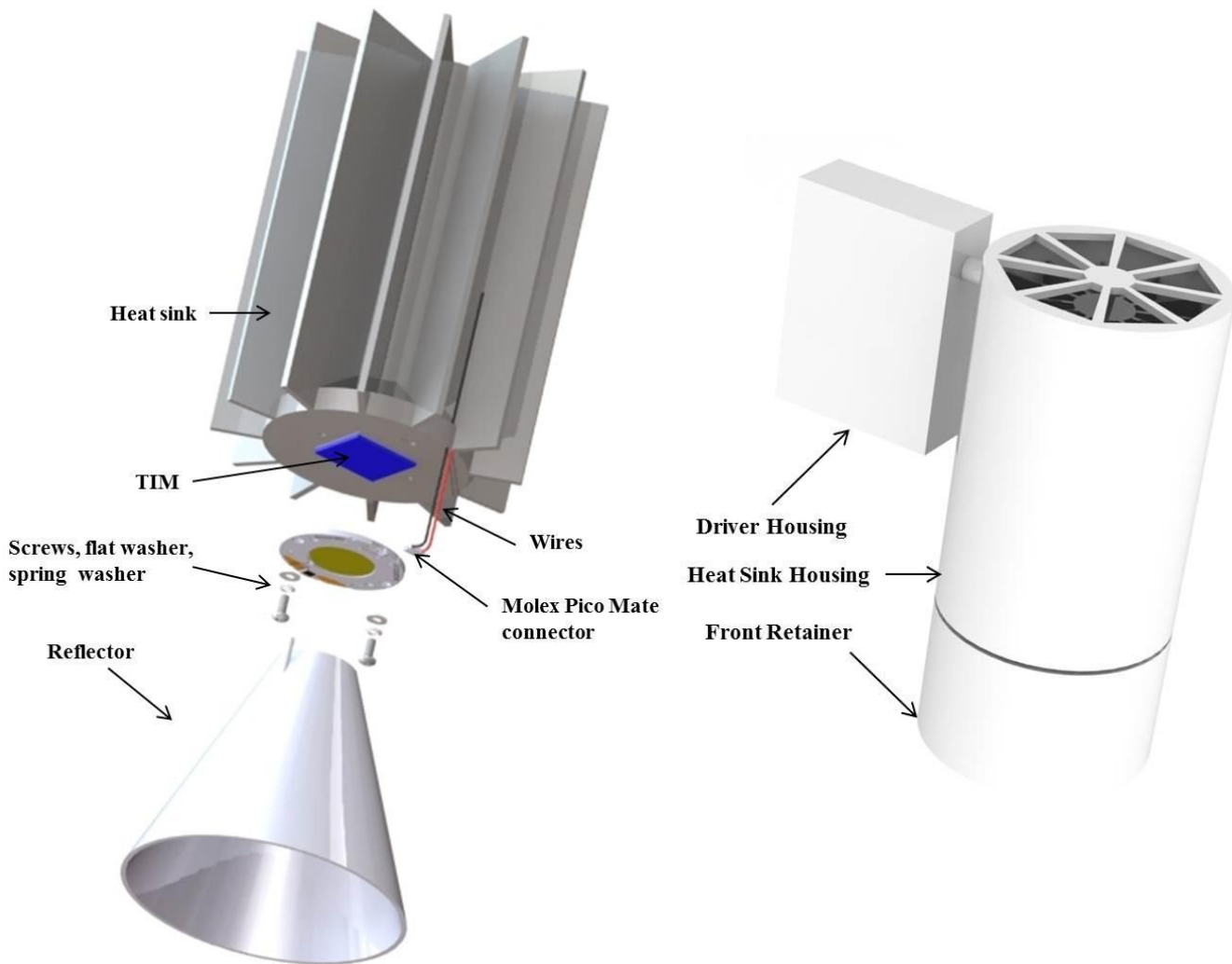


Figure 1: Vero System Assembly Drawing

Chemical Compatibility

Optimizing performance and reliability of a lighting system using Bridgelux Vero LED modules requires safe handling and use of appropriate manufacturing procedures and materials during the assembly of the Bridgelux Vero LED module into the lighting system. Careful consideration must be given to the materials and chemicals used when processing the Bridgelux Vero LED modules 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 Vero LED modules 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 Vero LED module and cause degradation in performance of the Vero LED module. 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" luminaires that create "air tight environments" around the Vero LED module which can trap potentially damaging gas molecules from manufacturing processes or subsequent out-gassing of materials used in the luminaire which can then result in long term exposure of the Vero LED module 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 Vero LED module 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 Vero LED module to come into contact with the fluids or solvents. Care should be taken such that the Vero LED module 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 Vero LED modules 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 Vero LED modules 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 Vero LED modules.

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 Vero LED modules 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 do not cause damage to the Vero LED module.

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/>

Handling Bridgelux Vero LED Arrays

CAUTION: CONTACT WITH OPTICAL AREA

Avoid any contact with the optical area. Do not touch the optical area of the Vero 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 Vero 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 Vero LED modules are packaged for volume shipment in trays of various sizes. Low volume sample shipments may be packaged using other methods. To manually remove the Vero LED modules simply lift the Vero LED module from the tray by gripping the white plastic portion of the Vero LED module. The trays come with notched areas around the array that accommodate fingers for grabbing the arrays from the sides. Figure 2 illustrates a suitable method of removing the Bridgelux Vero LED modules from the shipping tray.

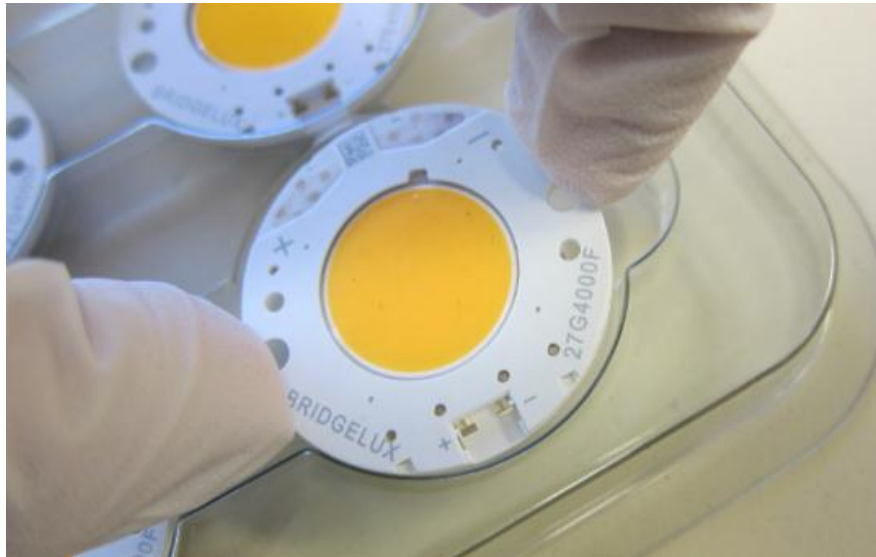


Figure 2: Removal of a Vero LED module from a tray

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 Vero LED module (see Figure 3). Bridgelux Vero LED modules 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 Vero LED modules are assembled should be clean, avoiding dust and particles, which may adhere to the resin area of the Vero LED module.

Bridgelux Vero LED modules 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 Vero LED modules.



Figure 3: Wear gloves or finger cots when handling Vero LED modules from the plastic portion of the module

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 so as to avoid contact on the resin area and the thin white ring surrounding the resin area. Contact with the outer plastic is acceptable

Wire Harness Options

Wire Harness Assemblies

To further enhance ease of assembly of Vero LED modules, wire harness options are available using the Molex Pico-EZmate™ Connector, sold separately by Molex and through their distribution network. This option simplifies manufacturing by eliminating the need for a soldering process at the luminaire manufacturer's facility. Please refer to www.molex.com for additional information on the available wire harness options.

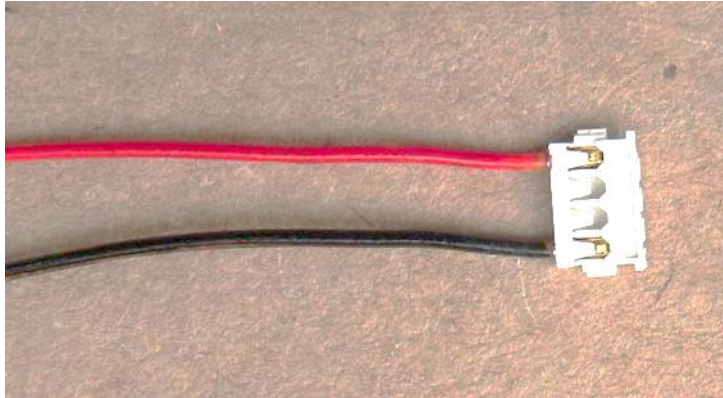


Figure 4: Molex Pico-EZmate™ Connector and Wire Harness

Connector mating method

Align plug on top of receptacle as per datum shown in fig.1. Press down the plug at highlighted area toward the receptacle to mate the connectors.

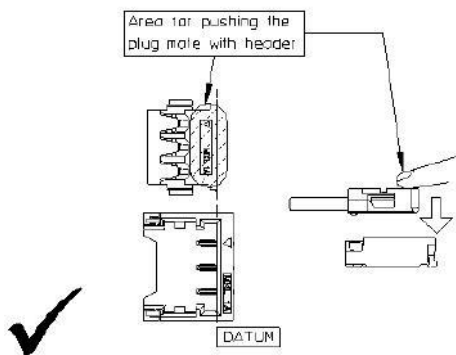


Figure 5

During mating process, if the plug is angled toward the straight part of mating entrance as in fig. 6, the allowed angle must not exceed 5°.

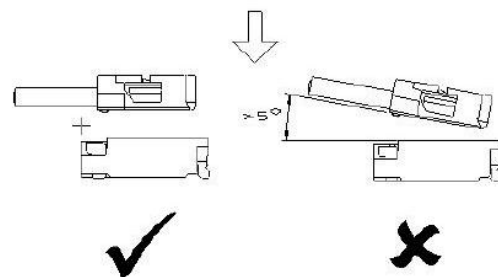


Figure 6

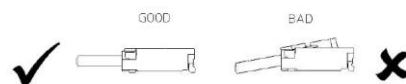
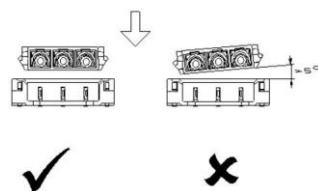


Figure 6 – Correct and incorrect connector insertion

Connector unmating method

Hold gently on plug wires and pull up to unmate the connector as per fig. 7 shown.

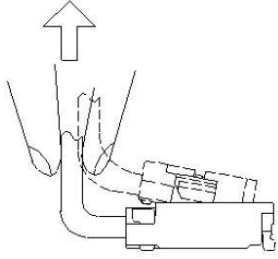


Figure 7

For unmating process, plug wires pull and stress angle must be maintained within 15° as per fig.8 shown.

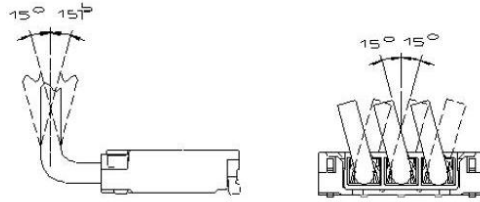


Figure 8

Connector shall not be unmated horizontally as shown in fig. 9 to prevent part damage

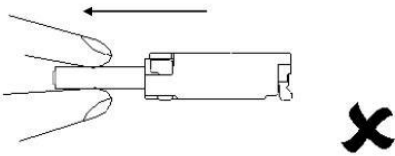


Figure 9

Make certain the areas & space where the connector placed are clear and sufficient to prevent over stress on plug wires as example shown in fig. 10.

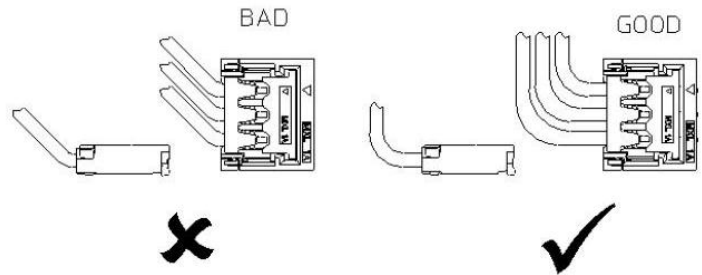


Figure 10

Soldering Bridgelux Vero 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. Even with the proper equipment, as a manual process the technique utilized by the operator can cause dramatic variation in the results obtained. The information provided in this section provides guidance for reasonable starting points for developing a suitable manual soldering process for soldering wires on Bridgelux Vero LED arrays. 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 50 to 80 watt capacity and a temperature control range of at least 350C to 450C. 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 and as large as possible that will fit the solder pad size without overlapping the plastic housing surrounding the solder pad. 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 Vero Arrays and also summarizes recommended tips for each of the different Bridgelux LED array form factors. Many similar soldering systems are commercially available from other manufacturers.

Table 2: Soldering systems and tip a sizes

Model	Wattage	Pencil	Tips (by LED array type)	
			Vero 10, 13 & 18	Vero 29
WTCPT	60	TC201	PTBB	PTBB or PTCC
WESD51	50	PES51	ETB	ETB or ETCC
WD1	80	WP80	LTB	LTB or LTC

3. 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 than a smaller diameter wire with the same LED array. Suggested wire size, soldering temperatures and soldering times are provided in Table 3.

Table 3: Wire sizes and soldering temperature/time

Array Form Factor	Suggested wire Gauge	Wire Diameter	Suggested Soldering Temperature	Suggested Soldering Time
Vero 10	24 AWG	0.590mm	325C	3 to 5 Secs
Vero 13	22 AWG	0.744mm	325C	3 to 5 Secs
Vero 18	20 AWG	0.938mm	325C	3 to 5 Secs
Vero 29	18 AWG	1.182mm	350C	5 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 few 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 1mm 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 Vero plastic housing during the soldering process. Since the Vero housing is electrically non-conductive plastic there is no danger of shorting the exposed wire to the substrate where the wire exits the soldering pad, however it is good practice to minimize the amount of exposed wire beyond the soldering pad.

3. Solder

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 solders 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	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 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.

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 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 array solder pad should not exceed 350°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 there 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 325 to 350°C.
2. Pre-tin the tip of the soldering iron and the tip of the wires with a small amount of solder (see Figure 11).

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 11a: Pre-tin the wire using a soldering iron



Figure 11b: Pre-tin the wire by dipping the tip of the wire in a solder pot

3. Pre-tin the LED Array 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 12).

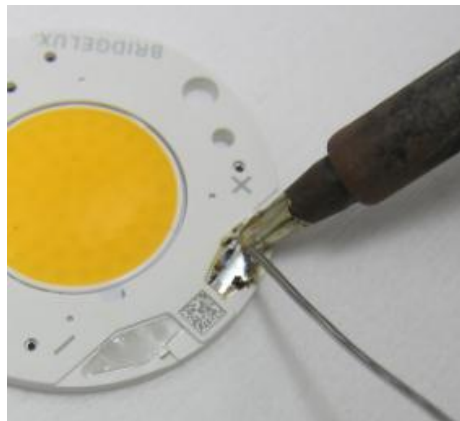


Figure 12: Pre-tin solder pads

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 13). 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 10 seconds.

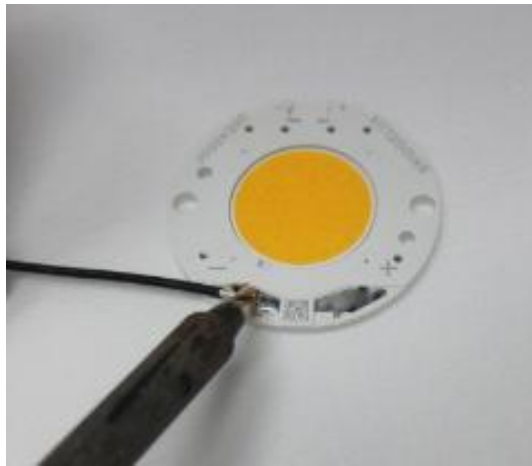


Figure 13: Soldering a pre-tinned wire to a pre-tinned solder pad

- D. Allow the solder joint to cool until the molten solder solidifies. Do not move the wire or the array during this time. Figure 14 shows examples of good solder joints.



Figure 14: Good solder joints

- E. (Optional) Remove excess flux from the LED Array using IPA, allow to dry.

Figure 15 shows examples of bad solder joints or problems associated with soldering.



Figure 15a: Burnt or melted plastic due to the solder tip being held on the solder pad too long or due to the solder tip being too hot

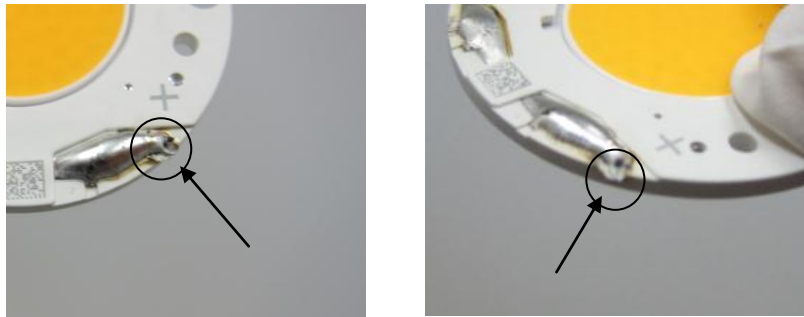


Figure 15b: Burnt plastic due to solder tip slipping and having direct contact on plastic

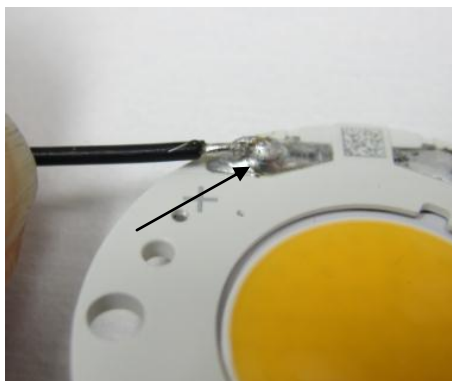


Figure 15c: Cold solder joint due to insufficient heat

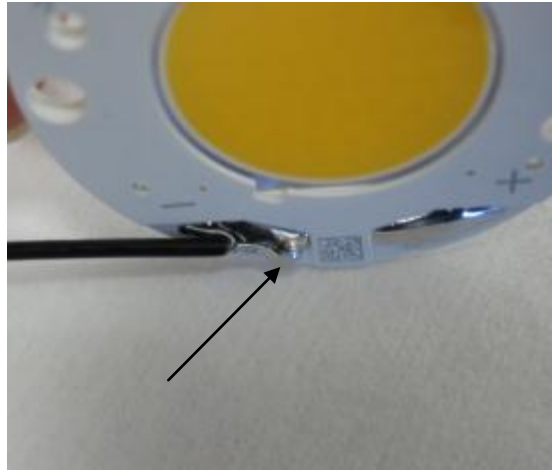


Figure 15d: ICICLE due to excess solder and slow tip withdrawal

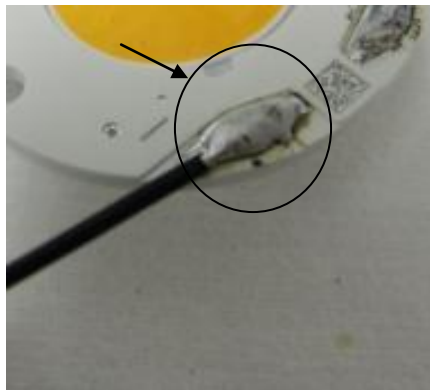


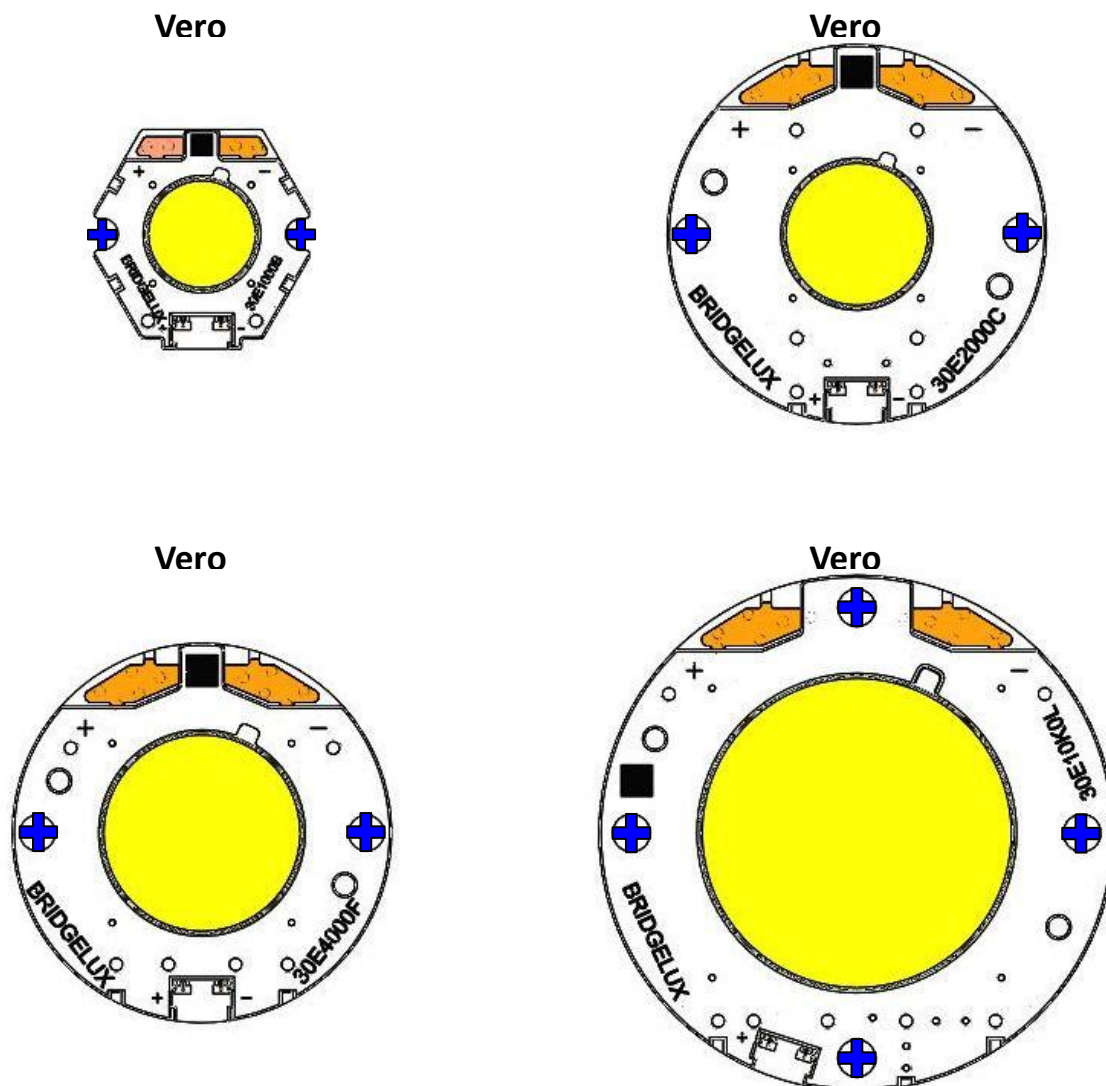
Figure 15e: Too much solder on the joint

Mechanical Assembly and Fasteners

Bridgelux Vero LED modules are provided with slots or holes to facilitate mounting the Vero LED modules using screws. Figure 16 below shows the four Vero form factors and identifies the slot and hole locations for mounting to the heat sink or lighting fixture. All form factors have 2 mounting positions with the exception of the Vero 29 module which has 4 mounting positions. The slots and holes are sized to fit a wide variety of standard machine screws and thread forming screws. Refer to the mechanical drawings included in the Bridgelux Vero LED module Product Data Sheets and 3D CAD files for additional information regarding the slot and screw hole size and position with tolerances.

Screw Location and Quantity

Figure 16: Vero LED Modules with Mounting Slots/Holes Identified with Blue Cross



Screw Head Type

Bridgelux recommends using screws with a flat shoulder for mounting Vero LED modules, see figure 17 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.

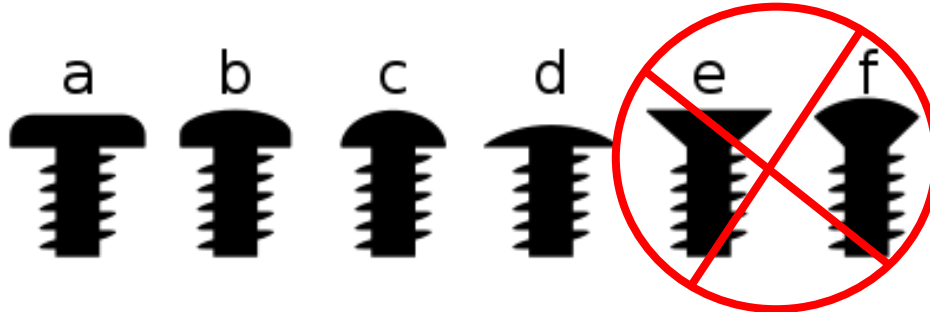


Figure 17: Screw Head Types for Vero LED Modules

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 Vero LED module. 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 Vero LED module to a heat sink. If too little torque is applied, the thermal path between the Vero LED module and the heat sink will be compromised while excessive torque may result in damage to the Vero LED module housing. 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. It is the responsibility of the customer to test and ensure the correct torque values are specified and used during the assembly process.

Note that the holder of the Vero LED module is constructed from a plastic material and is engineered to flex so that the bottom of the plastic will contact the heat sink surface, see figure 18.



Figure 18: Typical Flex of Vero LED Module

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

Flat washers may be used to protect the Vero LED module 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: Vero LED Module Mounting Specifications

Module	# Mounting Positions	Nominal Diameter	Suggested Screw Size	Suggested Torque N-cm (lbf-in)
Vero 10	2	3.0	M2.5	23 (2)
Vero 13	2	3.4	M2.5	34 (3)
Vero 18	2	3.4	M2.5	34 (3)
Vero 29	4	3.6	M3.0	45 (4)

Heat Sink and Thermal Interface Materials

Heat sink design and thermal interface material (TIM) selection is described in detail in the Thermal Design Application Note (AN30). Effective Thermal Management of Bridgelux Vero LED modules, will not be discussed further in this application note. Please consult AN30 for further information.

Design Resources

Included below is a partial list of available design resources that may be used to handle and assemble Bridgelux Vero LED modules 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 Solderability Tests for Component Leads, Terminals and Wires

J-STD-004 Requirements for Soldering Fluxes

Disclaimer

This applications note has been prepared to provide guidance on the application of Bridgelux Vero 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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