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Taking the LED Pick and Place Challenge

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Abstract
For the past few years there has been a shift in the Lighting Industry that has carried over to the surface mount technology assembly line. What is this shift you may ask? Well it is the LED revolution. This revolution or change in lighting has some very promising results already in practice and many more companies looking to implement the LED technology into their product portfolio's. With a number of companies looking to expand their portfolio to include LED fixtures there has been an increase in the number of companies that have started their own SMT lines, as well as a significant number of contract manufacturers to meet this new industries demands. With this surge in the new style of lighting the manufacturers need the automated pick and place process to achieve the throughputs that are being forecasted; there has been a sudden increase of companies that have faced issues around the pick and place process with less than desirable results. The automated pick and place systems have been used for high-speed, highly accurate placement of a wide range of electronic components. A major factor in the automated pick and place manufacturing for surface mount devices (SMDs) is that most of the components previously being placed have been in use since the1980s. These process parameters and speeds specified have been focused on a solid or hard epoxy molded, flat topside packages, like capacitors, resistors and integrated circuits. Over the multitude of years since the inception of the automated pick and place system, the parameters used to control the equipment have been refined. Now that there is a new product in the industry; it may require some adjustments, Especially when LEDs with a glass or soft silicone molded dome are introduced. This presentation will discuss some issues in the pick and place process for LEDs and presents a method to troubleshoot and resolve these issues.

Introduction The inclusion of high-power LEDs in the pick and place process introduced many variables that can affect the performance of the pick and place system. LEDs require specific process parameters for the pick and place equipment to optimize the system's performance. This is due mainly to the dome material and weight distribution of the LED component. Pick and place manufacturers have gained a great deal of knowledge over the past 25 years picking various types components. A typical example is shown in Figure 1.1 The high-power LED, with its soft molded silicone or glass dome, as shown in Figure 2, has been in use for only about 5 years and there is still a significant amount of pick and place process refinement to ensure these components can be placed similar to the SMDs already being used.

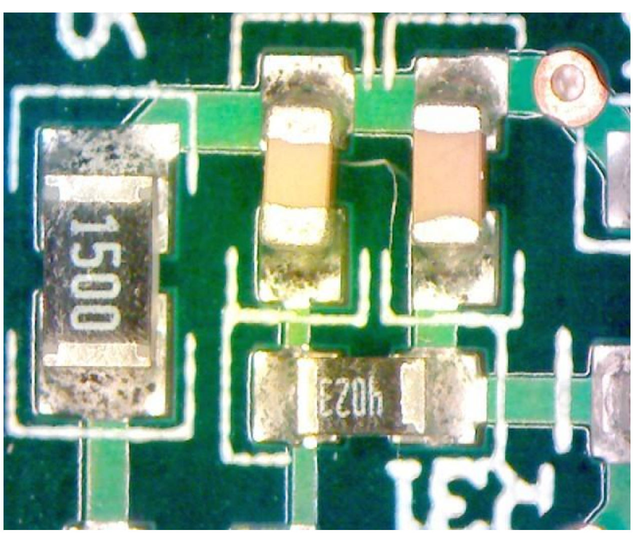


Figure 1: Typical SMD

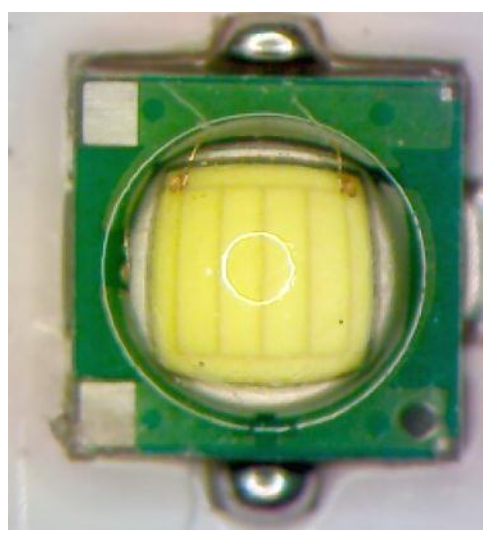
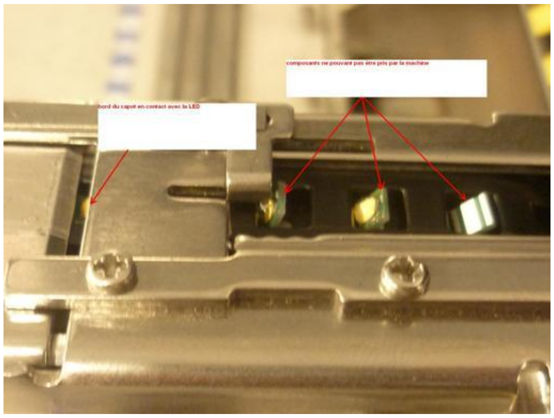


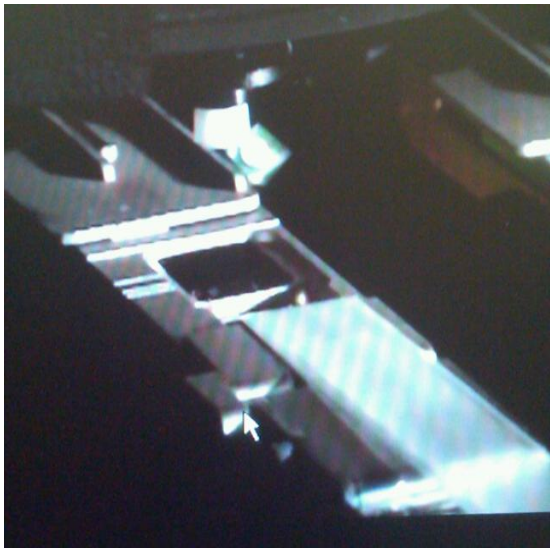
Figure 2: high-power LED in SMD format

For solid-state lighting products to be successful, not only are the best and brightest LEDs on the market required, but the knowledge and support to handle these components in a high-speed, accurate manufacturing process resulting in high yields, low defect rates and no damages to LEDs is critical. There has been a significant amount work by a number of pick and place manufacturers to assist the industry in identifying the best options available to maximize their system's performance through modifications and adjustments to minimize mis-picks and increase yield. Mis-pick is the term generally used to describe what happens when a component is not picked properly out of the carrier tape pocket. A mis-pick can be due to a number of reasons that will be discussed. These mis-picks can cause a large rate of attrition and therefore cause delays in production as well as cost associated with the fixture.

Common issues When it comes to high attrition rates with any pick and place system there are a variety potential concerns. Most of these concerns are attributed to the new component because these issues have been addressed on legacy components over the years during the evolution of these high speed, accurate placement systems. Although these problems appear to be component related this may not be the case! There could be a number of other potential issues; but due to the speed at which these machines perform their function it is almost impossible for the eye to truly see where the root cause of the issue is coming from. Some apparent issues that you may come across and not visually catch during operation could look like some of the following graphics:



Graphic 1 parts sticking in feeder unit



Graphic 2 part not being picked by nozzle

Graphic 3 Part not releasing during placement

Troubleshooting approach Most companies experiencing pick and place problems with high-power LEDs automatically assume the component is the cause of the problem. This is often the case when the LED component with which they are experiencing issues is new to their assembly process, and there is not a clear understanding of the LED and its unique processing demands. Through assisting both customers and Pick and Place manufacturers we have achieved a fairly straightforward approach to assist in the resolution of these pick and place process issues. To graphically illustrate the best methods for troubleshooting a mis-pick issue with silicone-domed style components. It has found it helpful to think of the approach as a pyramid. The simple illustration in Figure 3 should help clarify this analogy by indicating the steps to follow in order from 1 to 4. Starting troubleshooting at the top of the pyramid will not produce much change but, by starting at the bottom with some fundamental items, the foundation is strong and finishing touches can be applied the at the top of the pyramid.

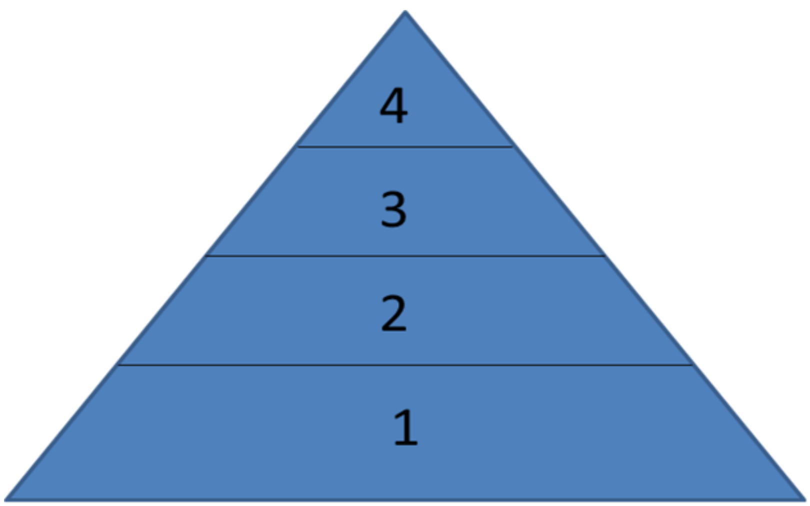


Figure 3: Troubleshooting pyramid

This simple illustration conveys a step-by-step approach that has been found to help resolve most issues and provides direction to the corrective actions required. This also helps prevent spending time fine tuning when the issue may be more than what can be resolved from a few minor parameter changes.

Areas to focus Figure 4 illustrates the key areas on which to focus to reduce failure rates. The incremental gains in the failure rate are listed next to each level of the pyramid. In many cases, quick fine tuning is attempted to resolve pick and place failures, but when there are more significant areas to address, fine adjustments can actually show very little result. First, the more significant issues must be addressed.

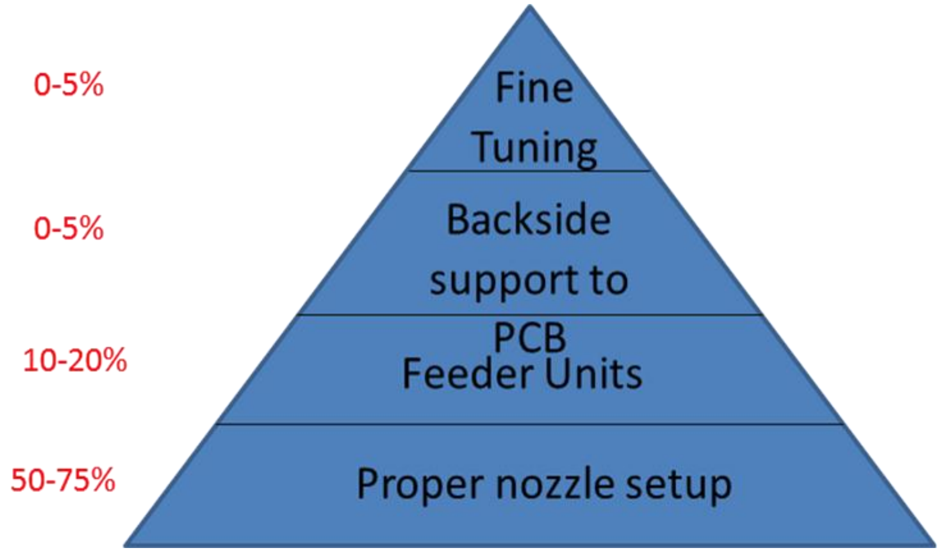
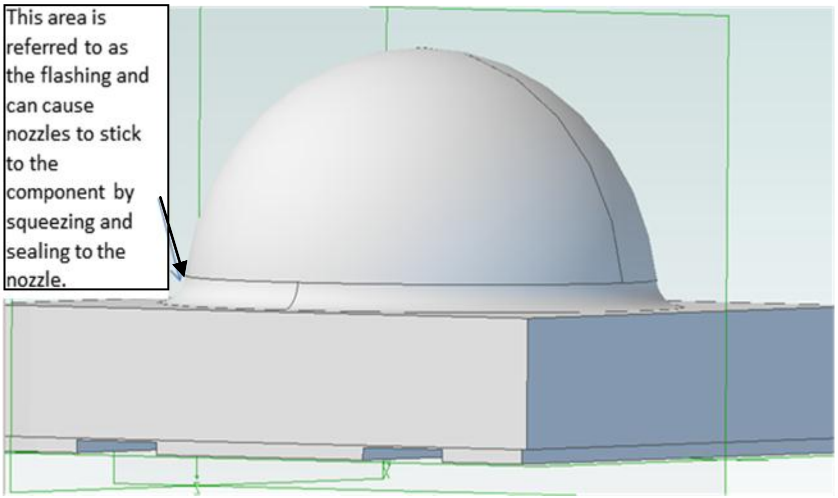


Figure 4: Troubleshooting pyramid and gains expected

The best option for resolving the major factors in mis-pick fallout is to start at the bottom of the pyramid in Figure 4 and ensure compliance with the recommendations provided by the LED manufacturer as well as the pick and place equipment manufacturer.

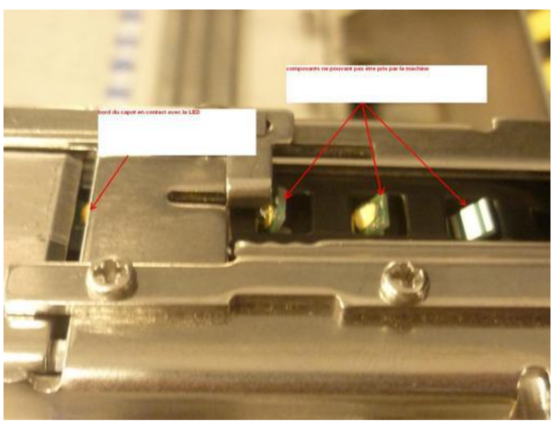
Proper nozzle setup The first item to verify would be that you are utilizing the proper nozzle setup. This is one of the most important steps and results show the fastest and largest percentage of improvement. Pick and place systems can handle a variety of components and can handle from1-30 components at a given time. Pick nozzles and process parameters for SMDs have been developed over many years, but the softer silicone dome of an LED requires specific nozzle materials. In the past, metal or steel pick and place nozzles were the norm, but since silicone can act like a gasket and form a seal to a metal nozzle, releasing an LED component after placement can be an issue. Due to this interaction between the silicone dome and the steel nozzle, there has been nozzle material development by pick and place manufacturers and third-party suppliers to improve the pick and the release of the soft silicone LED. These nozzle materials can vary from a plastic type material an organic type of material or nozzle made from a polyurethane. These materials have shows the best results across the industry when handling a low durometer silicone dome or lens. There is also an area at the base of most silicone domes called the “flashing”. This is the area around the base of the dome where the material makes contact with the over mold of these types of LED’s as shown is Graphic 4.



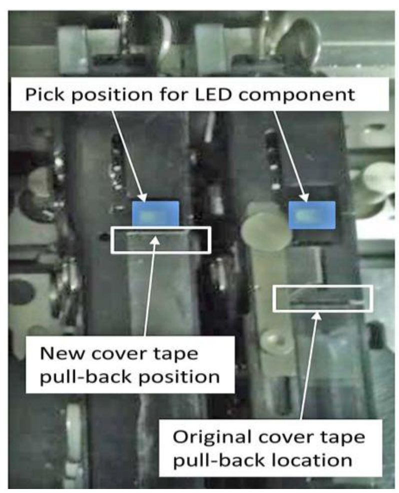
Graphic 4 Flashing on molded package

Feeder unit Once the proper nozzle configuration has been implemented, the next step for reduction in attrition rate is to investigate the feeder unit. There are two sections to this unit that can exhibit issues when indexing the component and exposing the LED to the pickup nozzle. Addressing these two areas, listed below, can significantly minimize the effects on the LED and how it sits in the pocket during indexing.

Cover tape pull back location and Cover tape peel back angle The first item to address is the location from where your cover tape is pulled back. Most systems have the tape being pulled back exposing 3-4 open pockets which allow the LED's to "jump" during indexing and can create a similar scenario to what is seen in Graphic 1. A simple change as shown in **graphic 5** illustrates what some manufacturers have started to do to help minimize the effects of the cover tape peel back location.

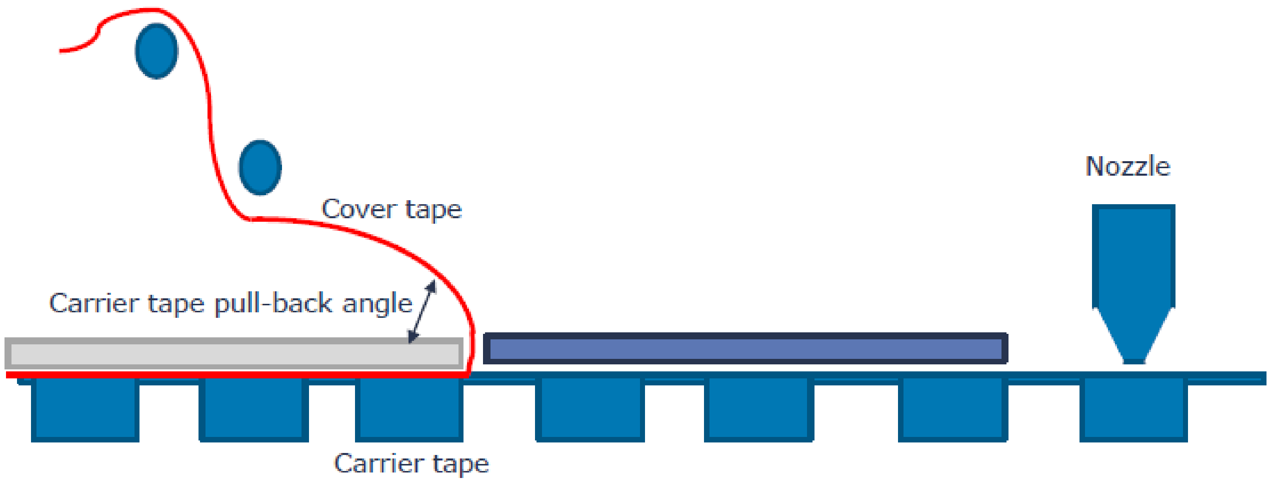


Graphic 1 parts sticking in feeder unit

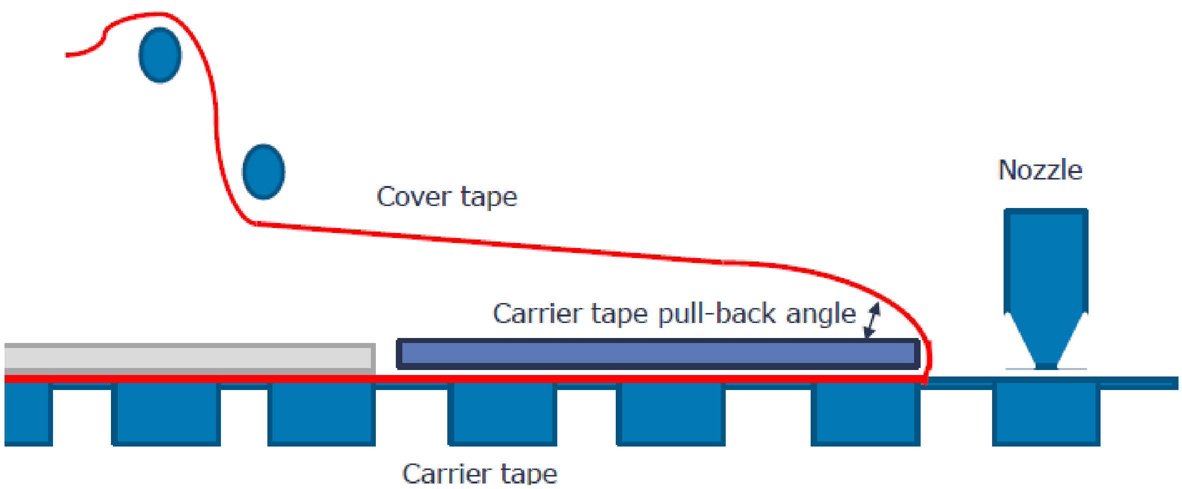


Graphic 5 feeder peel back modification

The next item angle at which the cover tape pulls back. This may sound trivial, but pulling the cover tape back at a high angle can pull the LED out of the pocket or arrange the LED in the pocket so that the nozzle does not pick the LED properly similar to what was shown in **Graphic 1**. **Graphic 6** is a rough sketch of the change to the angle and what should be considers for proper peel back angle. **Graphic 7** shows the recommended low angle pull back which helps minimize parts from flipping during indexing.



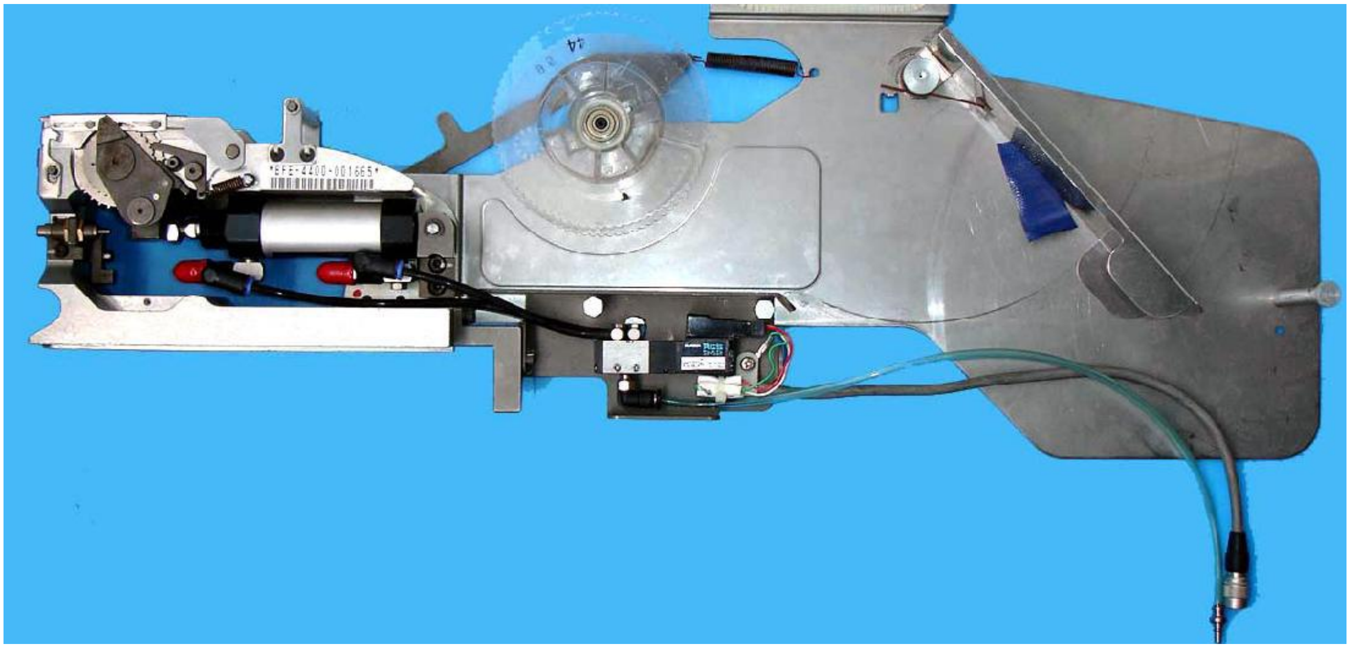
Graphic 6 shows a peel back angle that can attribute to part mis-alignment in the pocket



Graphic 7 shows a preferred peel back location to minimize the chance for improper part presentation to the nozzle

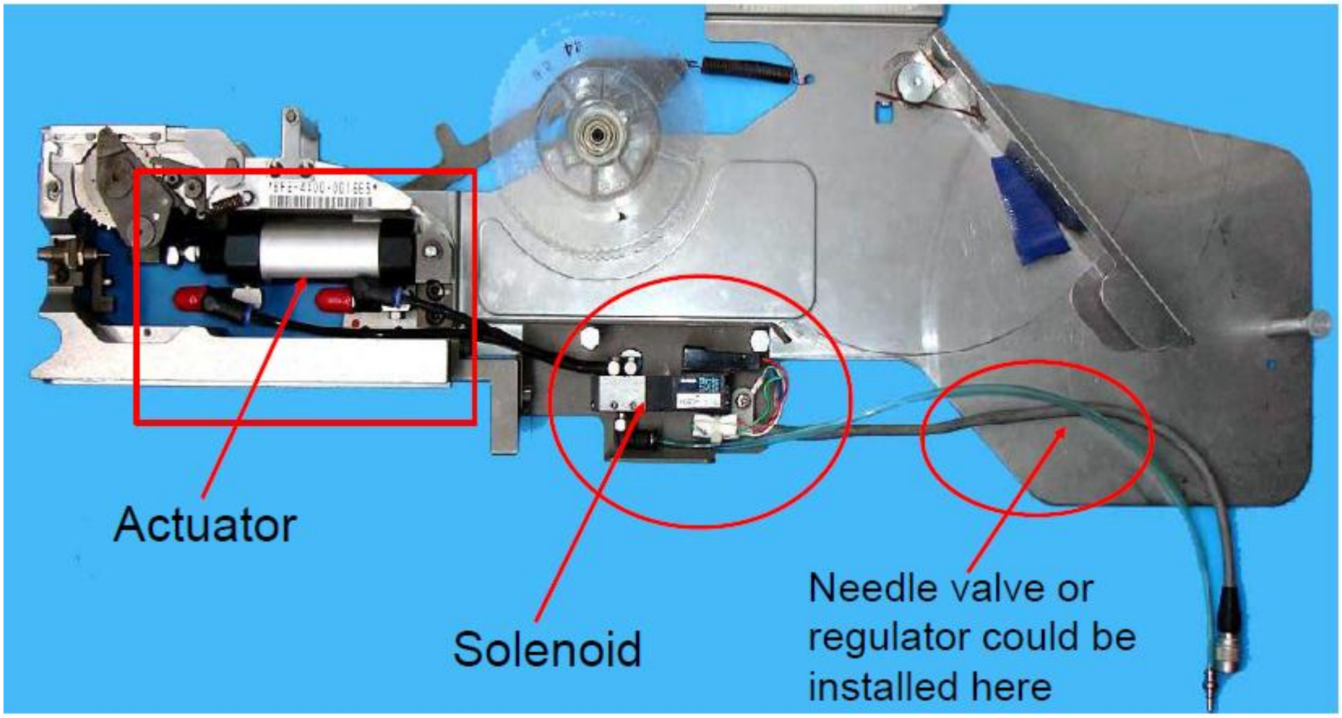
Indexing systems The second area that can attribute to mis-orientation of the LED to the nozzle during picking is the method by which the system performs indexing. There are two main indexing methods.

Pneumatic indexing Pneumatic indexing is one of the most common methods to index components on automated assembly equipment. A pneumatic actuator uses compressed air to create the linear indexing motion. In addition to the actuator, the system is comprised of a piston, a cylinder and valves or ports that supply air pressure from the actuator to the piston, and exhaust the air to allow the cylinder to release. The piston is covered by a diaphragm, or seal, that keeps the air in the upper portion of the cylinder, allowing air pressure to force the diaphragm forward, moving the piston, which in turn moves the valve stem to create the indexing on the feeder sprocket wheel. This method of indexing can be seen in **Graphic 8.**



Graphic 8 pneumatic indexing on pick and place system

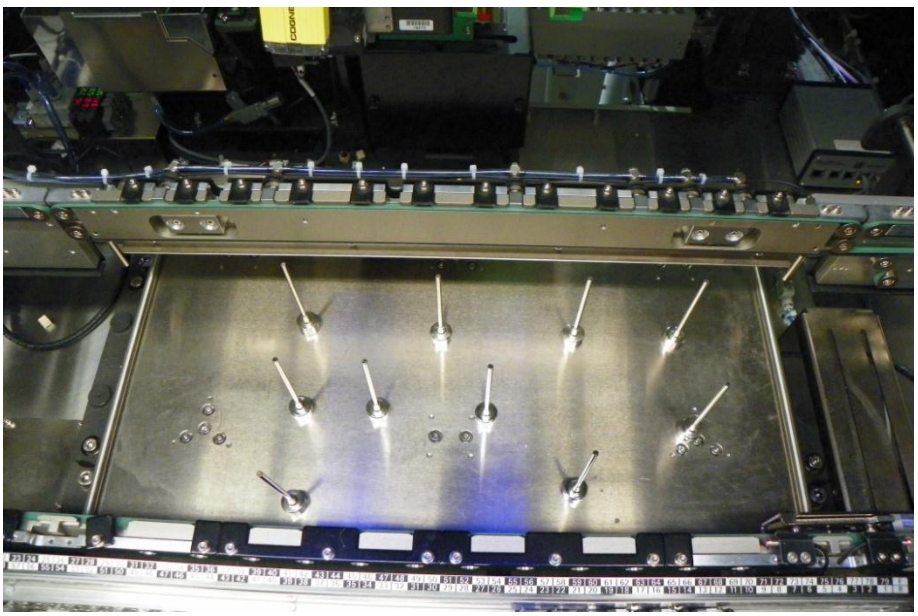
Using this same indexing unit in **Graphic 9** there is a location at which we can install a regulator or a needle valve to help control the speed at which the system indexes.



Graphic 9 suggested improvement called out for pneumatic feeders

Servo-motor or belt-driven indexing A stepper motor is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can be commanded to move to and hold at one of these steps. The DC servo motor is usually coupled directly to the sprocket wheel through a spring type of coupling device. Belt-driven indexing also uses a DC servo motor, but allows the motor to not directly couple to the sprocket wheel. This system usually has a gear or sprocket on the DC motor connected by a belt to a secondary gear on the sprocket wheel that does the indexing. Servo motor or DC stepper motors have been found to have the smoothest indexing, due mainly to their ability to precisely control the motor. The motor can be tuned by most field engineers through changes to the acceleration, deceleration, and overall velocity at which the system indexes. Other changes to a proportional integral derivative (PID) controller can help make this motion as smooth as needed to maximize feeder efficiency. There is less wear on the mechanics and a smoother indexing motion with this type of feeder unit.

Backside support for PCB A factor that can contribute to issues with placement that is not commonly considered is flexure of the PCB during the clamping process. As a PCB is indexed into an automated pick and place system, the board is typically driven against a mechanical stop at which time the system activates pneumatic actuators that clamp the board and hold it in place. Depending on the size of the PCB, a downward flexure that changes the placement zero plane may occur. By changing this zero plane location, the pick head moves down to the known position and may not have the over-travel to touch the solder, causing the tackiness of the solder to not assist in accurately placing the LED. Most systems have the option for backside support. This can be a pneumatically or mechanically actuated bar or multiple long pins that come up behind the PCB and ensure that the zero plane is maintained across the PCB's entire surface. This can be seen in **Graphic 10**.



Graphic 10 example of back side support

Fine tuning There are a number of fine tuning adjustments to help reduce the mis-pick rate. The Appendix lists a number of these adjustments for specific systems. These adjustments include the following items; The depth to which the pick nozzle moves inside the pocket; The speed at which the pick head moves out of the pocket; The alignment acceptable percentage for the automated optical inspection (AOI); The values for the component alignment systems; The amount of over-travel used during placement; The spring tension or force feedback used to place the component; The vacuum level settings for component presence checks.

Summary The suggestions covered in this presentation should assist anyone experiencing issues with picking and placing LEDs on an automated high-speed production line. The recommendations presented here have shown significant reductions in mis-picks as well as other component handling issues with automated systems. From my travels and multiple visits to contract manufacturers around the world, I have found that using the pyramid troubleshooting method helps reduce errors and operator interaction during the pick and place process. The proper nozzle, feeding adjustments, backside support, and settings have been demonstrated in numerous situations to assist in making pick and place equipment perform at a high level with low attrition rates. The steps of the pyramid are not the only items that can cause errors, but the suggestions in this application note provide direction for use in the correction of some of the concerns with placing LEDs. Millions of LEDs are processed daily resulting in a wealth of knowledge being gained, so if you have questions please contact your pick and place manufacturer or visit www.Cree.com and search Pick and Place applications note for more information.