

THE CHALLENGES OF LGA SERVER SOCKET TRENDS

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ABSTRACT

The high end server market trends present several manufacturing and technical challenges to socket manufacturers. There are five notable trends that present challenges:

1. There is a trend towards lower contact resistance. Contact resistance has a negative impact on current carrying capability and leads to higher socket operating temperatures. Given space constraints, the best approach to lowering contact resistance is by selecting materials with higher electrical conductivity. However, the tradeoff to higher conductivity materials is reduced mechanical performance.
2. There is a trend towards increasing pin-counts coupled with a need to maintain or lower the socket's overall loading force. Larger loading forces can impact the socket's mechanical integrity and create ergonomic challenges. One way to achieve this is by reducing contact normal force.
3. There is a trend towards contacts having shorter electrical paths. As server frequencies increase, signal becomes more sensitive to noise. Reducing the seating plane height forces a shorter contact signal path and reduces the potential for noise in the circuit.
4. There is a trend towards higher contact density. The need for maintaining legacy real estate requirements along with the need for higher pin-counts results in the need for contact pitch reduction.
5. Due to the higher pin counts and smaller contacts, the trend in manufacturing is towards robotic assembly lines to make the production process more stable and increase yield rates.

This presentation aims to discuss the challenges and some potential solutions for each of these trends.

INTRODUCTION

With each succeeding year, as the technology of high end servers advances, the requirements for the LGA sockets used in these servers becomes more varied and restrictive. As mentioned in the abstract, there are five notable trends in connector requirements. As can be seen in Chart 1 below, the requirement for LGA server sockets is constantly evolving, with changes in pitch, pin counts, style of contacts, and seating plane height.



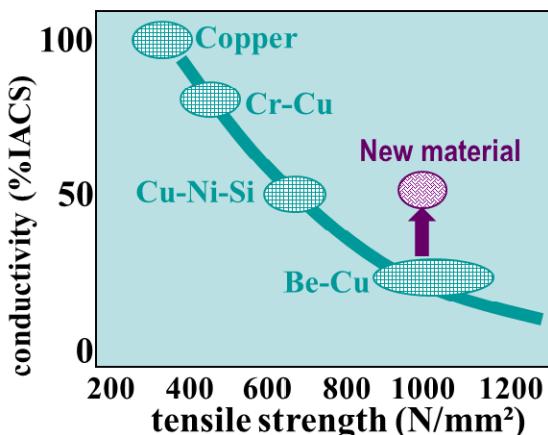
Chart 1. Recent trends in LGA Server Sockets

Thus, it is necessary to be constantly working on developing new stamping, molding, and assembly technologies. Additionally, it is necessary to work with the material suppliers to provide contact materials that have higher conductivity without compromising strength properties and thermoplastics that have better flow properties and maintain high strength with thinner walls.

LGA SOCKET TECHNOLOGY DEVELOPMENT

Reduced Contact Resistance

There is a need to be able to carry higher current levels thru the LGA sockets as the processing power increases. In order to accomplish this, the bulk contact resistance needs to be reduced. There are several ways to accomplish this task. The contact length could be made shorter, the contact material width could be increased, the contact material thickness could be increased, the conductivity of the material could be increased, or a combination of the above. Each of these changes has its limitations, but generally due to space constraints finding a higher conductivity material is the preferred solution. The tradeoff, however, is that the higher conductivity materials typically have lower material strength properties, thus adversely affecting the mechanical performance of the socket. Graph 1 below shows how the material selection between conductivity can change with respect to tensile strength, illustrating the tradeoff that occurs.



Graph 1. Contact material conductivity versus tensile strength

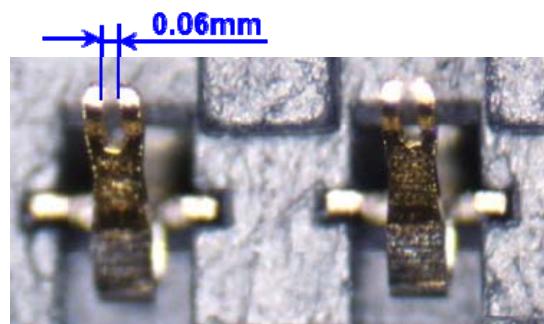
The challenge for the contact material industry is to develop new materials that have higher conductivity without a significant loss in material strength properties. We are actively working with our contact material suppliers to find new materials that will meet these requirements.

Reduced Contact Normal Force

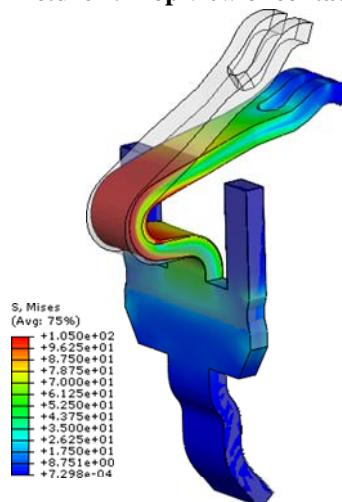
Another way to try combating the loss of material strength with the higher conductivity material is to lower the normal force requirement for the contact without increasing the contact resistance. This is also being driven by the higher pin count requirements for the sockets. With higher pin counts the loading force required to activate the sockets increases, which increases spacing requirements for loading mechanisms, as well as, the integrity of the socket body. For example, if you have a 3000 pin LGA socket and the nominal contact normal force is 36gf, then the nominal loading force required to activate the socket is 108 kgf. Now if the pin count increases to 3777, the loading force

will increase to 136 kgf, a significant jump in the amount of force that must be applied and maintained.

The contact normal force can be reduced if a high hertz stress is maintained. We have developed a contact to achieve this by employing a proprietary thin gap blanking technology to reduce the width of the contact by 28%, which allowed us to reduce the contact normal force by 47%, while maintaining a high hertz stress, reference Pictures 1 and 2.

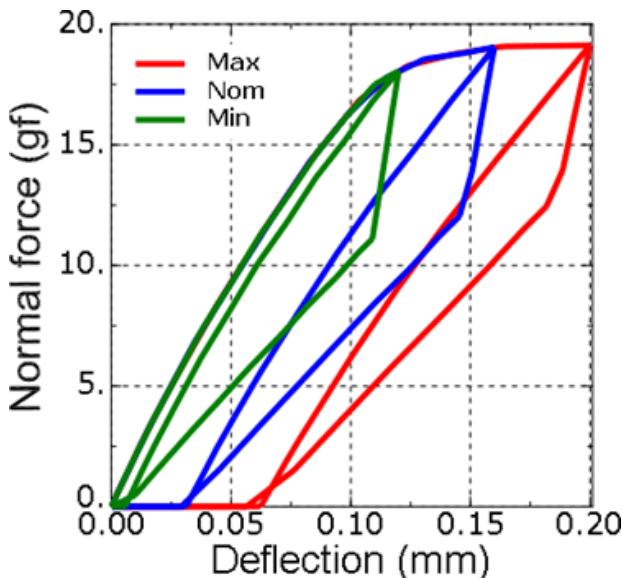


Picture 1. Top view of contact with smaller gap



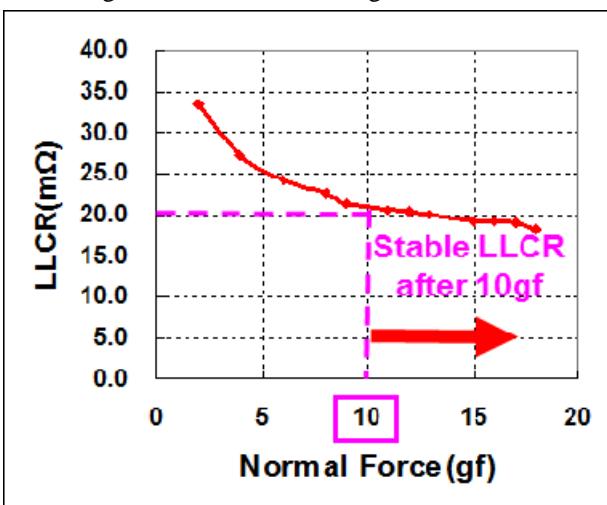
Picture 2. FEA deflected stress model of redesigned contact

The contact normal force went from 36gf in our current contacts to 19gf in the redesigned contact, as shown in Graph 2.



Graph 2. Normal force versus deflection of redesigned contact

As can be seen in the Graph 3 below, the LLCR on the contact begins to stabilize at the 10gf level.

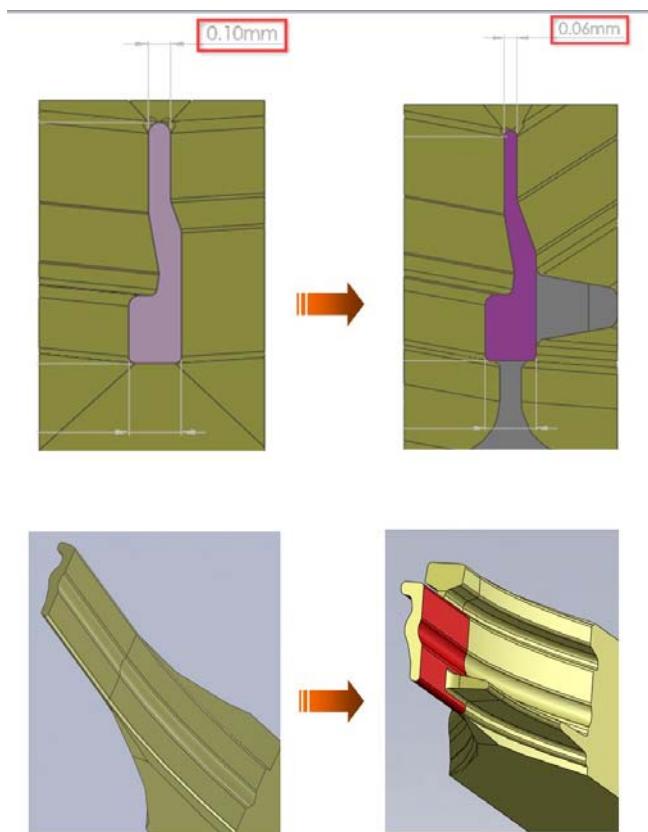


Graph 3. Contact LLCR versus contact normal force

Thin Blanking Technology

As mentioned above, thin blanking technology was utilized to decrease the space requirements for the contact, and keep the hertz stress high while lowering the contact normal force. The thinner gap requires a thinner blanking punch, which would shorten the life of the tool due to higher tool breakage.

We internally developed a tool punch using FEA simulation to optimize the tool geometry. With the redesigned punch, and optimizing our stamping process, we were able to thin the punching area by 40% as shown in the first two sets of pictures in Picture 3. We strengthened the punch by adding two reinforcing side ribs, as shown in the last two set of pictures of Picture 3. [1 and 2]

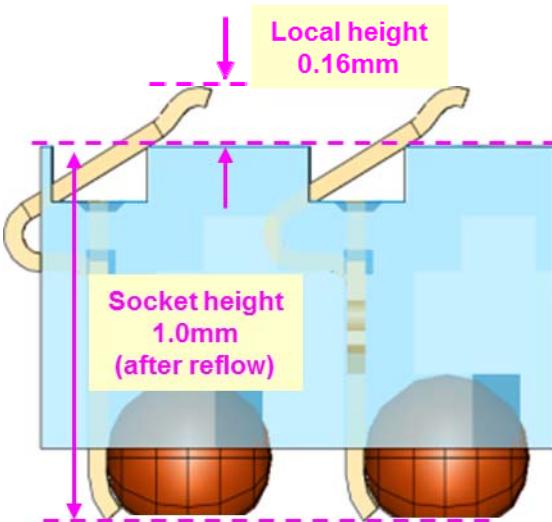


Picture 3. Standard Blanking tool on left side versus optimized thin blanking tool on right side

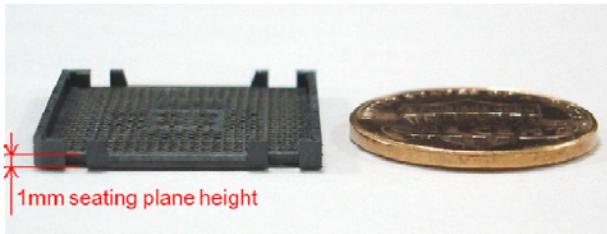
With the new punch design, we were able to reduce the blanking gap from 0.10 mm to 0.06mm, without reducing the tool life.

Reduced Seating Plane Height

As the processor's speed increases, there is a need to reduce the electrical length of the contact. If the electrical length is too long, there will be more noise in the system with the higher speeds. This requires reducing the seating plane of the socket (the height from the top of the motherboard to the bottom of the processor package). One method that can be employed to reduce the seating plane height is to use thinner material so the deflection range of the contact can be maintained with a shorter spring beam length. Employing a proprietary thin metal stamping technology, we have been able to design a contact that has a lower profile and reduces the seating plane from the current 1.6 mm to 1.0 mm as shown in Pictures 4 and 5.



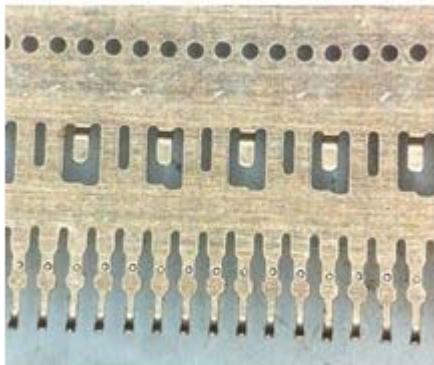
Picture 4. Drawing side view showing seating plane



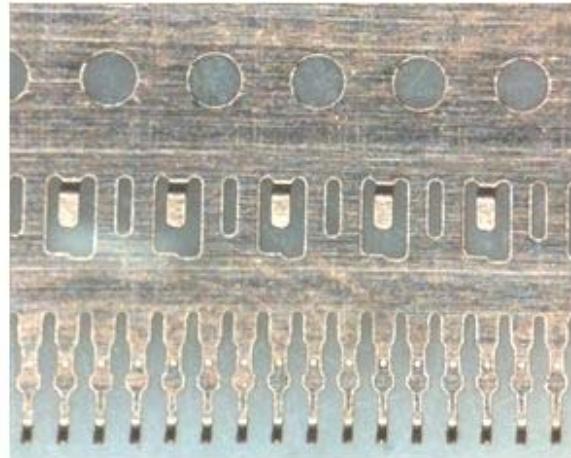
Picture 5. 1.0 mm seating plane height socket

Thin Metal Stamping Technology

Progressive die stamping is the preferred method for producing LGA contacts. In a progressive die, a strip of metal is horizontally fed into a long die that has a series of stations for punching, swaging, blanking, shearing, and bending to produce the contacts. However, one of the problems with using thinner metal for progressive die stamping is that the carrier strip strength becomes significantly weaker. This makes it difficult to properly feed the material in the progressive die. [3 & 4] We were able to optimize our contact carrier design, and enhance the strength of the pilot hole, allowing us to reduce the material thickness of the contact strip by 33% from 0.06 mm to 0.04 mm, while maintaining good manufacturability, as shown in Pictures 6 and 7.



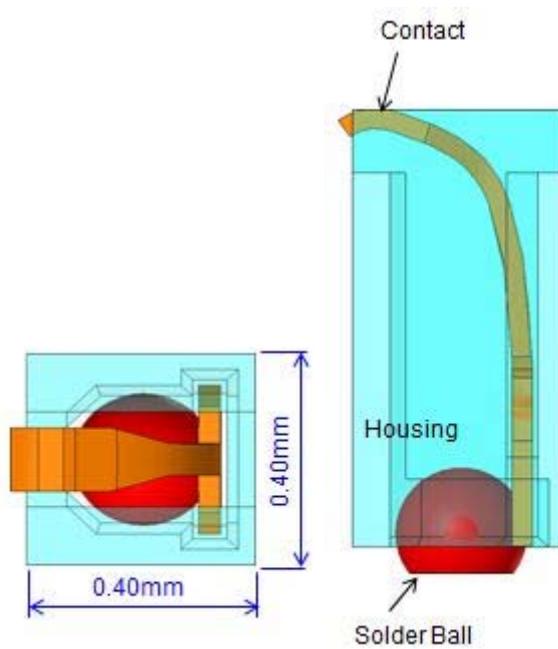
Picture 6. Standard contact carrier



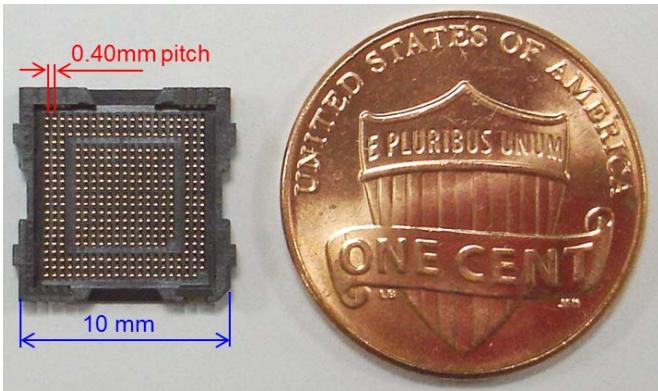
Picture 7. Optimized contact carrier

Reduced Contact Pitch

As the processors become more powerful, there is a need for more pins to utilize this capability. However, it is also desired to not take up more of the board real estate to achieve the higher pin count, as the board also needs more components to maximize the processor capability. Thus, methods need to be found for reducing the contact pitch. We used a combination of thin metal stamping technology, thin wall injection molding technology, changing the method of solder ball attachment, and FEA to design a socket with a pitch of only 0.40 mm from the current pitch of 0.7424 mm. Pictures 8 & 9 show the socket.



Picture 8. Top and side view drawings of contact



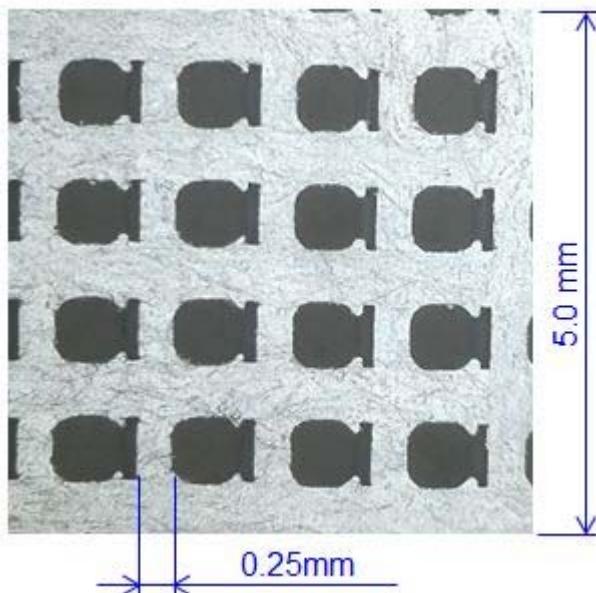
Picture 9. Top view of 0.40 mm pitch LGA socket

Thin Wall Injection Molding

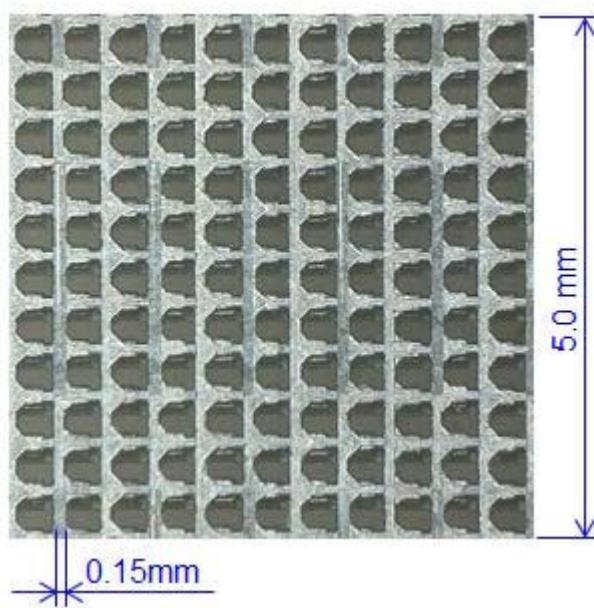
Thin wall injection molding requires higher pressures and speeds than more conventional molding. There are many design considerations to take into account, such as harder steel for the molds, gate and runner sizes, core pin and ejector pin designs, heating and cooling systems, and venting [5 & 6].

Thin wall molding can also create issues with maintaining true position of contact cavities and warpage of the socket body. For a 0.74 mm pitch socket, the TP is held to 0.25mm, so for a 0.40 mm pitch socket it might now be necessary to hold it to 0.125 mm or less depending on contact design, alignment pins, and pad design. Warpage control is also harder. Socket flatness is typically held to 0.20 mm. With the smaller pitch, socket walls are not as stiff and there exists fewer areas to employ coring to control warpage.

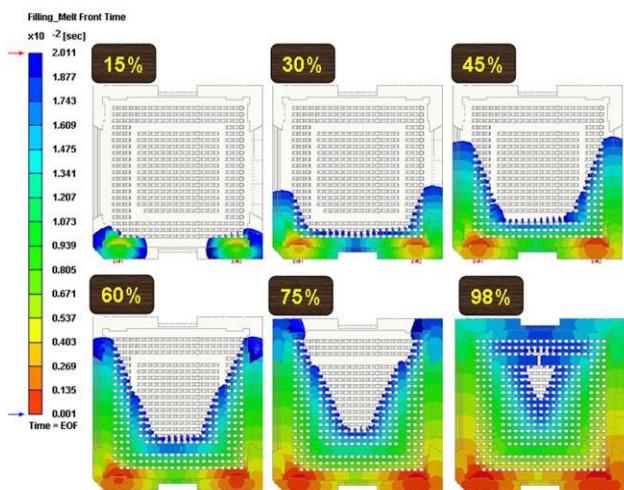
We were able to employ thin wall injection molding technology to reduce the wall thickness on a socket from 0.25 mm down to 0.15 mm. In particular, we utilized mold flow analysis to optimize the core pin and gate designs, optimized processing parameters, heating and cooling of the mold, and used a small form factor ejector pin system. As shown in Pictures 10, 11, and 12.



Picture 10. Top view of standard injection molded housing



Picture 11. Top view of thin walled injection molded housing



Picture 12. Mold flow analysis showing fill pattern of housing

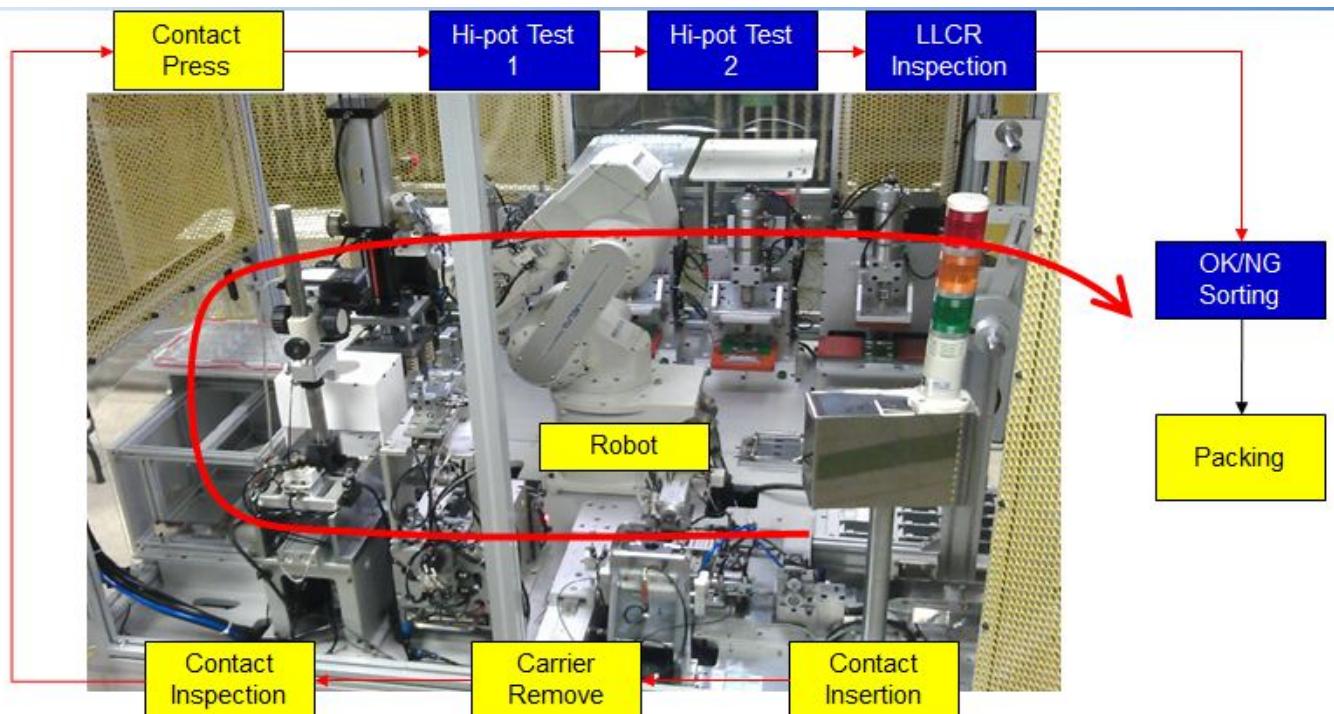
Robotic Assembly of LGA Sockets

The above trends that have been discussed have put more pressure on efficiently assembling the sockets. As the sockets become smaller, it becomes difficult to assemble the sockets using the traditional methods. It becomes necessary to remove as much human interaction as possible from the socket assembly process. Thus, we have developed a completely self-contained automated robotic process for assembling high pin count LGA sockets. The system utilizes a robot to move and precisely position the socket

assembly from station to station. Thus, operator error is removed from the process. The contacts are fed and cut from a stamping reel and inserted into the socket body. The socket bodies are fed into the robotic line from a tray. A high resolution camera, with 15 million pixels, is used to inspect the sockets after assembly to verify the contacts have been inserted correctly, before pressing them to their final position. The sockets are then routed thru automated electrical testers to verify the socket is functioning properly. Defective sockets are automatically sorted out and the good sockets are tray packaged for shipment. A descriptive picture of the robotic assembly cell is shown below. Yield rate was increased from 85% to 95%. The output volume was not increased, but the number of operators required for assembling was reduced by 75% versus the old assembly method. Picture 13 shows the robot assembly line and the flow of the product.

CONCLUSIONS

As can be understood from the preceding discussion, there is much work in many areas that needs to be done to continue to meet the difficult requirements of future high end LGA sockets. Not only does the manufacturing technology need to continue to be optimized and improved, but also the raw materials used to make the sockets needs to also be developed. In particular, contact materials with high strength and better conductivity are needed to meet the increased current requirements on tighter pitches, and thermoplastics that have good flow characteristics, while maintaining high strength with thinner walls.



Picture 13. Robotic cell used to assembled LGA socket

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REFERENCES

- [1] Kalpakjian & Schmid, "Manufacturing Processes for Engineering Materials," 5thed, Chapter 7, Pearson Education, 2008.
- [2] Sue Roberts, "Tips for Punching Thin Material", Canadian Industrial Machinery, August, 2012.
- [3] Art Hedrick, "Die Basics 101", TheFabricator.com, August, 2005.
- [4] Wikipedia, "Progressive Stamping", October, 2012.
- [5] Kurt Weiss, "Secrets of Successful Thin-Wall Molding", Plastic Technology, February, 2002.
- [6] Donna Bibber, "Secrets of Success in Micro Molding", Plastic Technology, March, 2012.