

01005 Rework – barricades and technological processes

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Abstract

Chip components are important elements in electronic production since surface mount technology was introduced. Over the years, package size has constantly decreased. The small resistors and capacitors are still required, even if chip designs and integration rates for integrated circuits are improving almost constantly as well. 0201 packages are state-of-the-art in electronic production and smaller versions enter the market rapidly. While production systems like screen printers and pick-and-place machines can handle the small chips perfectly, touch up and repair processes become more challenging and many questions arise. What are the obstacles in the rework of 0201 and 01005 components? Which strategies and equipment lead to successful repair of these extremely small and sensitive devices?

Introduction

In the electronic industry production quality is constantly improving. Higher automation, better equipment and standardized processes lead to better production results. Nevertheless, a zero-defect production is hard to reach. As a result, touch up and repair processes are implemented and need to fulfil the high-quality demands of today's highly integrated and complex electronic products.

Besides “Big Board Rework Challenges”¹ professional repair processes of the smallest chip components are one of the remaining challenges in PCB rework. Other than expected, small chip components do not appear in compact applications like smart phones, smart watches or hearing aid devices, but also show up on large boards. Here, of course, the package density is more relaxed in terms of repair requirements.

Processing chip components

In production, the processing of chip components is mainly dependent on the tolerances of the components and the parameters of the pick-and-place machines. Additionally, the screen printing process is crucial for the later soldering result.

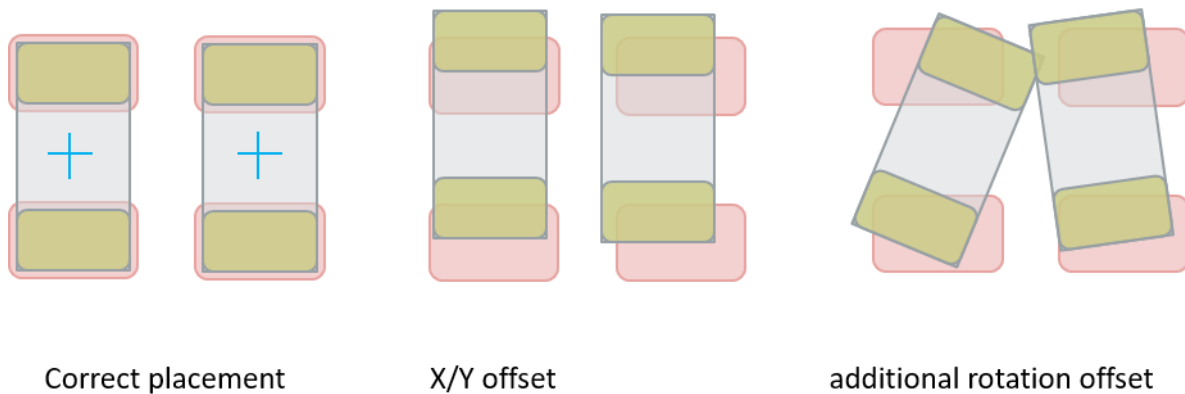


Figure 1 correct placement of chip components (Source: ASM)

The machine parameters and component datasheet information specify the minimum possible placement gap. This gap finally is defining the possible population density on the printed circuit board (see figure 2). This population possibilities on the other hand may interfere with the ability to rework the components. If the gap is too narrow, it cannot be excluded that repair operations on one chip has effects on the chips next to it.

The inline soldering processes usually fits to the demand of the chip components. High quality reflow ovens provide homogeneous heating, and if the transportation system meets today's standards there are no risks for the component on the thermal side.

¹ “Big Board Rework Challenges”, Abstract IPC APEX conference, Joerg Nolte, 2019

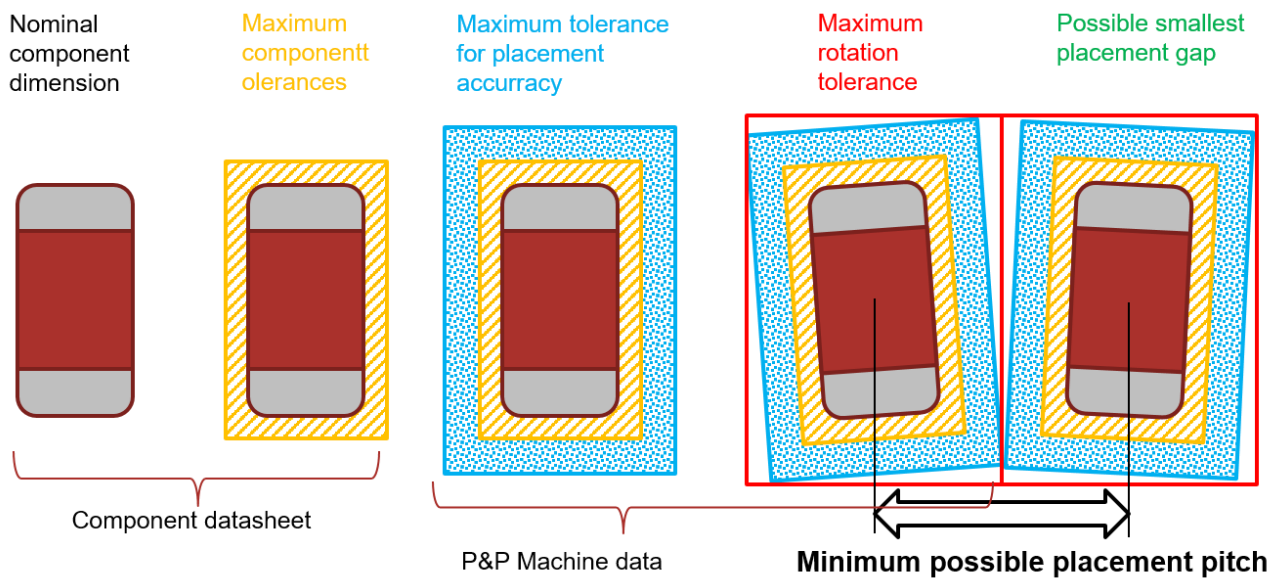


Figure 2 datasheet tolerances and machine data define the smallest gap (Source: ASM)

Manual rework of chip devices

As previously stated, processing of 0201 components in line production is standard. Smaller versions are coming up and all equipment manufacturers focus on these demands. At the same time, in rework the situation is different. The following parameters can be barricades to successfully removing and installing the tiny chips in a touch up situation:

- Component dimension and handling
- Visualization and magnification
- Tools for heating processes

The pure dimensions of small chip components (**0201**: 0,6 x 0,3 mm; 0,024 x 0,012 inch and **01005**: 0,4 x 0,2 mm; 0,016 x 0,008) are so small that the manual handling of the device requires patience and training. Unloading the component from a tape can already be a difficult process. It is important to have the right handling tools (tweezers) to securely grab and release the chips. Carbon based tweezer materials are an alternative to those made from stainless steel. Adhesive effects sometimes hinder the operator to release the device, and of course the tips must not be contaminated with flux or solder paste.



Figure 3 01005 component in a tape

Very skilled operators can handle 0201s without any optical magnification. Working on 01005s will require some type of optical magnification. Most commonly is the use of magnification glasses or – even better - stereo microscopes. Depending on the device, it is important to see its orientation, i.e. the metallization can vary from top to bottom side. The assistance of optical devices, like cameras, is more than welcome for pad pre-inspection, the soldering process itself and final judgement of the soldering result.

Regarding the soldering tools, hand held hot air tools are commonly used and hybrid systems (a combination of infrared heating and convection) have proven themselves as suitable. With hot air soldering irons there are some parameters to notice: The air temperature must be safe in order to not damage the solder mask or PCB, and the air flow needs to be gentle. Chip components are very light weight and too high of an air speed will easily shift or blow them away. Note: Not only the target component needs to be watched, but also the neighbors! In such cases, the highest risk is not to lose

the component, but not to find it again. The device might stay somewhere inside the assembly and cause an issue during its life time. With low air flow rates of around 3 l/min or, gentle hybrid technology repair soldering is possible. In many cases, especially on multi - layer boards, preheating of the assembly is a must.

Also commonly used are desoldering tweezers. Here, the soldering energy is transferred directly into the solder joint. This is a good option for removing the wrong or defective component. Installation is almost impossible as the small chips just stick to one another or the tweezer tip. This is not recommended. In the case of ceramic capacitors there is still the risk of thermal shock cracks. Choosing a regular soldering iron to install chips is an option. Precise temperature control and lowest possible tip temperature are good conditions. The correct soldering tip size will be one of the other important parameters to succeed, besides the training of the executing person.

Automated chip rework

Considering the above, it is consequent to request higher automated processes in the chip repair process. At the same time, repair is a task which is not always handling multiple boards in a row. Thus, the cost aspect and flexibility need to stay in focus. If you take a closer look into the single steps of chip rework, the following four phases show up:

- Component removal
- Pad preparation
- Pick & place a new component
- Solder the component

Desoldering an SMT component with a rework system has been a well-established process for many decades. For small chip components, some aspects require additional attention:

- Finding the correct position of the component on the PCB requires a high resolution camera, and a precise axis system. Otherwise it is impossible to lift up the component during the desoldering process.
- The vacuum pick up nozzle needs to overcome the adhesive forces of the liquid solder. Different nozzle designs are required to eventually not pick but also suck off the chip (see figure 4).
- The thermal process needs to be gentle and precise to reduce the thermal stress to the assembly. Closed-loop hybrid heating processes have proven their ability to fulfil this demand. It is known that the solder joint reliability of neighbor components, like other chips, is not affected by an additional heating cycle, nevertheless sensitive components nearby need to be protected.

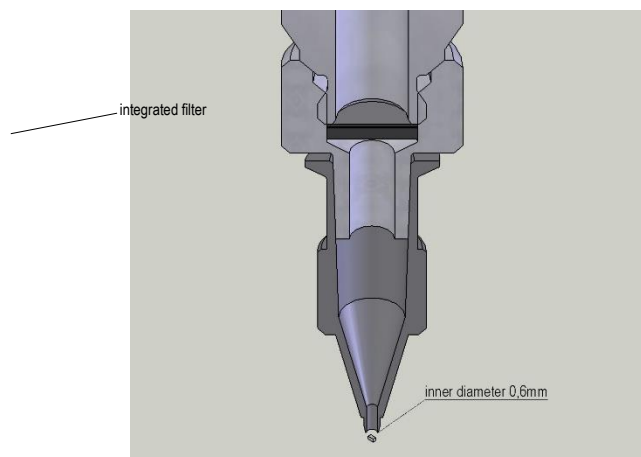


Figure 4 nozzle design with integrated filter to capture chip components during removal

When the component is removed from the PCB the pads need to be prepared for new installation. During this phase different options are possible and also depending on the initial production process, the customers' requirements and strategy. As the amount of solder in a 01005 joint is already very small, a separate scavenging process will not be needed in many cases. The remaining solder on the pad after component removal is small. Also, flux residues should be negligible.

Flux deposition or adding solder paste can be operated by assistance of a dispensing device or with a manually or integrated dip transfer process. Here a small needle is dipped into a paste depot and a defined amount of solder paste is transferred to the pads.

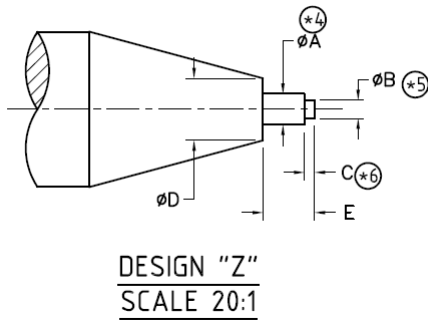


Figure 5.1 nozzle design to transfer solder



Figure 5.2 transferred solder paste to the solder pads (Source: Micro Mechanics)

Pick-and-place of 01005 components is probably the most challenging part of the entire repair process. In a production line, chip shooters are often the most expensive systems. For rework the available budget is often limited. At the same time the precision and repeatability should be on an “equal to production” level as well.

When an 01005 chip needs to be picked, the simple question is: How to do that?
And an even simpler question is: How to ensure the usage of the correct component?

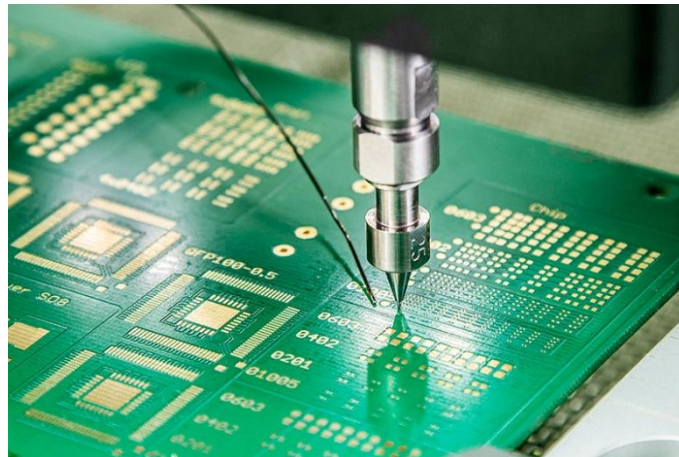


Figure 6 Placement of a 01005 component

Manual picking out of a box is not a good choice for several reasons:

1. Is it sure to have only the correct components in the box? Anyone who has ever picked screws from a magazine will know this problem.
2. What is the right tool to grab the device and release in the right spot for pick up? Like explained above, adhesion forces will hold the device on your tweezers once they are not the right material or 100% clean.
3. Will the component be ideally oriented for pick up? These components behave like placing an egg on its tip.

The only reasonable solution is to directly pick the component from the tape (see figures 7). Identification, orientation and transportation provide the best basis. A tape feeder is needed to present the device at a fixed position and allow the rework machine to find the device by help of image processing. Moreover, it is ensured that the component will sit on the nozzle in die correct orientation.

Ideally, the tape is easy to be loaded or the feeder consists of an exchangeable unit for different component tapes.



Figure 7.1 picking an 01005 from a tape feeder



Figure 7.2 tape feeder to install on a rework system

As for the removal of the chips, also for pick-and-place, the nozzle design is important. Size and material need to be suitable. To pick and release the device.

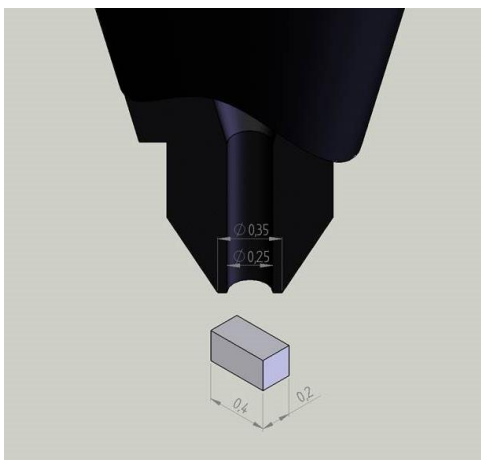


Figure 8.1 pick-and-place nozzle for 01005

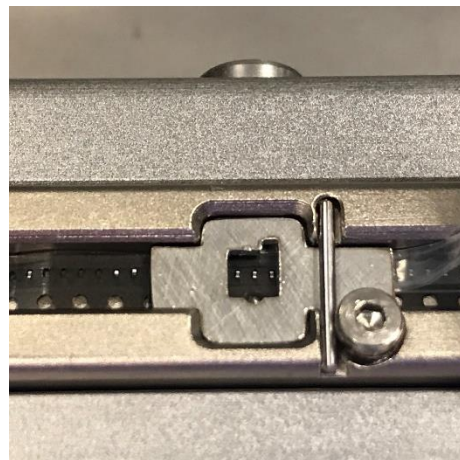


Figure 8.2 components in tape feeder

Image processing is the final but likewise important integral part to automatically handle the small chips. The component orientation and pins need to be detected. On the PCB, the system needs to find the adequate lands and the best overlay (see figure 9.1) needs to be calculated. Later, the axis system moves the component to the target position and releases it onto the previously prepared solder paste or flux depot.

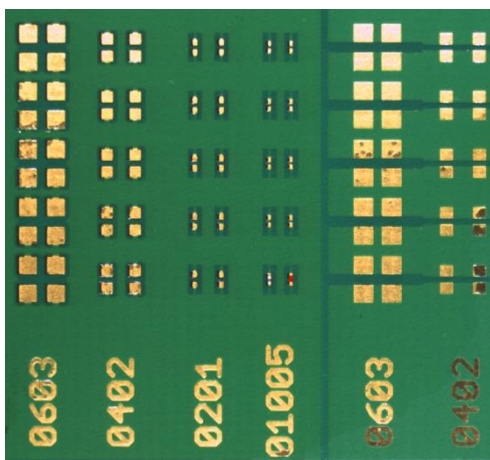


Figure 9.1 Test board with 01005 overlay and placements



Figure 9.2 installed 01005

The thermal demands for chips are usually not an issue. Nevertheless, the heating processes should be controlled and gentle. As mentioned above, the light weight components tend to shift from their position when treated with intensive air flow. A hybrid heating method seems to be the best way of soldering the components. Energy transmission via infrared radiation and a convective proportion are ideal. Further component specific nozzles are not required and during the heating process the view towards the very tiny solder joint is always given. Visual process observation with a reflow process camera device with high magnification and resolution can take place.

Summary and Outlook

As 01005s and even smaller components are becoming more common in electronic assemblies, it is clear that the demand for prototyping and repair of such elements will rise. At the same time, process repeatability and process documentation are becoming more important. No process without documentation is the goal. All OEM and contract manufacturers are heading the same direction, and the system suppliers are requested to offer integrated, highly automated rework solutions for all kinds of assemblies and components. It can be foreseen that further steps will be integrated into advanced rework system solutions: Component loss alerts as well as automatic post placement and post soldering inspection are only some examples.