

# Step Stencil design when 01005 and 0.3mm pitch uBGA's coexist with RF Shields

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## Abstract

Some of the new handheld communication devices offer real challenges to the paste printing process. Normally, there are very small devices like 01005 chip components as well as 0.3 mm pitch uBGA along with other devices that require higher deposits of solder paste. Surface mount connectors or RF shields with coplanarity issues fall into this category. Aperture sizes for the small devices require a stencil thickness in the 50 to 75  $\mu\text{m}$  (2-3 mils) range for effective paste transfer whereas the RF shield and SMT connector would like at least 150  $\mu\text{m}$  (6 mils) paste height. Spacing is too small to use normal step stencils.

This paper will explore a different type of step stencil for this application; a "Two-Print Stencil Process" step stencil. Here is a brief description of a "Two-Print Stencil Process". A 50 to 75  $\mu\text{m}$  (2-3 mils) stencil is used to print solder paste for the 01005, 0.3 mm pitch uBGA and other fine pitch components. While this paste is still wet a second in-line stencil printer is used to print all other components using a second thicker stencil. This second stencil has relief pockets on the contact side of the stencil any paste was printed with the first stencil.

Design guidelines for minimum keep-out distances between the relief step, the fine pitch apertures, and the RF Shields apertures as well relief pocket height clearance of the paste printed by the first print stencil will be provided.

## Introduction

A printing challenge exists when very small devices coexist on a PCB with components requiring either high volume or high paste height. When printing solder paste for 01005 and / or 0.3 mm pitch uBGA a thin stencil, normally (50 to 75  $\mu\text{m}$ ) thick is preferable to achieve sufficient paste transfer efficiency and low paste volume dispersion. If a 100  $\mu\text{m}$  thick stencil is used to print these small devices, the area ratio is less than 0.5 which is lower than the recommended value for both Laser-Cut stencils and E-FAB Electroform stencils. It is very common to print solder paste for RF shields for hand-held devices. Normally, higher solder paste deposits are required because of coplanarity issues with RF shields. To achieve these higher solder paste deposits a thicker stencil is needed. A step stencil<sup>(1)</sup> is normally used to achieve different solder paste heights. However in many hand-held devices the spacing between the small pitch components and the RF shield is normally very small, in many cases as small as 500  $\mu\text{m}$  (20 mils). The design guideline<sup>1</sup> for a normal step-down stencil is that the aperture in the step-down region be positioned at least 890  $\mu\text{m}$  (35 mils) from the step-up wall for every 25 $\mu\text{m}$  (1mil) of step-up thickness. Otherwise the squeegee blade (metal or rubber) does not do a very job of depositing paste into the lower level apertures. In the case of RF shields a stencil thickness of 150 to 175  $\mu\text{m}$  (6 to 7 mils) may be required to achieve the desired solder paste height. The height difference; 75 $\mu\text{m}$  (3 mils) thick stencil for the small components and 150 $\mu\text{m}$  (6 mils) thick stencil, prevents a normal step stencil to be used for this application.

However, a "Two-Print Stencil Process" allows for very small spacing between the apertures of the smaller components and apertures of the RF shield. The objective of this study is to determine the smallest spacing between small component apertures and RF shield apertures for the Two-Print stencil process. Another objective is to determine the minimum clearance between the relief pocket of the 2<sup>nd</sup> print stencil and the 1<sup>st</sup> print stencil without paste smearing in the relief pocket.

## Two-Print Stencil Test Plan

The Two-Print stencil process consists of two stencils. The 1<sup>st</sup> print stencil is used to print 0.3 mm pitch uBGA (198  $\mu\text{m}$  circular apertures), 0.4 mm pitch uBGA (244  $\mu\text{m}$  circular apertures), 01005 chip components (178  $\mu\text{m}$  circular apertures), and 0201 chip component apertures (300  $\mu\text{m}$  square apertures). Two 1<sup>st</sup> print stencils were fabricated. Both were E-FAB Electroform stencils; one was 50  $\mu\text{m}$  (2 mils) thick and the other was 75  $\mu\text{m}$  (3 mils) thick. The 2<sup>nd</sup> print stencil is used to print RF shields and a SMT connector and some large capacitor apertures. Four 2<sup>nd</sup> print stencils were manufactured with four different stencil thicknesses; each stencil had a relief pocket etched in the area where solder paste was printed with the 1<sup>st</sup> stencil. The design is summarized in Table 1.

**Table 1**  
Two-Print Stencil Test Plan:

1<sup>st</sup> print stencil is an E-FAB Electroform stencil and prints solder paste for 0.3 mm and 0.4 mm uBGA's, 01005 and 0201 chip components.

Two stencils were manufactured:

- 50 um (2 mil) thick E-FAB stencil
- 75 um (3 mil) thick E-FAB stencil.

2<sup>nd</sup> print stencil is a Laser-Cut / Chem-Etch stencil with apertures for RF Shields, capacitors, and a SMT connector. This 2<sup>nd</sup> print stencil has relief pockets anywhere paste is printed by the 1<sup>st</sup> print stencil.

Four 2<sup>nd</sup> print stencils were manufactured:

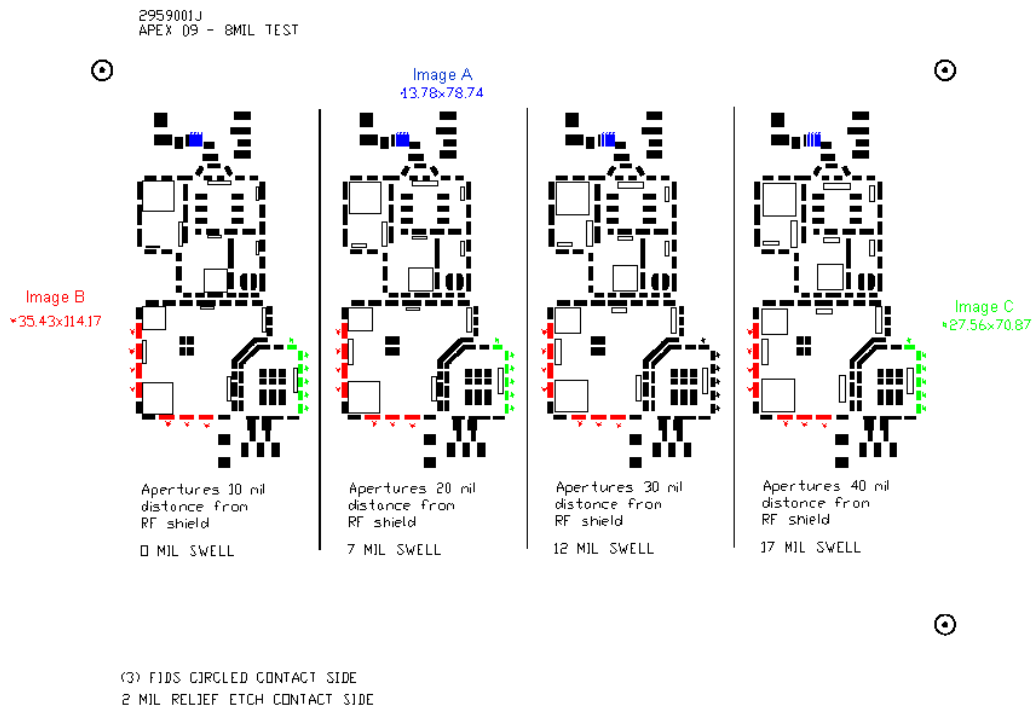
- 8 mil thick with a 6 mil deep relief pocket
- 7 mil thick with a 5 mil deep relief pocket
- 6 mil thick with a 4 mil deep relief pocket
- 5 mil thick with a 3 mil deep relief pocket

Design of the aperture spacing between 1<sup>st</sup> and 2<sup>nd</sup> print stencil and relief pocket (4 images in the stencil):

- Image 1 250 um (10 mil) spacing between apertures in 1<sup>st</sup> and 2<sup>nd</sup> stencil
- Image 2 500 um (20 mil) spacing between apertures in 1<sup>st</sup> and 2<sup>nd</sup> stencil
- Image 3 750 um (30 mil) spacing between apertures in 1<sup>st</sup> and 2<sup>nd</sup> stencil
- Image 4 1000 um (40 mil) spacing between apertures in 1<sup>st</sup> and 2<sup>nd</sup> stencil

The manufacturing process for the 2<sup>nd</sup> print stencils was to Chem-Etch the Relief pockets in the metal foil then to Laser-Cut the apertures for the RF shields and other devices in this stencil. The 2<sup>nd</sup> print stencil is designed to have different spacing's between the apertures in the 1<sup>st</sup> print stencil and the apertures in the 2<sup>nd</sup> print stencil. This design is shown in Figure 1.

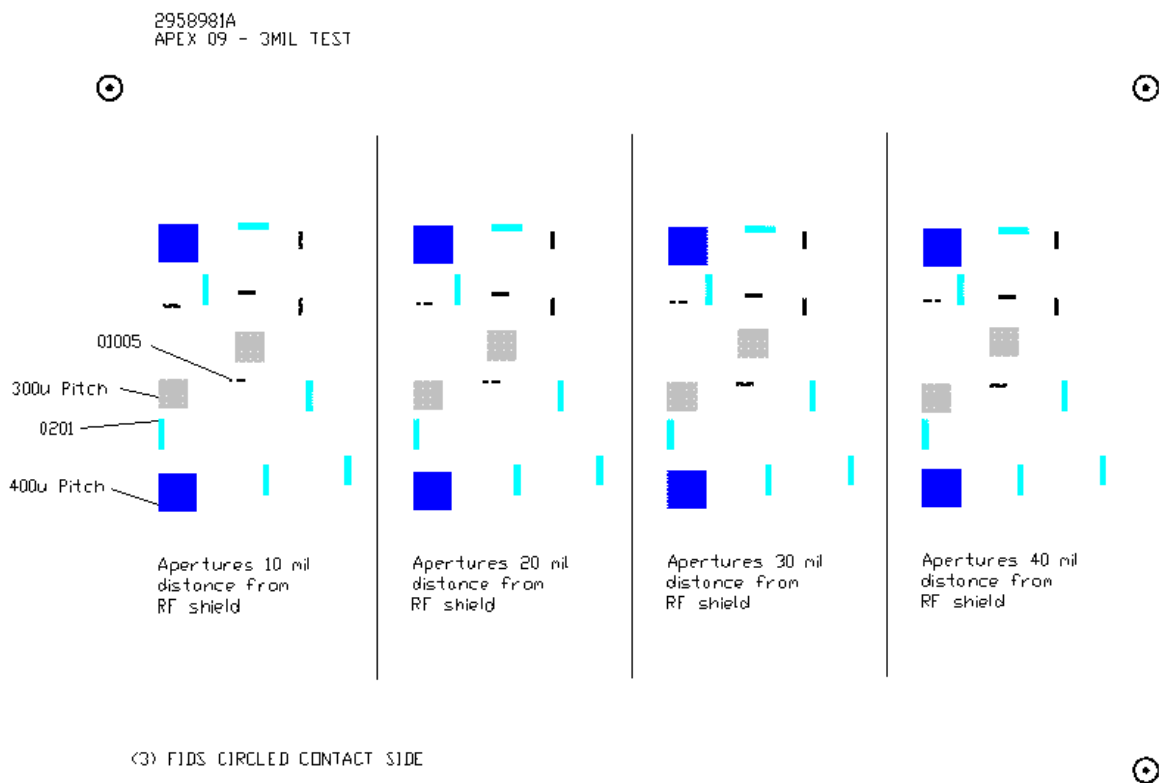
## 2<sup>nd</sup> Print Stencil showing apertures and Relief Pockets



**Figure 1. Schematic Layout of 2<sup>nd</sup> Print Stencil**

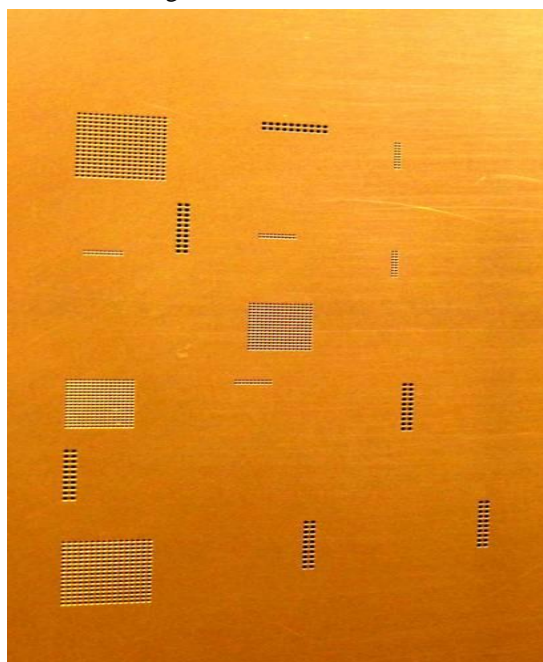
As seen the spacing is 250 um (10 mils) for Image 1, 500 um (20 mils) for Image 2, 750 um (30 mils) for Image 3 and 1000 um (40 mils) for Image 4. Figure 1 is a schematic drawing of the aperture layout and relief pockets for the 2<sup>nd</sup> print stencil.

As seen in Figure 1 there is 0 swell for Image 1. This means that the relief etch pocket edge was designed to line up with the edge of the apertures in the 1<sup>st</sup> stencil. No etch compensation was used for this relief pocket. When the pocket is etched it not only etches down but it also etches out making the pocket larger. The increase in pocket size depends on how deep the pocket is etched. The increase in pocket size is about ½ of the depth of the relief pocket. As an example in the case of the 175 um (7 mil) thick stencil with a relief pocket 125 um (5 mils) deep the increase in size of the relief pocket is 64 um (2.5 mils). The layout of the 1<sup>st</sup> print stencil is shown Figure 2.



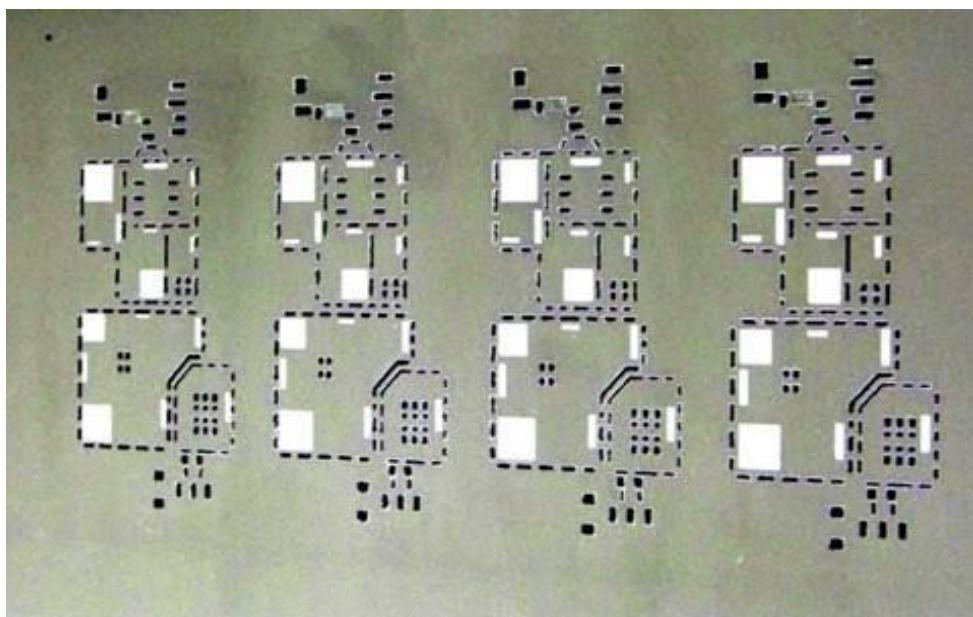
**Figure. 1<sup>st</sup> Print Stencil showing aperture sizes and aperture position**

A photograph of the 1<sup>st</sup> print E-FAB stencil is shown in Figure 3.



**Figure 3. 1<sup>st</sup> Print E-FAB Stencil**

Figure 4 shows a picture of the 2<sup>nd</sup> print stencil, a Laser-Cut / Chem-Etch stencil, showing the apertures along with the relief pockets.



**Figure 4. 2<sup>nd</sup> Print Laser-Cut Chem-Etch Stencil**

#### Print Results

The test boards used in this experiment were bare copper clad FR4 with 3 fiducials for registration between the 1<sup>st</sup> print and 2<sup>nd</sup> print stencil.

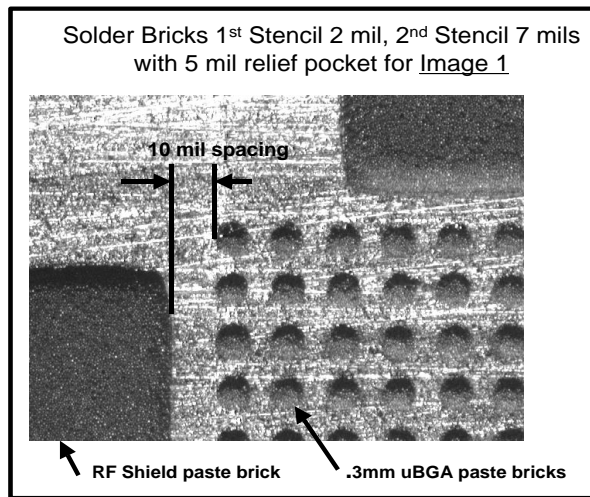
**Table 2 Printer Set-Up**

Printer:	Speedline Momentum
Squeegee:	E-Blade Electroformed blade
Board:	Blank Copper Clad FR4 with Fids
Print Speed:	1 inch / sec
Print Pressure:	11 lbs.
Paste:	Type 5 Heraeus BD72 SAC 305
Print Sequence:	Print 1 <sup>st</sup> print stencil then immediately print 2 <sup>nd</sup> print stencil while 1 <sup>st</sup> print still wet

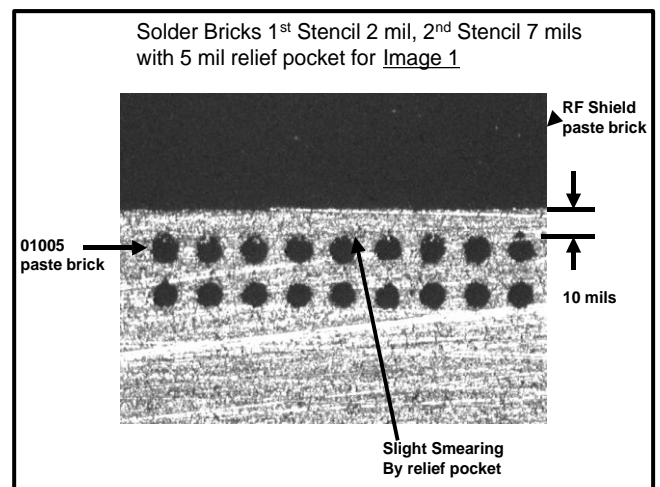
A Speedline Momentum printer, along with E-Blade Electroformed squeegee blades was used. The printer set-up and Printing test procedure are shown in Table 2.

Figure 5 shows solder bricks printed with the 1<sup>st</sup> and 2<sup>nd</sup> stencil for Image 1 with 250  $\mu$ m (10 mils) spacing between the 1<sup>st</sup> and 2<sup>nd</sup> print. This print sequence used a 50  $\mu$ m (2mil) thick E-FAB 1<sup>st</sup> print stencil and a 175  $\mu$ m (7 mil) Laser-Cut / Chem-Etch with a 125  $\mu$ m (5 mil) relief pocket 2<sup>nd</sup> print stencil.

Note that the spacing between the .3 mm uBGA and the RF shield is 250  $\mu$ m (10 mils). Figure 6 shows the same print sequence but for the 01005 chip component solder bricks next to the FR shield solder brick. Spacing is 250  $\mu$ m (10 mils) but a slight smearing of the 01005 solder brick can be seen.

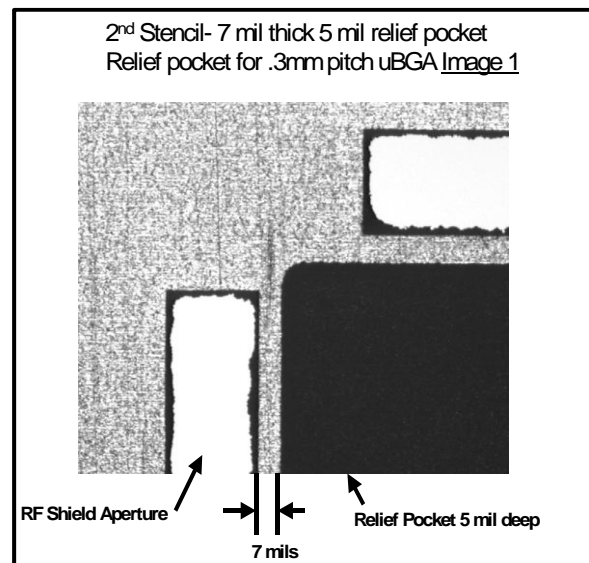


**Figure 5. Solder Bricks .3 mm uBGA Image 1**



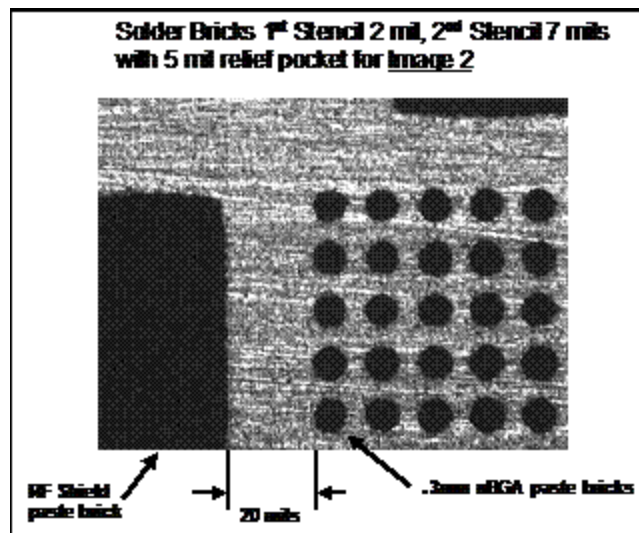
**Figure 6. Solder Bricks 01005 Image 1**

Figure 7 shows a close up of the 2<sup>nd</sup> print stencil which is 175  $\mu$ m (7 mils) thick with a 125  $\mu$ m (5 mil) deep relief pocket. Notice that the spacing from the wall of the relief pocket is 175  $\mu$ m (7 mils) to the RF shield aperture. This is as expected for the Image 1 since the relief pocket increased about 64  $\mu$ m (2.5 mils) from the original starting position of 250  $\mu$ m (10 mils) from the RF shield aperture.



**Figure 7. Relief Pocket for .3 mm uBGA Image 1**

Figure 8 shows the same print sequence for Image 2, where the 0.3 mm uBGA apertures were spaced 500  $\mu$ m (20 mils) from the RF shield aperture. There is no hint of smearing for this configuration.



**Figure 8. Solder Bricks .3 mm uBGA Image 2**

### Solder Paste Volume Results

The solder paste volume measurements were performed at Speedline using a Koh Young paste volume-measuring machine. The author wished to extend a special thanks to Vatsah Shah for making the measurements.

**Table 3**  
Paste Volume Measurement Summary

#### 1<sup>st</sup> Print Stencil

Component	Number of Solder Bricks Measured
01005	406
0.3 mm pitch uBGA	2048
0.4 mm pitch uBGA	2048
0201	480

#### 2<sup>nd</sup> Print Stencil

Component	Number of Solder Bricks Measured
5 pin Connector	16
RF Shield 1	24
RF Shield 2	28

Table 3 summarizes the solder bricks measured for each component type in the 1<sup>st</sup> print stencil and the 2<sup>nd</sup> print stencil. Figures 8 through Figure 11 show a comparison of the 50  $\mu$ m (2mil) thick E-FAB stencil and the 75  $\mu$ m (3 mil) thick E-FAB stencil for total solder paste volume, % solder paste volume compared to theoretical volume of the stencil aperture, % standard deviation of the solder paste volume from the mean value, and solder paste height. It is noteworthy, as seen in Figure 9, that for the smallest component, 01005 chip components with 178  $\mu$ m (7 mil) apertures, the volume of solder paste for the 50  $\mu$ m (2 mil) thick stencil is almost as much as for the 75  $\mu$ m (3 mil) thick stencil.

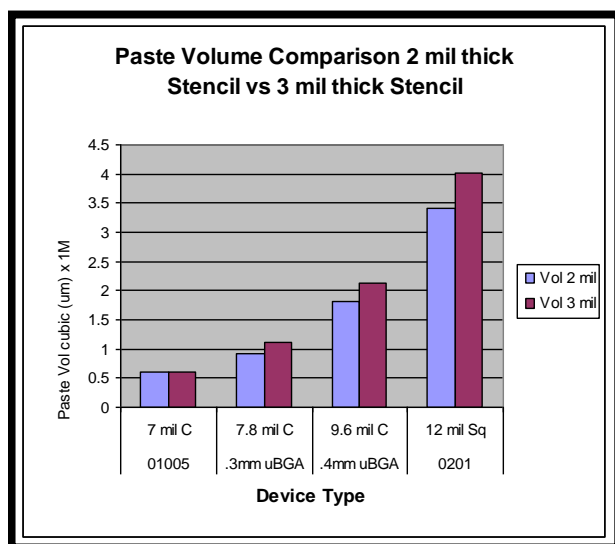


Figure 9. Paste Volume Comparison 2 vs. 3

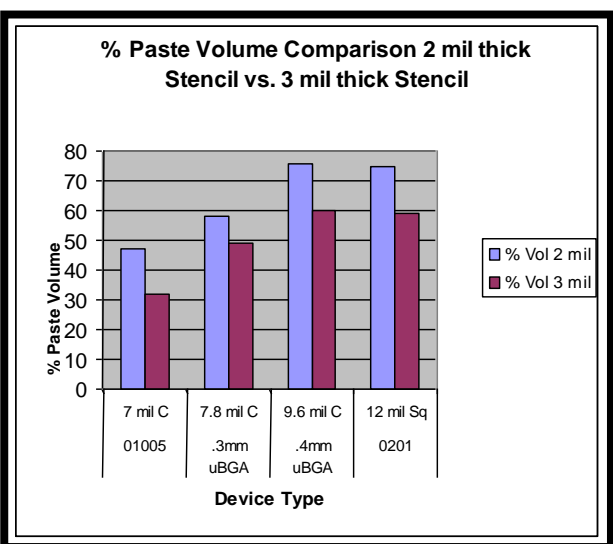


Figure 10. % Paste Volume Comparisons 2 vs. 3

Figure 10 shows that the % paste release is greater for all four components for the 50 µm (2 mil) thick stencil compared to the 75 µm (3 mil) thick stencil. As seen in Figure 11, the % standard deviation is also smaller for the 50 µm (2 mil) stencil than for the 75 µm (3 mil) stencil; especially for the 01005 chip component solder paste. Figure 12 shows the solder paste height comparison.

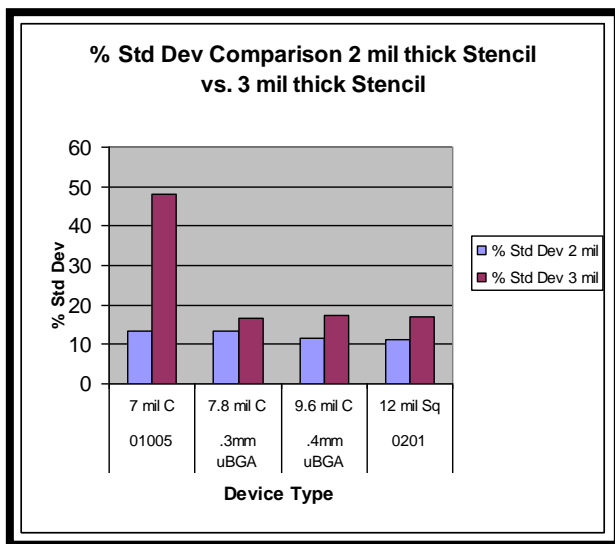


Figure 11. % Standard Deviation Comparison 2 vs. 3

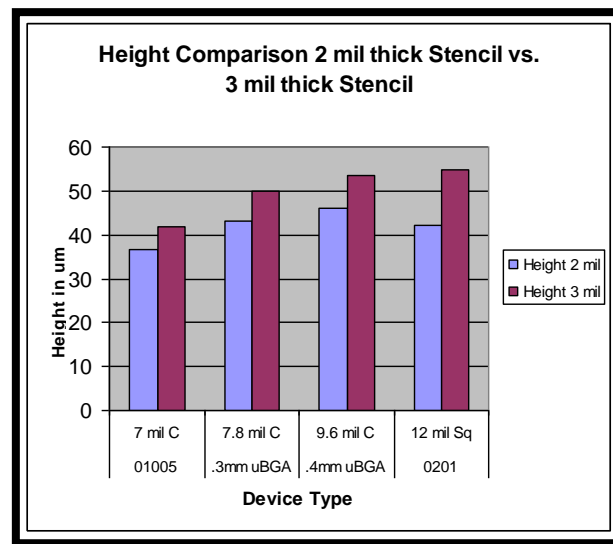


Figure 12. Paste Height Comparison 2 vs. 3

Similar solder paste volume measurements were recorded for the 175 µm (7 mil) thick stencil and the 200 µm (8 mil) thick stencil. These results are shown in Figures 13 through Figure 16.

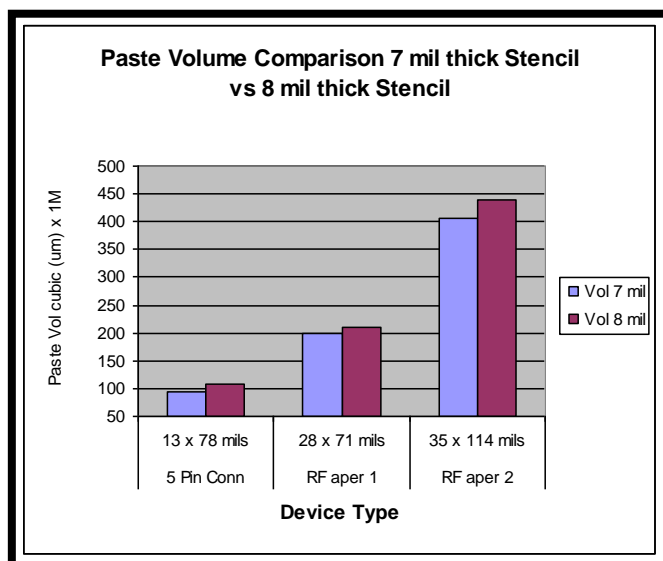


Figure 13. Paste Volume Comparison 7 vs. 8

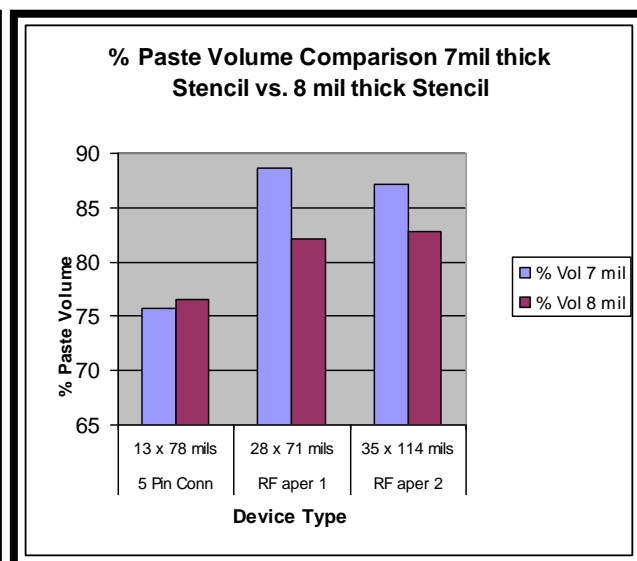


Figure 14. % Paste Volume Comparisons 7 vs. 8

As seen from Table 3, the number of data points was much smaller for these two stencils compared to the thinner stencils. As seen in Figure 14, the % standard deviation is much smaller for these larger apertures compared to the smaller apertures in the thinner stencils.

#### Additional Testing

The prior "Two-Print Stencil Process" dealt with two sets of stencils; (1) a 50 um (2mil) thick 1<sup>st</sup> print stencil used with a 175 um (7 mil) thick 2<sup>nd</sup> print stencil having a 125 um (5 mil) deep relief pocket and (2) a 75 um (3 mil) thick 1<sup>st</sup> print stencil used with a 200 um (8 mil) thick 2<sup>nd</sup> print stencil having a 150 um (6 mil) deep relief pocket. In order to establish the minimum clearance height required between the 1<sup>st</sup> print stencil and the thickness of the relief pocket of the 2<sup>nd</sup> print stencil a third set of stencils was tested. A 50 um (2 mil) thick 1<sup>st</sup> print stencil was used with a 125 um (5 mil) 2<sup>nd</sup> thick 2<sup>nd</sup> print stencil having a 75 um (3 mil) deep relief pocket. Print results for this test are shown in Figures 17 to Figures 19 for the Image 1 configuration [250 um (10 mils) spacing between apertures in the 1<sup>st</sup> and 2<sup>nd</sup> print stencils]. Figure 17 shows the position of the 0.3 mm uBGA solder paste bricks with respect to the RF shield solder paste bricks.

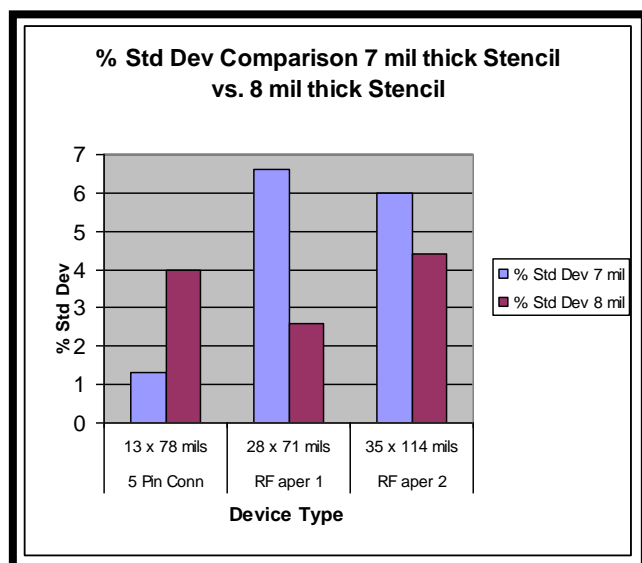


Figure 15. % Standard Deviation Comparison 7 vs. 8

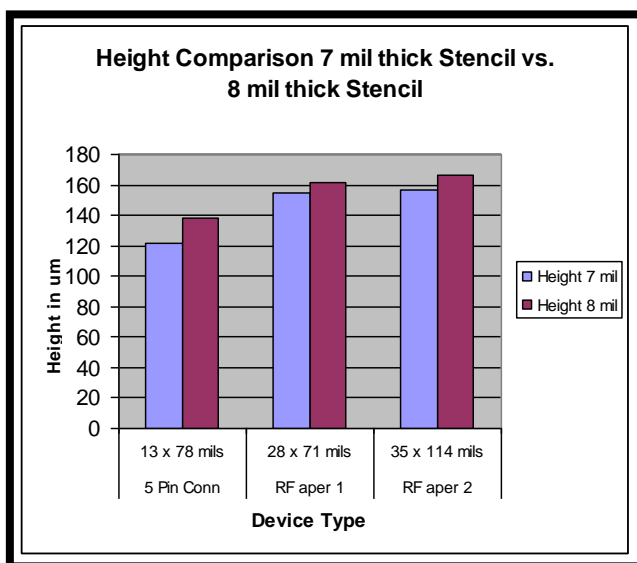
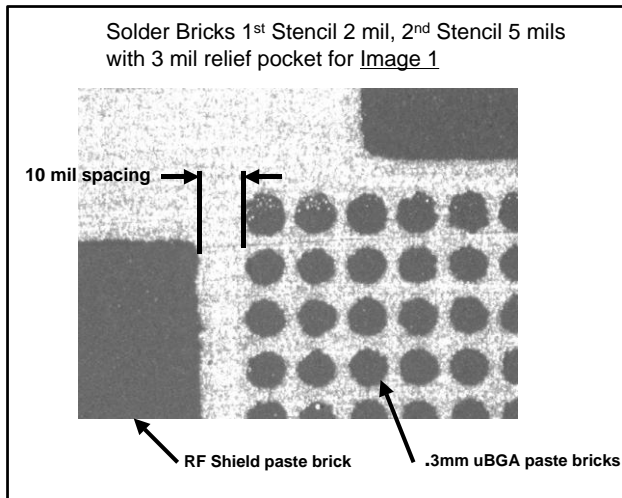
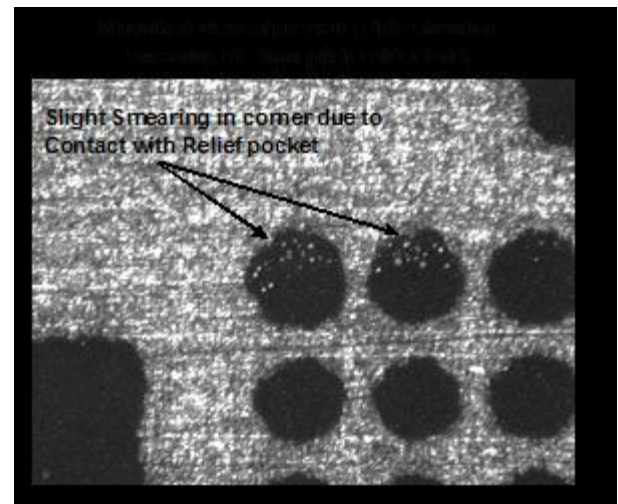


Figure 16. Paste Height Comparison 7 vs. 8



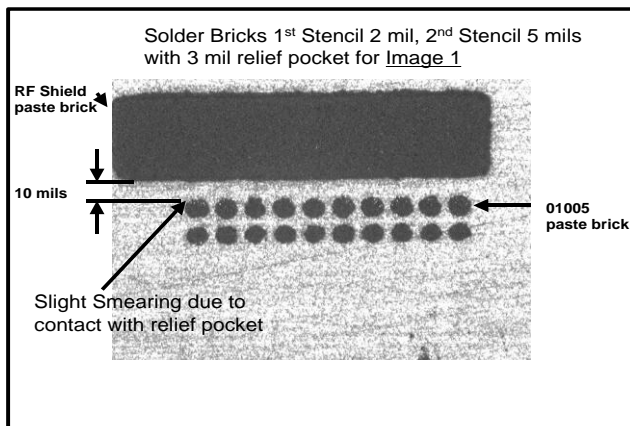


**Figure 17. .3 mm uBGA solder bricks 2 mil with 5 mil**

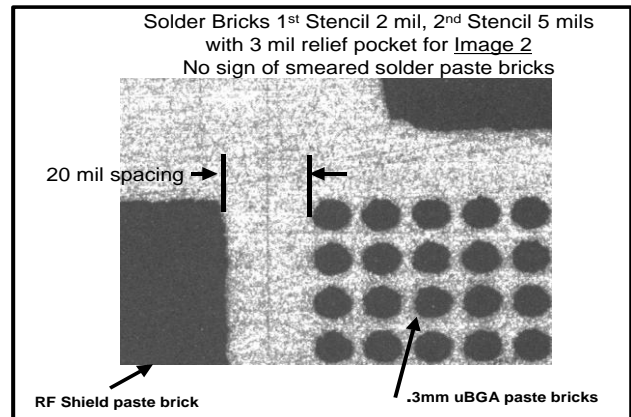


**Figure 18. Magnified view of 17 showing smearing**

Figure 18 is a close-up of the same image. This image shows slight smearing in the corner of the uBGA array caused by contact with the corner of the relief pocket. Figure 19 shows solder bricks for the 01005 chip component with respect to the RF shield solder brick. Again slight smearing is observed on the solder brick closest to the relief pocket. Figure 20 demonstrates that no smearing was observed when the spacing between apertures in the 1<sup>st</sup> stencil and 2<sup>nd</sup> stencil was increased to 500  $\mu$ m (20 mils). It can be concluded that with a spacing as low as 25  $\mu$ m (1 mil) between the 1<sup>st</sup> print stencil thickness and the depth of the relief pocket on the 2<sup>nd</sup> stencil no paste smearing occurred during the 2<sup>nd</sup> print as long as the clearance between apertures is between 250  $\mu$ m (10 mils) and 500  $\mu$ m (20 mils). Although not specifically confirmed by tests, I believe a safe keep-out spacing between apertures in the 1<sup>st</sup> print stencil and the 2<sup>nd</sup> print stencil is 380  $\mu$ m (15 mils). This is based on the fact that only the outer halves of the 0.3 mm uBGA solder brick touched the relief pocket at a spacing of 250  $\mu$ m (10 mils) as seen in Figure 18.



**Figure 19. 01005 solder bricks, slight smearing**



**Figure 20. 0.3mm uBGA solder bricks with 20 mil spacing**

## Conclusion

It has been demonstrated that “A Two-Print Stencil Process” is an effective solution to print solder paste when different paste heights are required. The spacing between apertures requiring different heights can be as small as 380  $\mu$ m (15 mils). It has also been demonstrated that the depth of the relief pocket in the 2<sup>nd</sup> print stencil can be as low as 25  $\mu$ m (1 mil) more than the thickness of the 1<sup>st</sup> print stencil. It should also be noted that aperture spacing between apertures in the 1<sup>st</sup> and 2<sup>nd</sup> print stencil is independent of the thickness of the 2<sup>nd</sup> print stencil. This is very useful when very thick paste heights are required from the 2<sup>nd</sup> print stencil. The “Two-Print Stencil Process” offers a new solution to cell phone and hand-held SMT assemblers. Thick solder paste for RF shields can be printed very close to solder paste bricks for very small devices like 0.3 mm uBGA and 01005 chip components. A design decision must be made as to which apertures are to be included in the 1<sup>st</sup> print stencil and which apertures are to be included in the 2<sup>nd</sup> print stencil. As a secondary outcome of this testing it is seen, for the particular print set-up, the standard deviation of the 50  $\mu$ m (2 mil) thick 1<sup>st</sup> print stencil is significantly lower than the thicker 75  $\mu$ m (3 mil) 1<sup>st</sup> print stencil. It is also observed that generally, the standard deviation for the 1<sup>st</sup> print stencils is lower for the larger apertures and the thinner stencil.

## **Design Guidelines**

General design guidelines are shown in Table 3.

## **Future Work**

The work presented here had relief pockets positioned in close proximity to apertures in the 1<sup>st</sup> and 2<sup>nd</sup> print stencils. The relief pockets encompassed the entire area of the device printed in the 1<sup>st</sup> print stencil. The largest relief pocket was 6.8 mm x 6.8 mm (0.270" x 0.270"). There was no support issue regarding the 2<sup>nd</sup> print stencil flexing down to touching solder bricks printed by the 1<sup>st</sup> stencil, even when there was only 25 um (1 mil) clearance.

As a future project it should be determined how large the relief pocket could be designed without flexing to touch 1<sup>st</sup> print solder bricks. The future project should also address the size and spacing of support pillars between apertures when the 1<sup>st</sup> print stencil has a high density of apertures.

## **Acknowledgements**

The author would like to extend his appreciation and thanks of Vatsal Shah of Speedline for his contribution in measuring the solder paste volume.

## **References**

(1) William Coleman and Michael Burgess "Step Stencils", Global SMT and Packaging, October 2006

# **Step Stencil Design When 01005 and .3mm Pitch uBGA's Coexist With RF Shields**

**William E. Coleman Ph.D.  
Photo Stencil**

## **Problem:**

- 01005 chip components with 150 - 175 micron apertures and .3mm pitch uBGA's with 150 - 200 micron apertures require thin stencils for good paste transfer.
- RF Shields and Surface Mount Connectors require thicker paste deposits to eliminate opens due to potential coplanarity issues with these components.

## **Solutions:**

- Step Stencil
- Two Print Step Stencil
- Others

### **Step Stencil:**

- Normal design guide is 35 mils (880um) of keep-out for every 1 mil (25um) of step-up or step-down.
- This amount of real-estate is not normally available for cell phones and other hand-held devices.

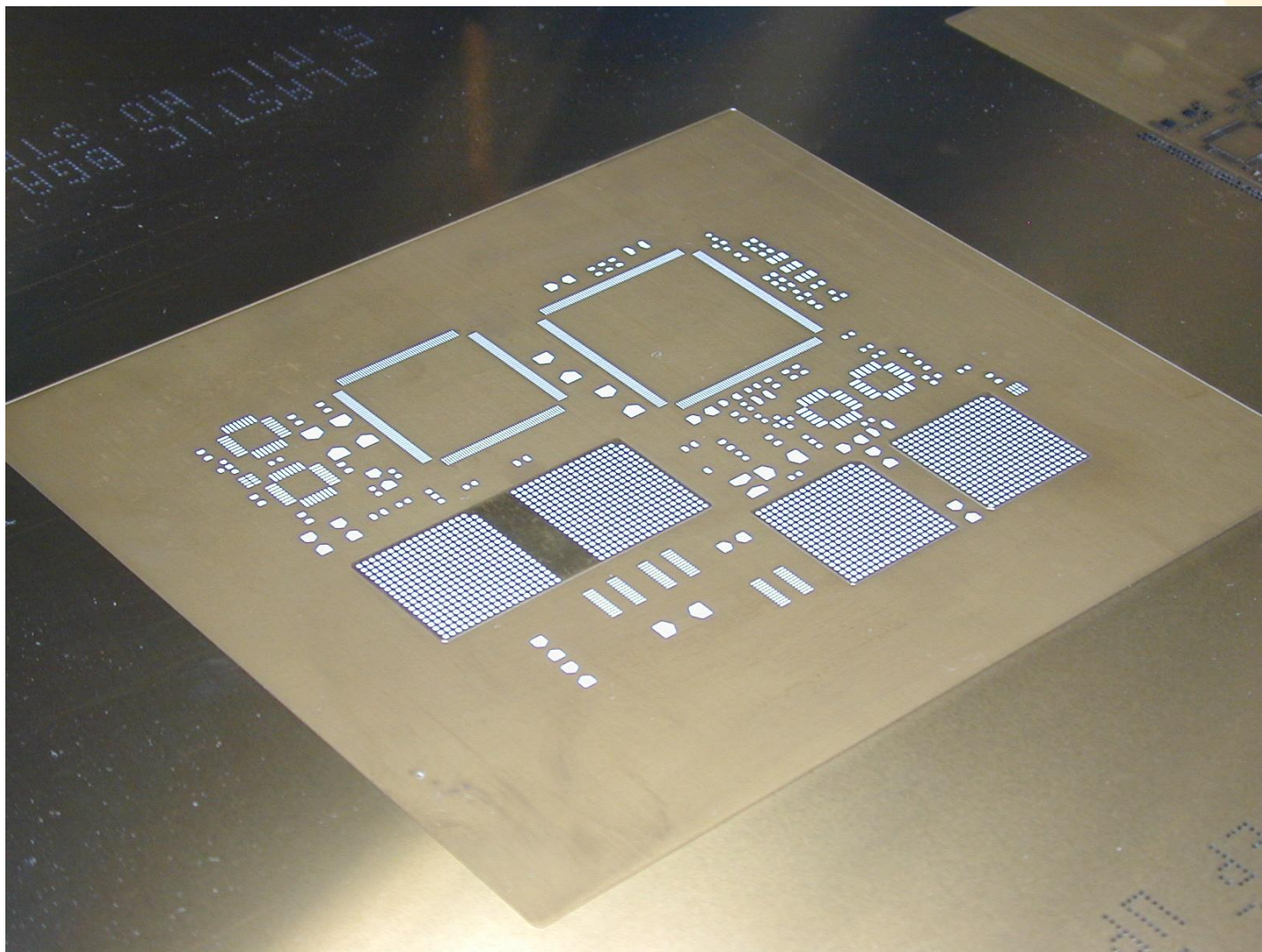
### **Two-Print Stencil:**

- Requires two inline printers.
- +Allows optimization of printing for small devices independent of devices requiring taller paste heights.
- + Small devices can be positioned close to RF Shields.

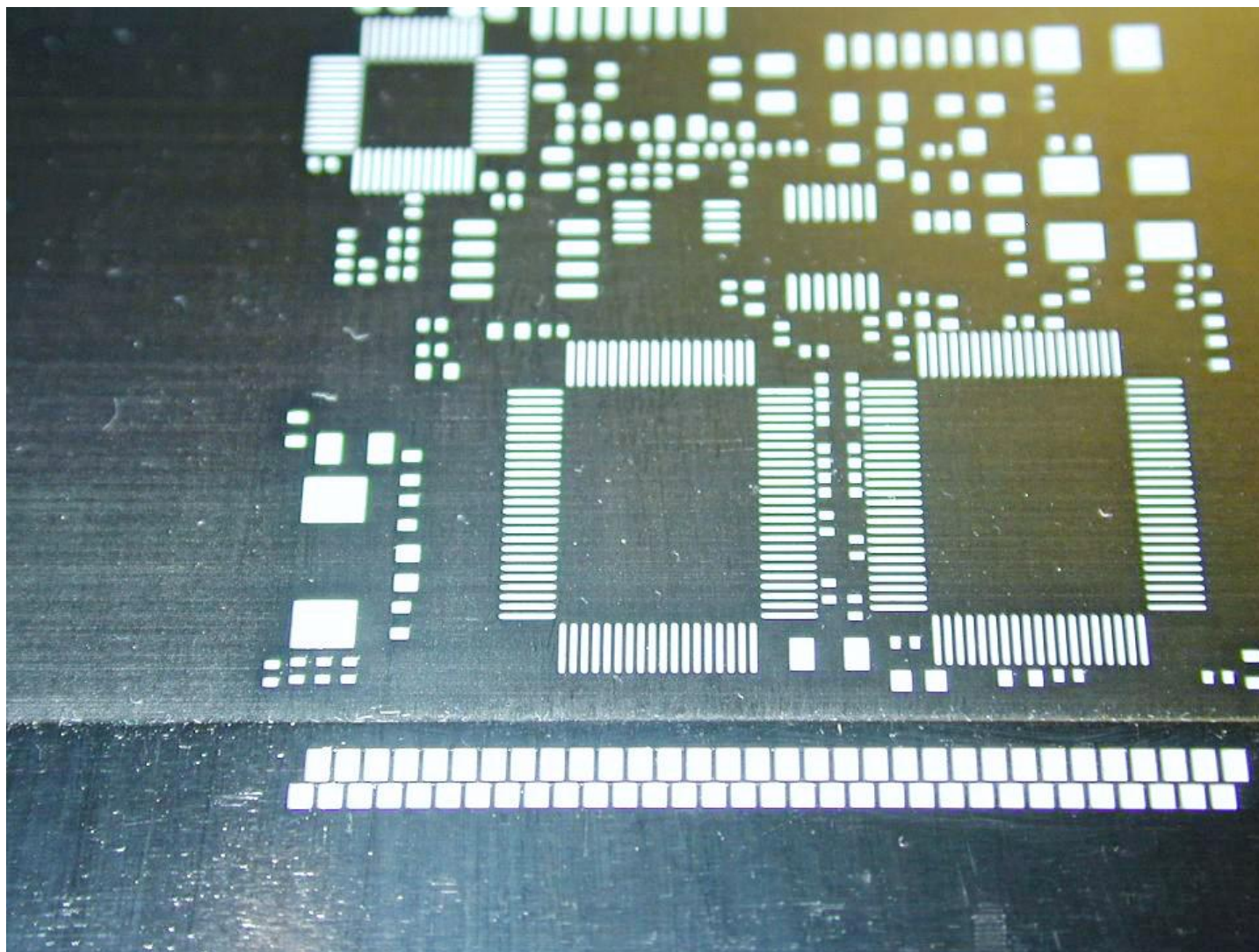


## **Example Step-Up Stencil**

Requires 35 mils keep-out per 1 mil of step



## Example Step-Down Stencil

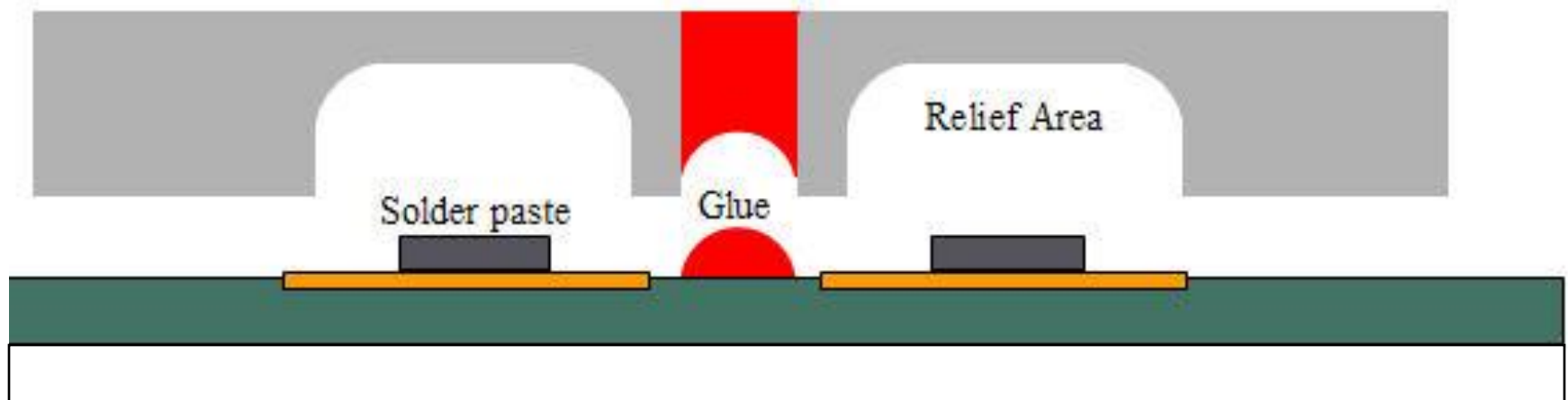


← 6 mils  
thick

← 8 mils  
thick

## Example 2<sup>nd</sup> Print Stencil of a Two-Print Stencil

Glue Print Application where solder paste is printed  
1<sup>st</sup> and glue 2<sup>nd</sup>





## Two-Print Stencil Definition:

**1<sup>st</sup> Stencil** - thin stencil prints solder paste for small components

**2<sup>nd</sup> Stencil** - thick stencil prints solder paste for RF Shields, connectors or other devices which require more solder volume. This stencil has relief pockets anywhere that the 1<sup>st</sup> stencil printed solder paste.

## Two-Print Stencil Test Plan

1<sup>st</sup> Stencil prints paste for 01005, .3mm uBGA's  
.4mm uBGA's and 0201's.

Two 1<sup>st</sup> Print Stencils:

2 mil (50u) and 3 mil (75u) thick

2<sup>nd</sup> Stencil prints paste for RF Shields.

Four 2<sup>nd</sup> Print Stencils:

- 8 mil thick 6 mil relief pocket
- 7 mil thick 5 mil relief pocket
- 6 mil thick 4 mil relief pocket
- 5 mil thick 3 mil relief pocket

## **Design of the Relief Pocket for the 2<sup>nd</sup> Stencil**

4-up images in the stencil

- 1<sup>st</sup> image design

apertures in 1<sup>st</sup> image 10 mils (250u) from RF shield aperture

- 2<sup>nd</sup> image design

apertures in 2<sup>st</sup> image 20 mils (500u) from RF shield aperture

- 3<sup>rd</sup> image design

apertures in 3<sup>rd</sup> image 30 mils (750u) from RF shield aperture

- 4<sup>th</sup> image design

apertures in 4<sup>th</sup> image 40 mils (1000u) from RF shield aperture

Schematic for Relief Pocket Design shown in next slide

## 2<sup>nd</sup> Print Stencil showing apertures and Relief Pockets

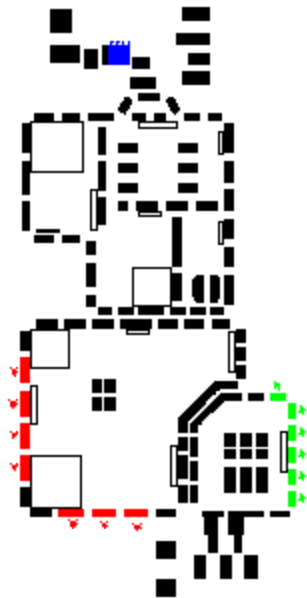
2959001J  
APEX 09 - 8MIL TEST



Image A  
13.78x78.74

Image B  
35.43x114.17

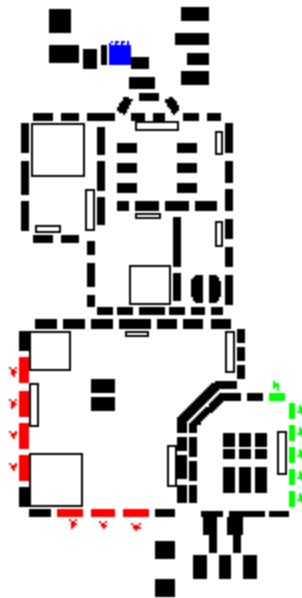
Image C  
27.56x70.87



Apertures 10 mil  
distance from  
RF shield

0 MIL SWELL

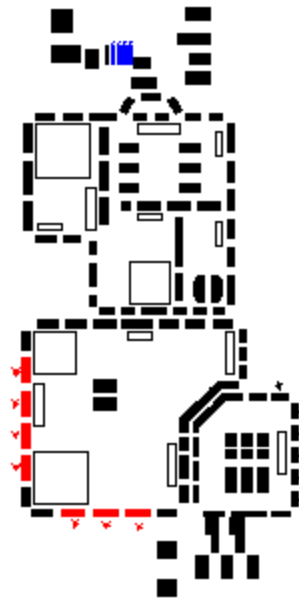
Image 1



Apertures 20 mil  
distance from  
RF shield

7 MIL SWELL

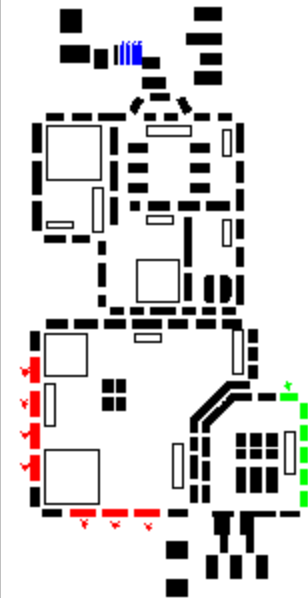
Image 2



Apertures 30 mil  
distance from  
RF shield

12 MIL SWELL

Image 3



Apertures 40 mil  
distance from  
RF shield

17 MIL SWELL

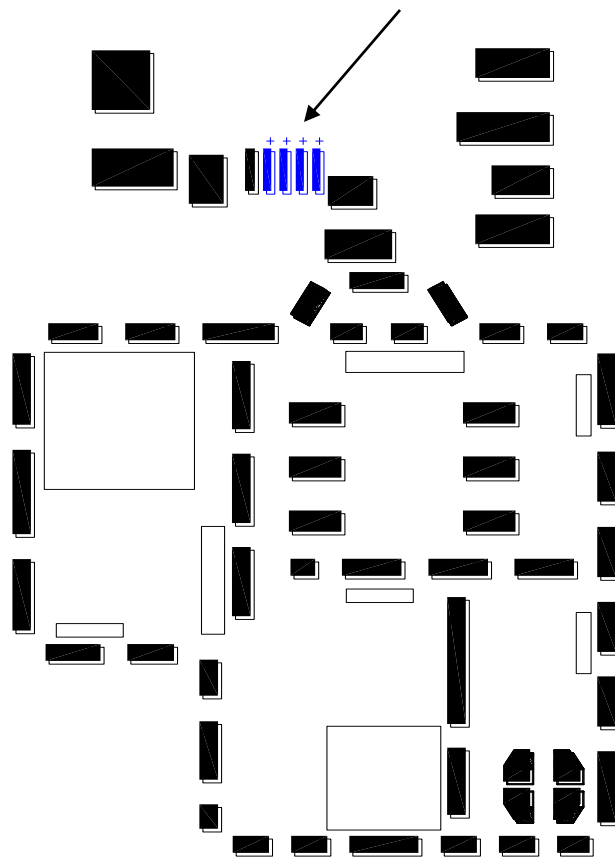
Image 4

(3) FIDS CIRCLED CONTACT SIDE  
2 MIL RELIEF ETCH CONTACT SIDE

## Top portion of 2<sup>nd</sup> Print Stencil showing apertures and relief pockets

Image A

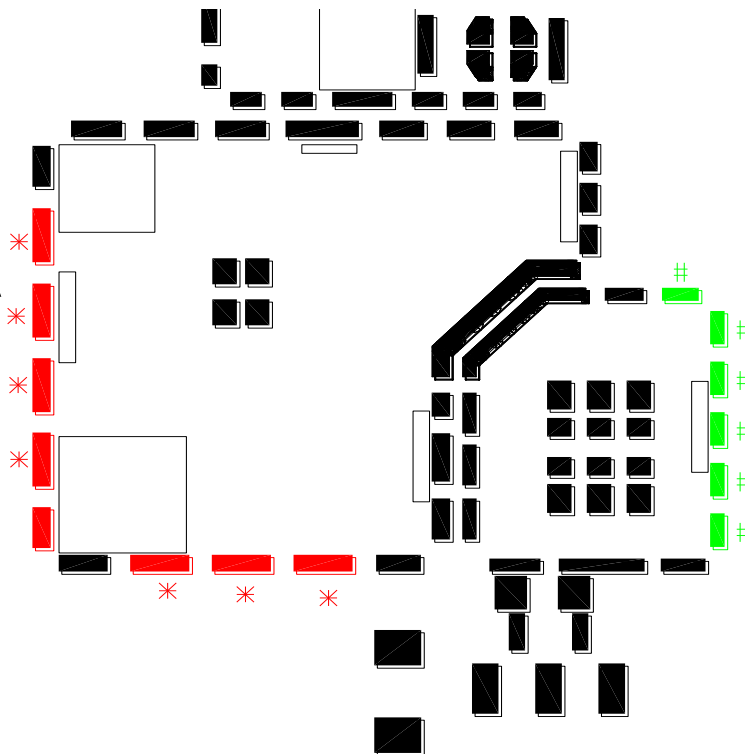
+13.78×78.74



## Bottom portion of 2<sup>nd</sup> Print Stencil showing apertures and relief pockets

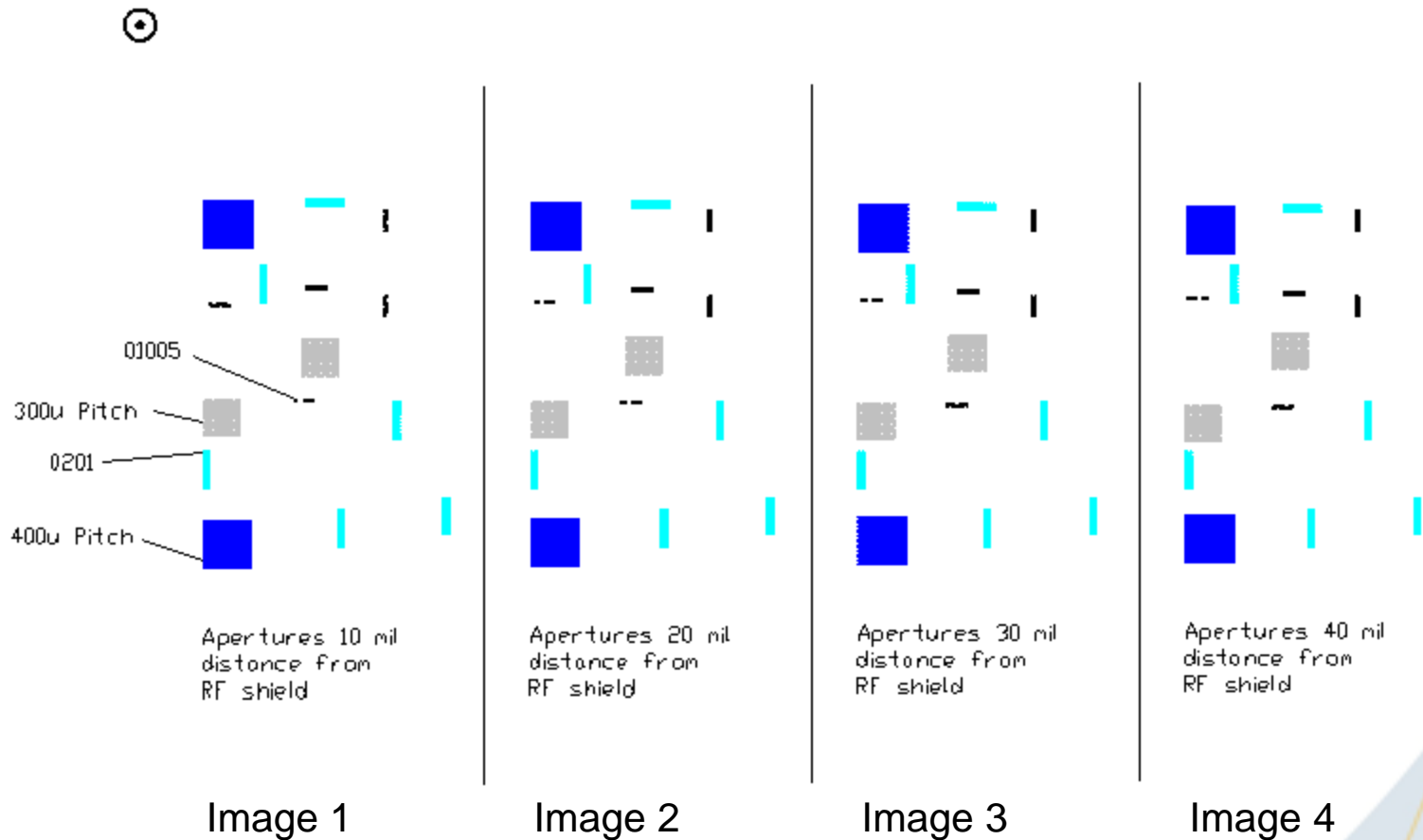
Image B

\*35.43×114.17

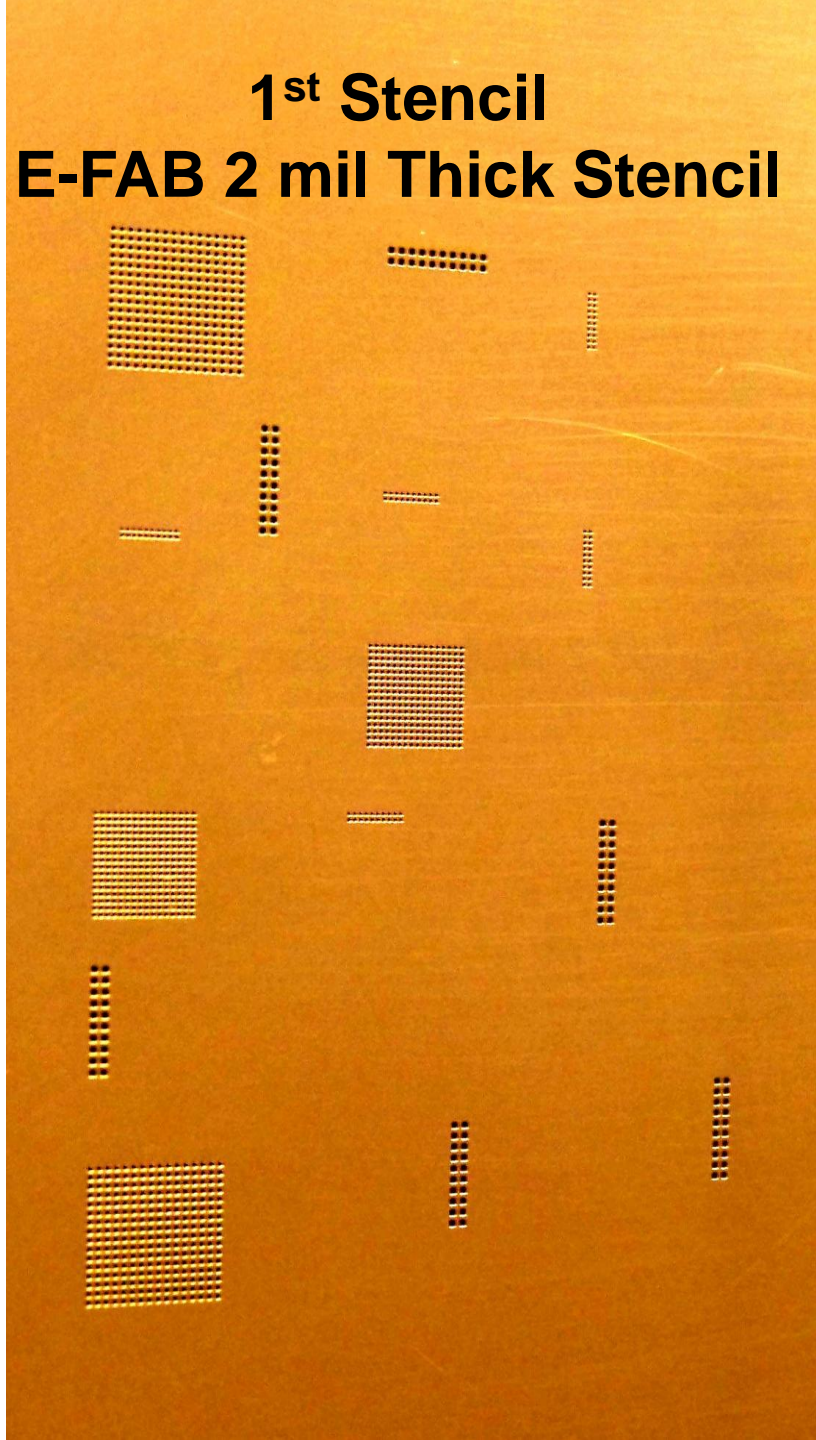


# 1<sup>st</sup> Print Stencil showing aperture sizes and aperture position

2958981A  
APEX 09 - 3MIL TEST

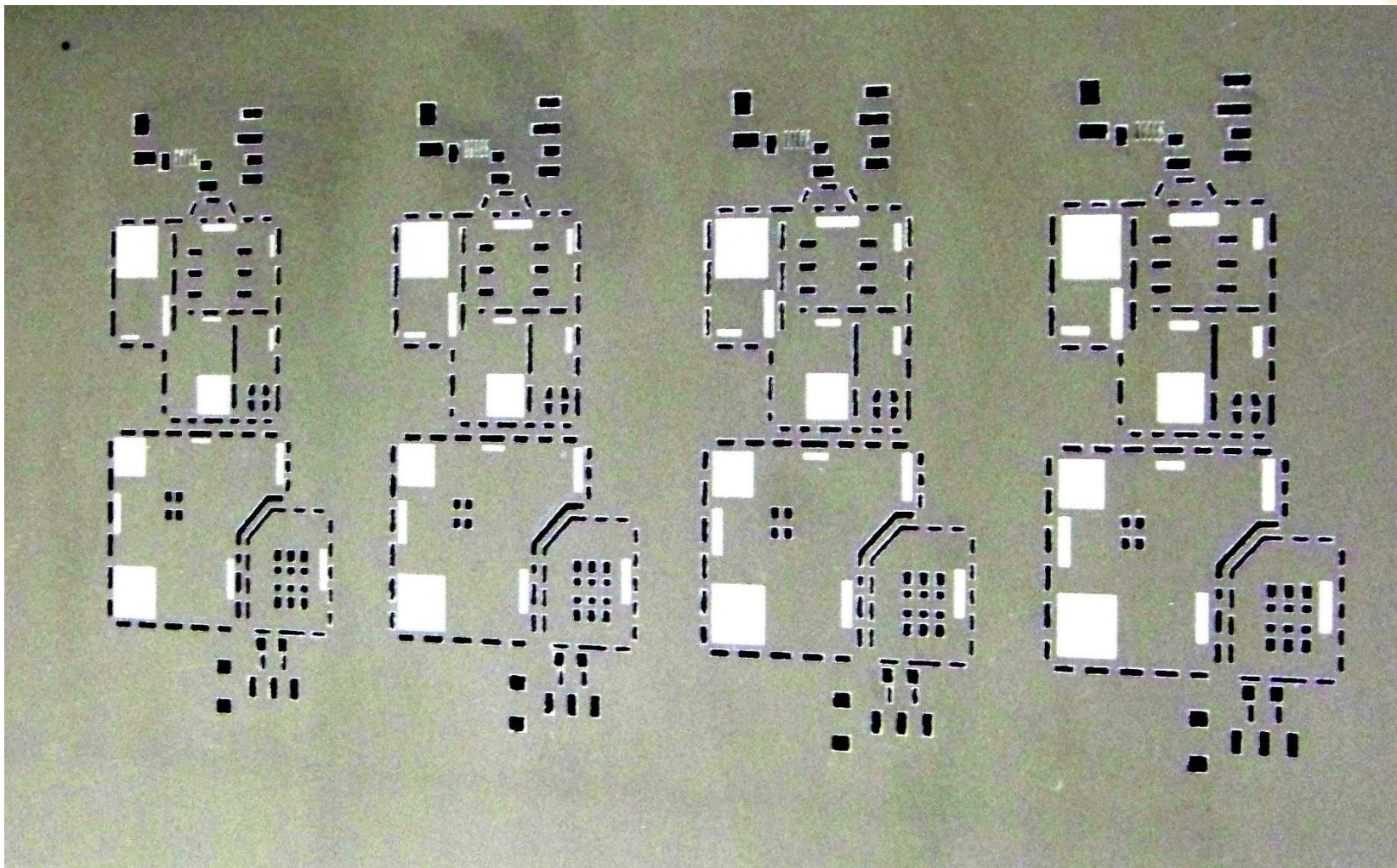


# 1<sup>st</sup> Stencil E-FAB 2 mil Thick Stencil



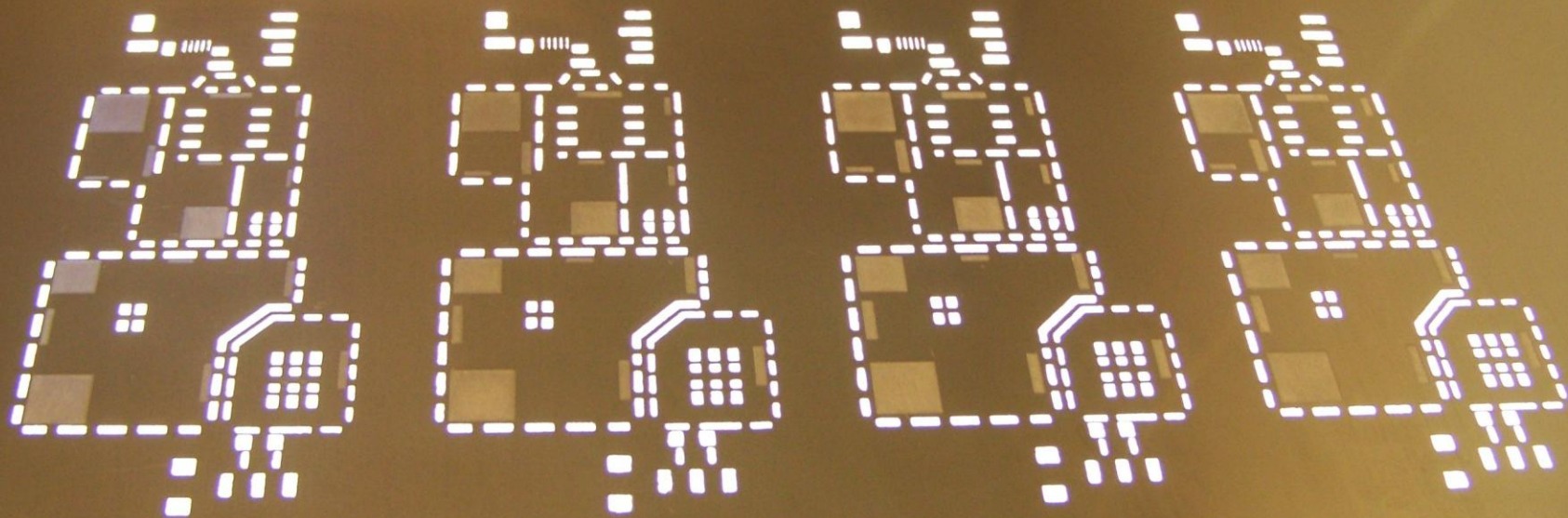


## **2<sup>nd</sup> Stencil - Laser-Cut / Chem-Etch** **7 mil thick with 5 mil relief pockets**





## **2<sup>nd</sup> Stencil - Laser-Cut / Chem-Etch 7 mil thick with 5 mil relief pockets**



## Printer Set-UP

Printer:	Speedline Momentum
Squeegee:	E-Blade (Electroformed blade)
Board:	Blank Copper Clad FR4 with Fids
Print Speed:	1 inch/sec
Print Pressure:	11lbs
Paste:	Type 5 Heraeus BD72SAC 305
Sequence:	Print 1 <sup>st</sup> Stencil and immediately print 2 <sup>nd</sup> Stencil while paste is still wet

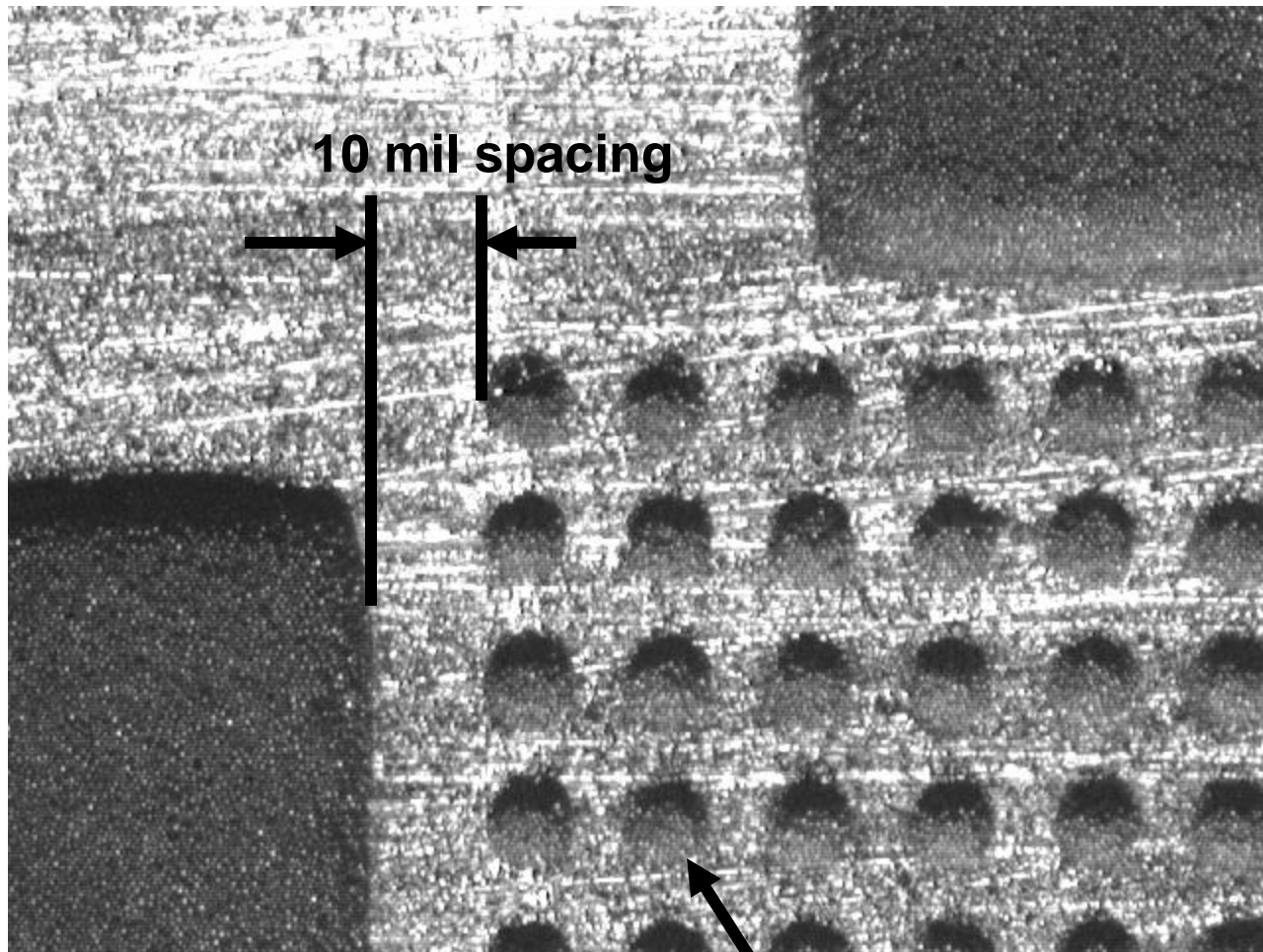
## **Stencil Printing Test Procedure (3 print tests)**

1<sup>st</sup> Print (2 mil stencil) then 2<sup>nd</sup> Print (7 mil stencil)

1<sup>st</sup> Print (3 mil stencil) then 2<sup>nd</sup> Print (8 mil stencil)

1<sup>st</sup> Print (2 mil stencil) then 2<sup>nd</sup> Print (5 mil Stencil)

**Solder Bricks 1<sup>st</sup> Stencil 2 mil, 2<sup>nd</sup> Stencil 7 mils  
with 5 mil relief pocket for Image 1**

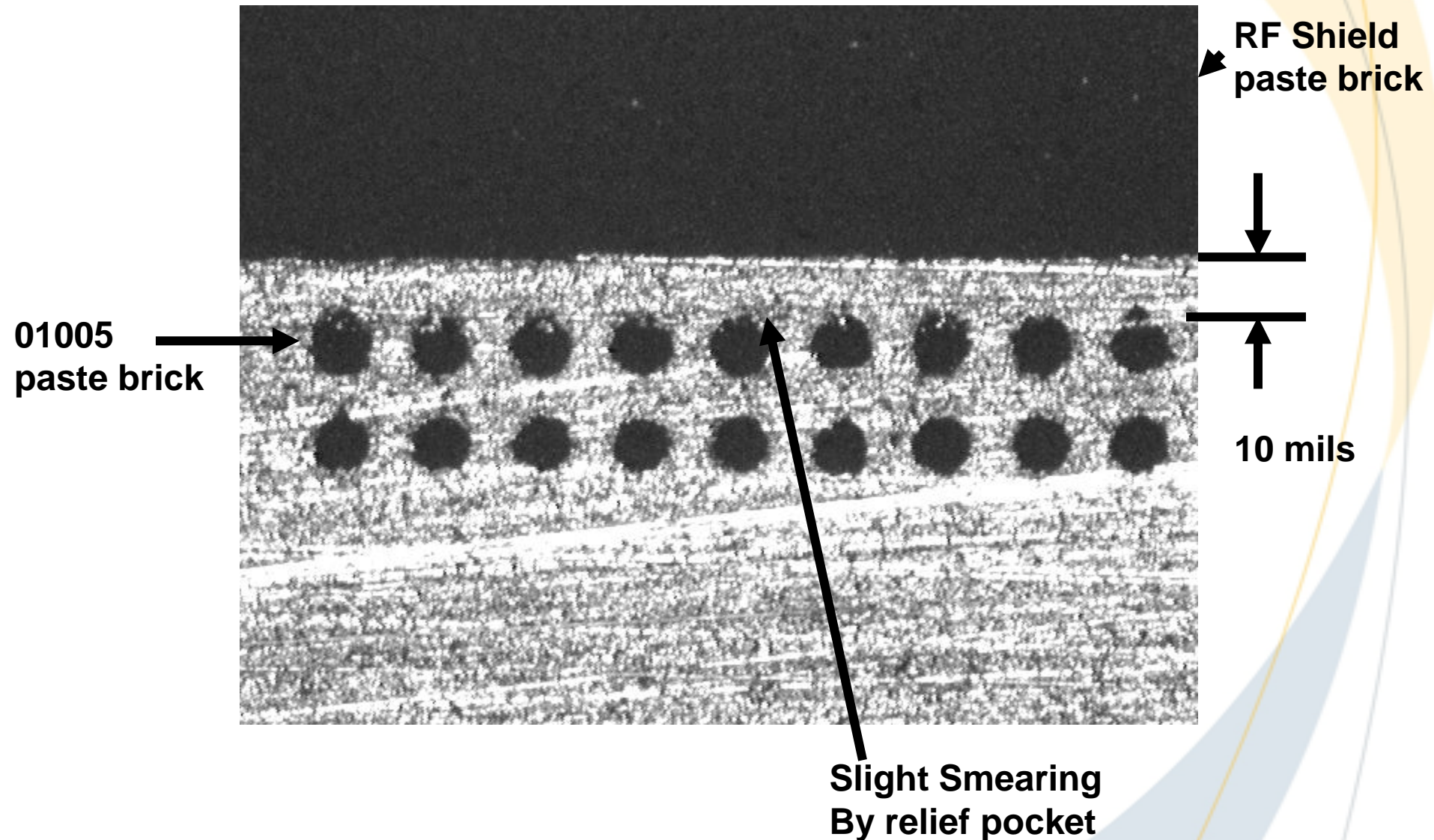


RF Shield paste brick

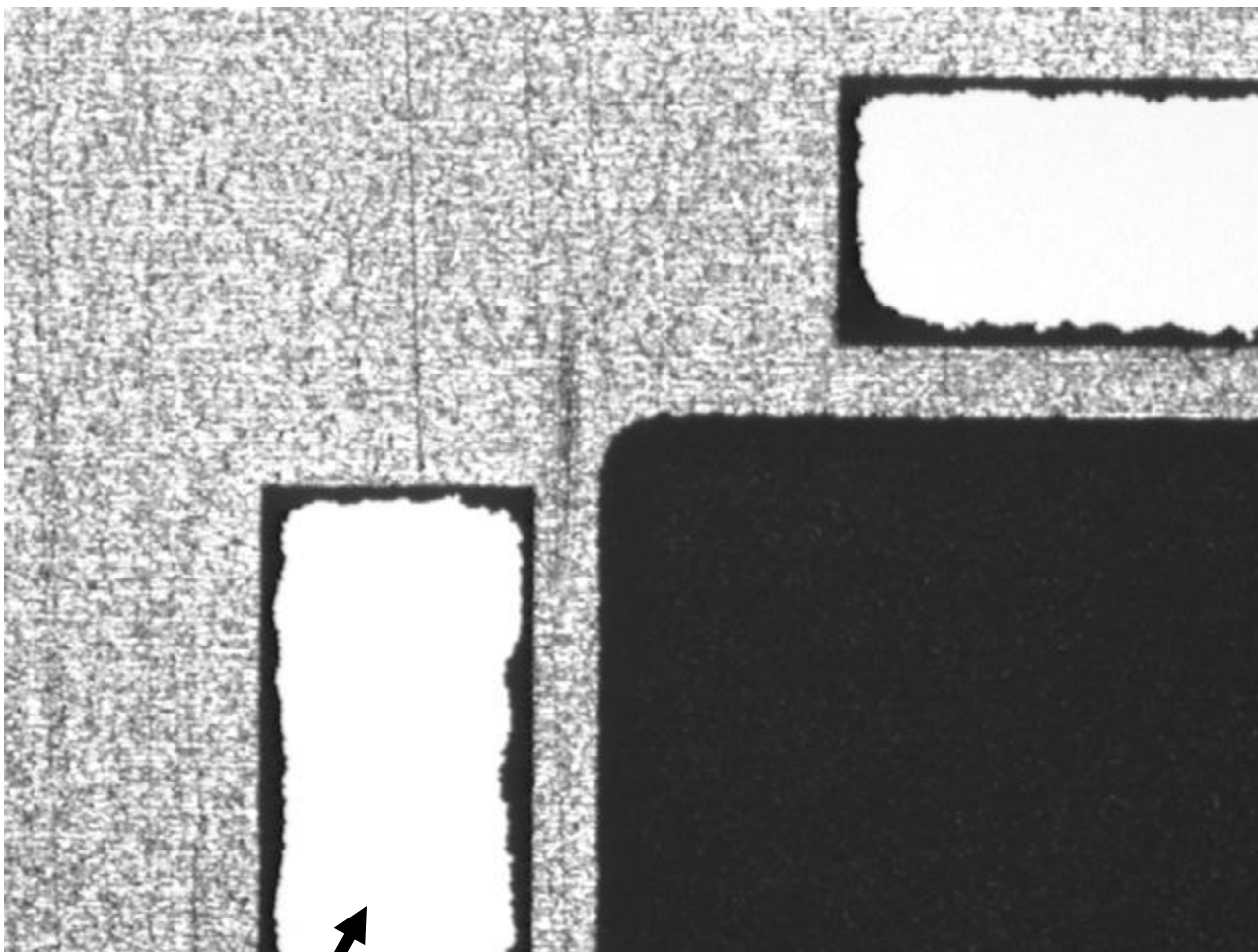
.3mm uBGA paste bricks



# Solder Bricks 1<sup>st</sup> Stencil 2 mil, 2<sup>nd</sup> Stencil 7 mils with 5 mil relief pocket for Image 1



## 2<sup>nd</sup> Stencil- 7 mil thick 5 mil deep relief pocket for .3mm pitch uBGA Image 1

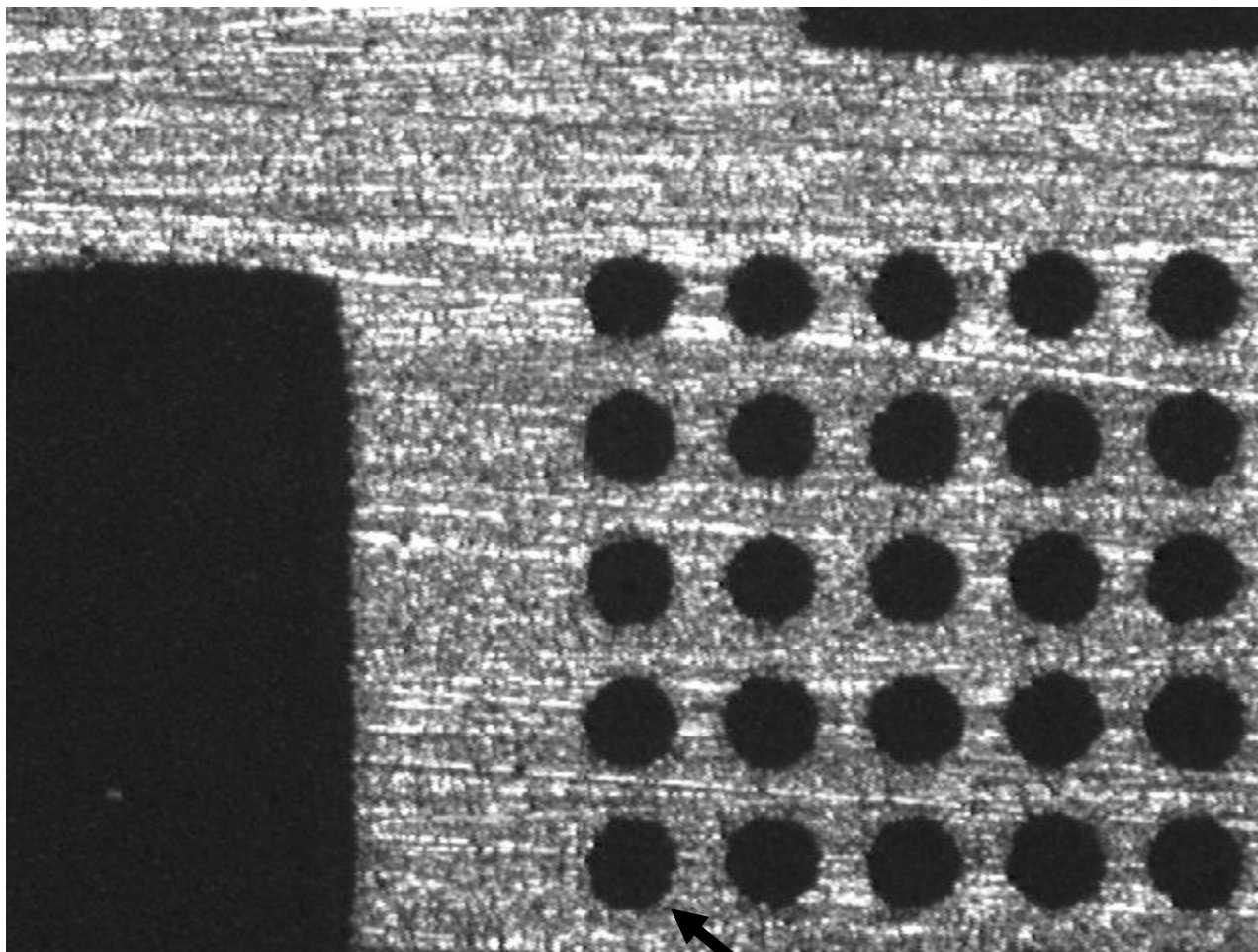


RF Shield Aperture

7 mils

Relief Pocket 5 mil deep

# Solder Bricks 1<sup>st</sup> Stencil 2 mil, 2<sup>nd</sup> Stencil 7 mils with 5 mil relief pocket for Image 2



RF Shield  
paste brick

20 mils

.3mm uBGA paste bricks



## Paste Volume Results

Paste Volume measured by Koh Young instrument

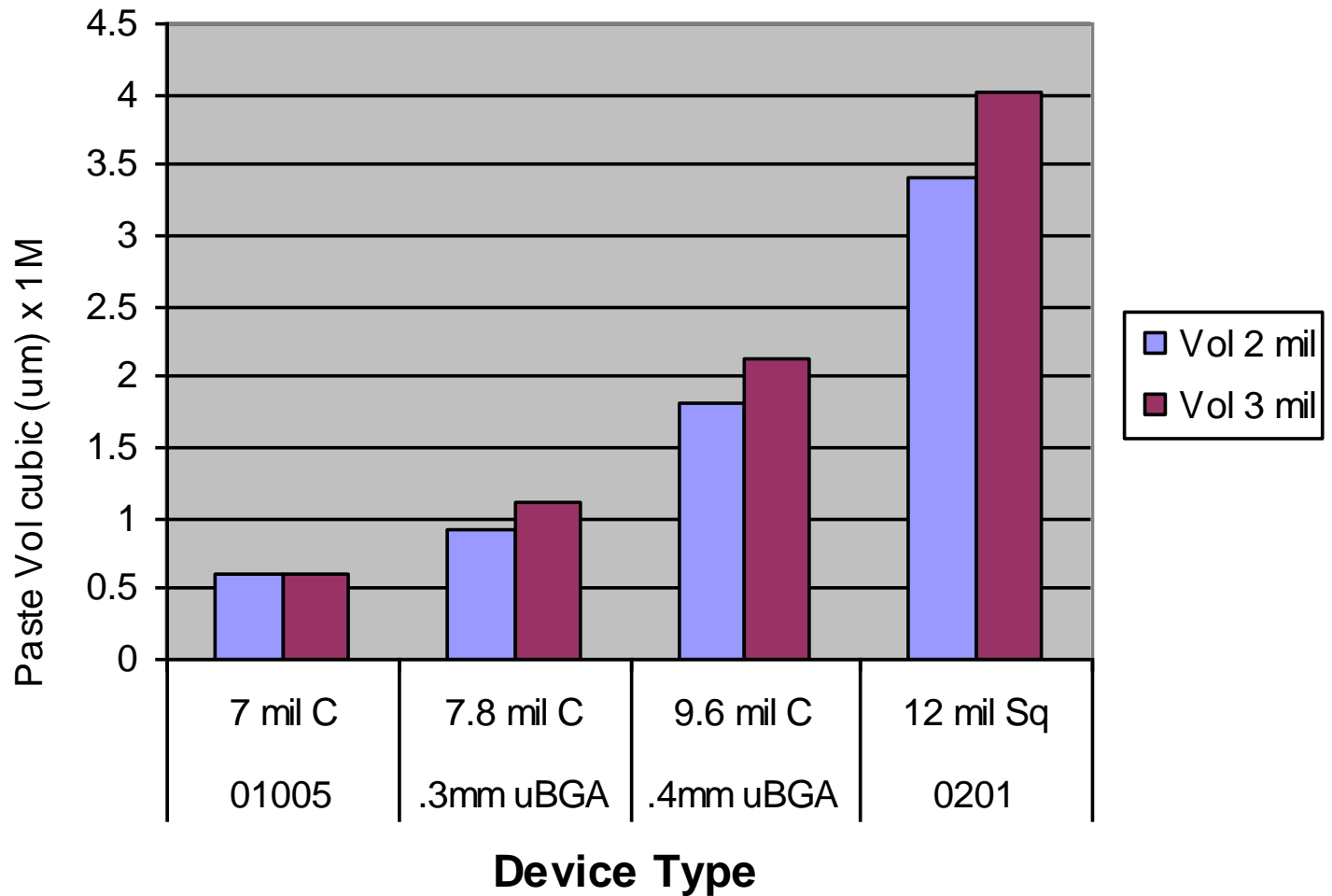
### 1<sup>st</sup> Print Stencil

<u>Component</u>	<u># of Bricks measured</u>
01005	406
.3 mm pitch uBGA	2048
.4 mm pitch uBGA	2048
0201	480

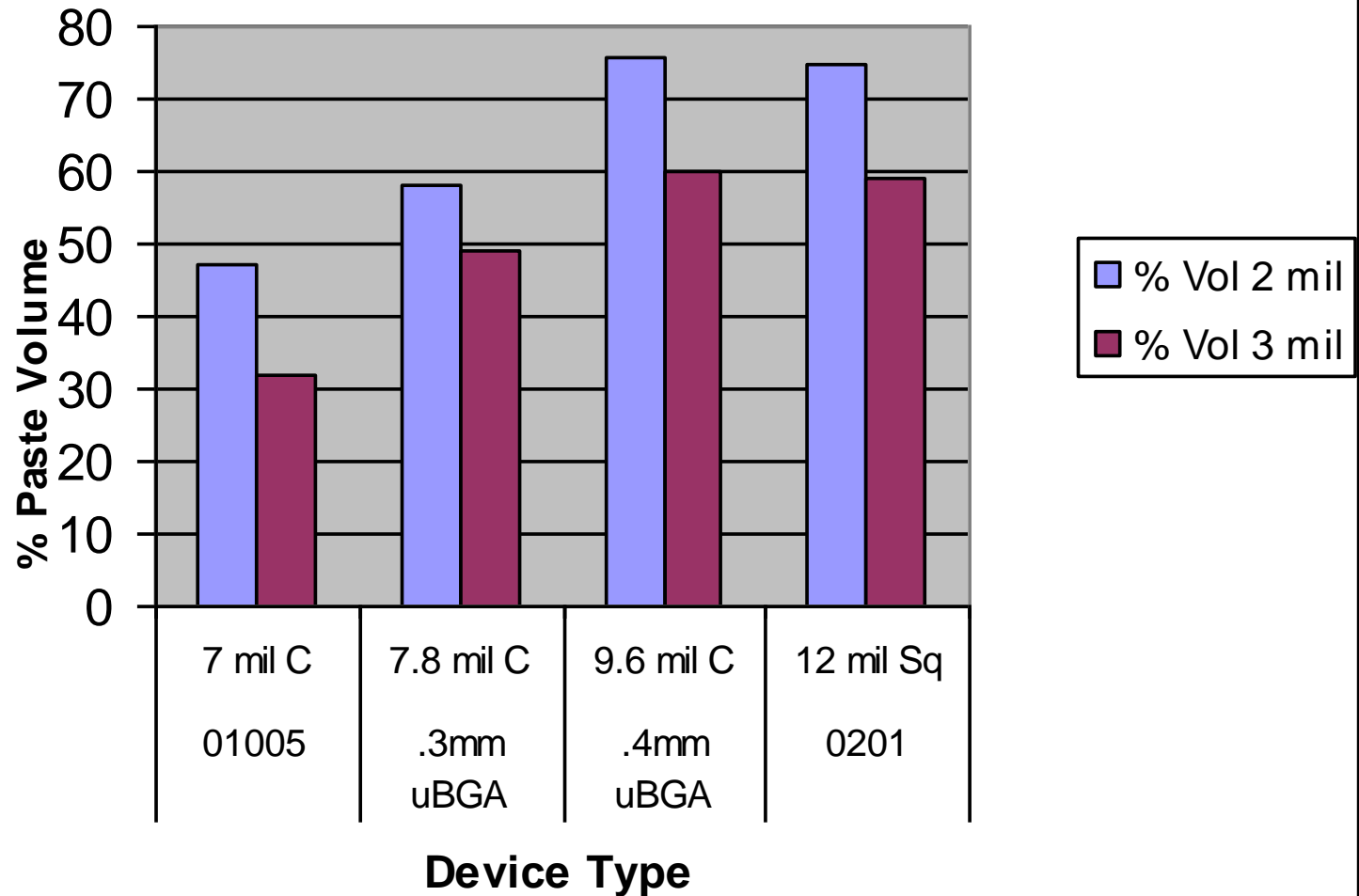
### 2<sup>nd</sup> Print Stencil

<u>Component</u>	<u># of Bricks measured</u>
5 pin Connector	16
RF aperture 1	24
RF aperture 2	28

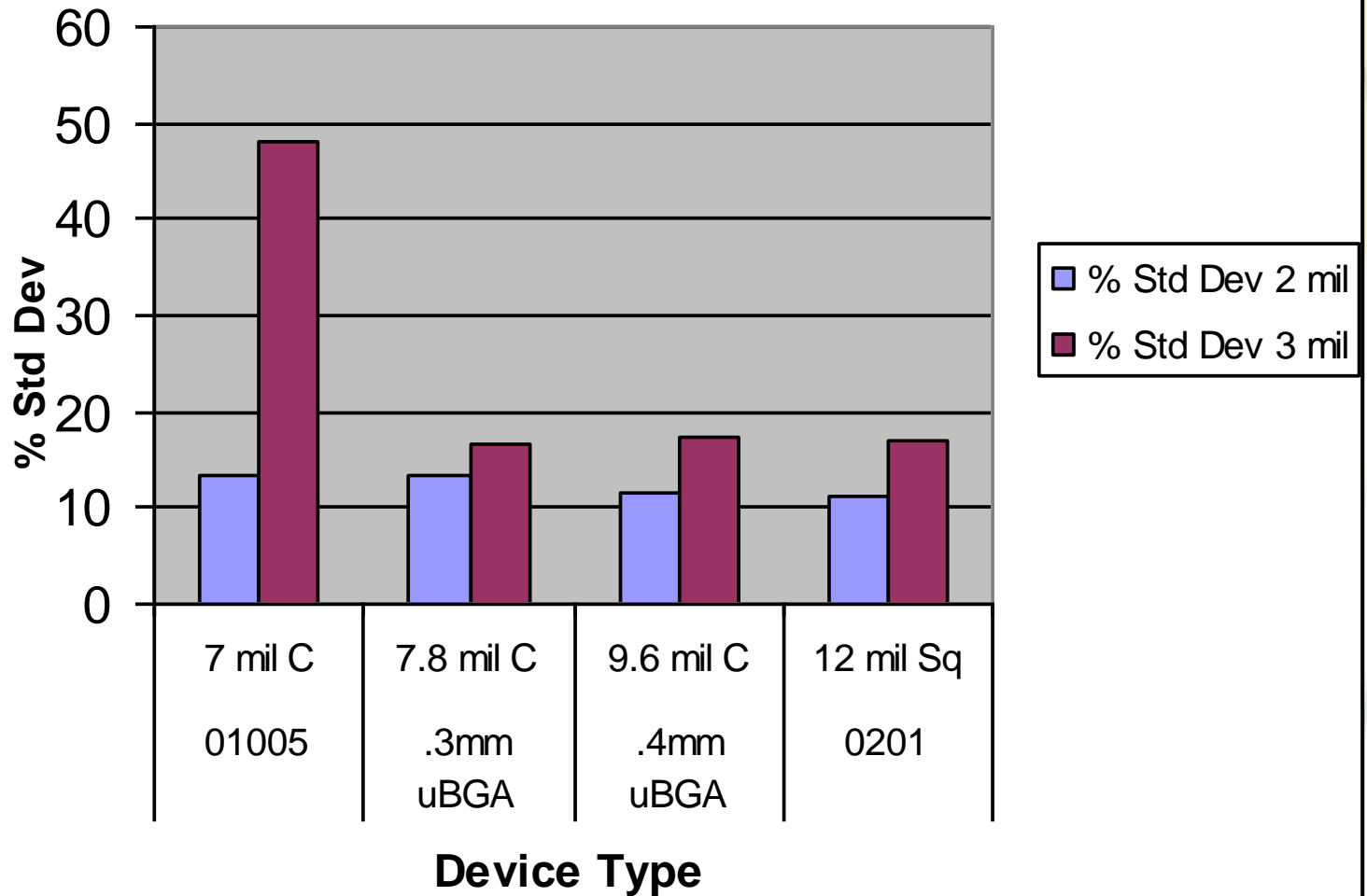
## Paste Volume Comparison 2 mil thick Stencil vs 3 mil thick Stencil



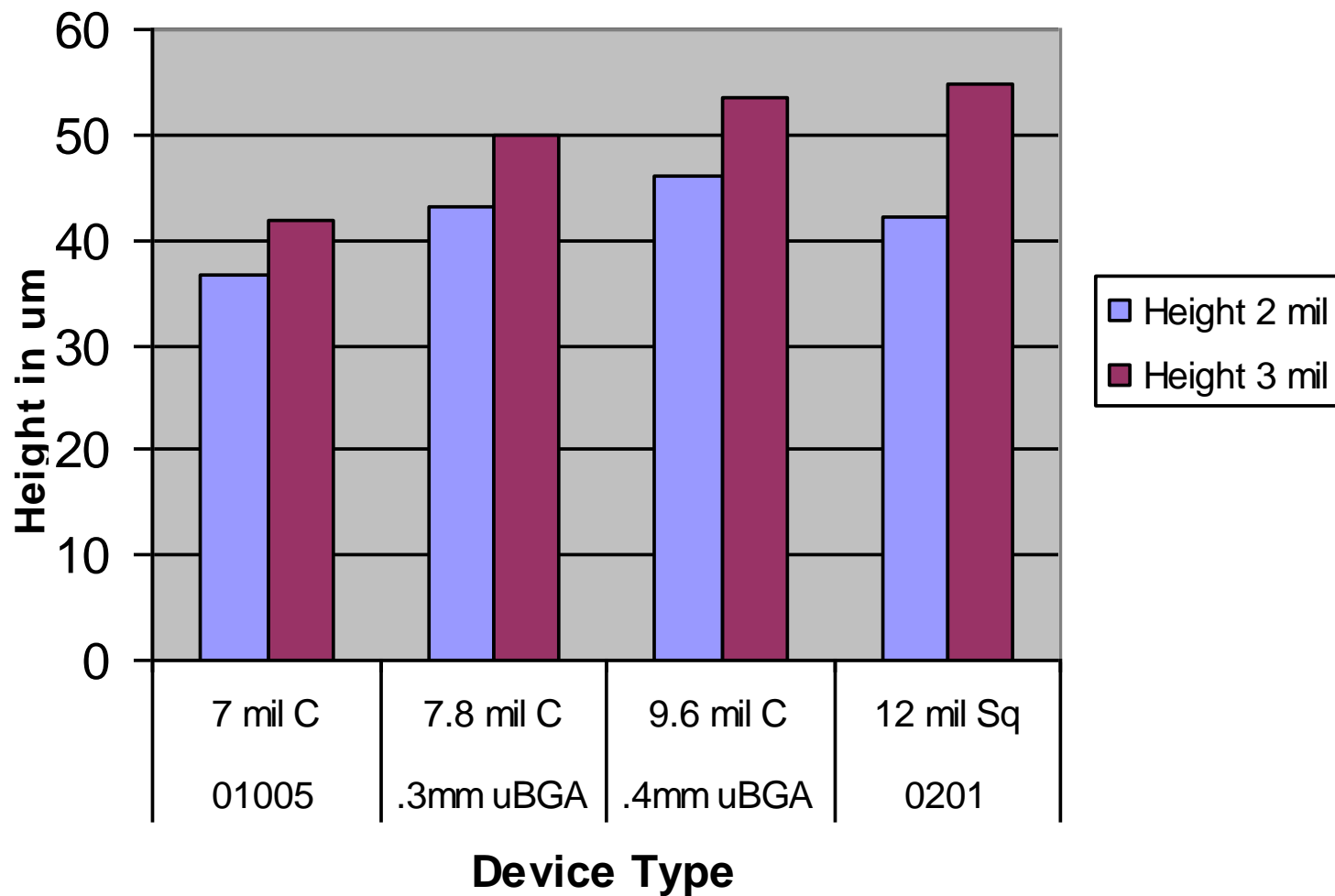
## % Paste Volume Comparison 2 mil thick Stencil vs. 3 mil thick Stencil



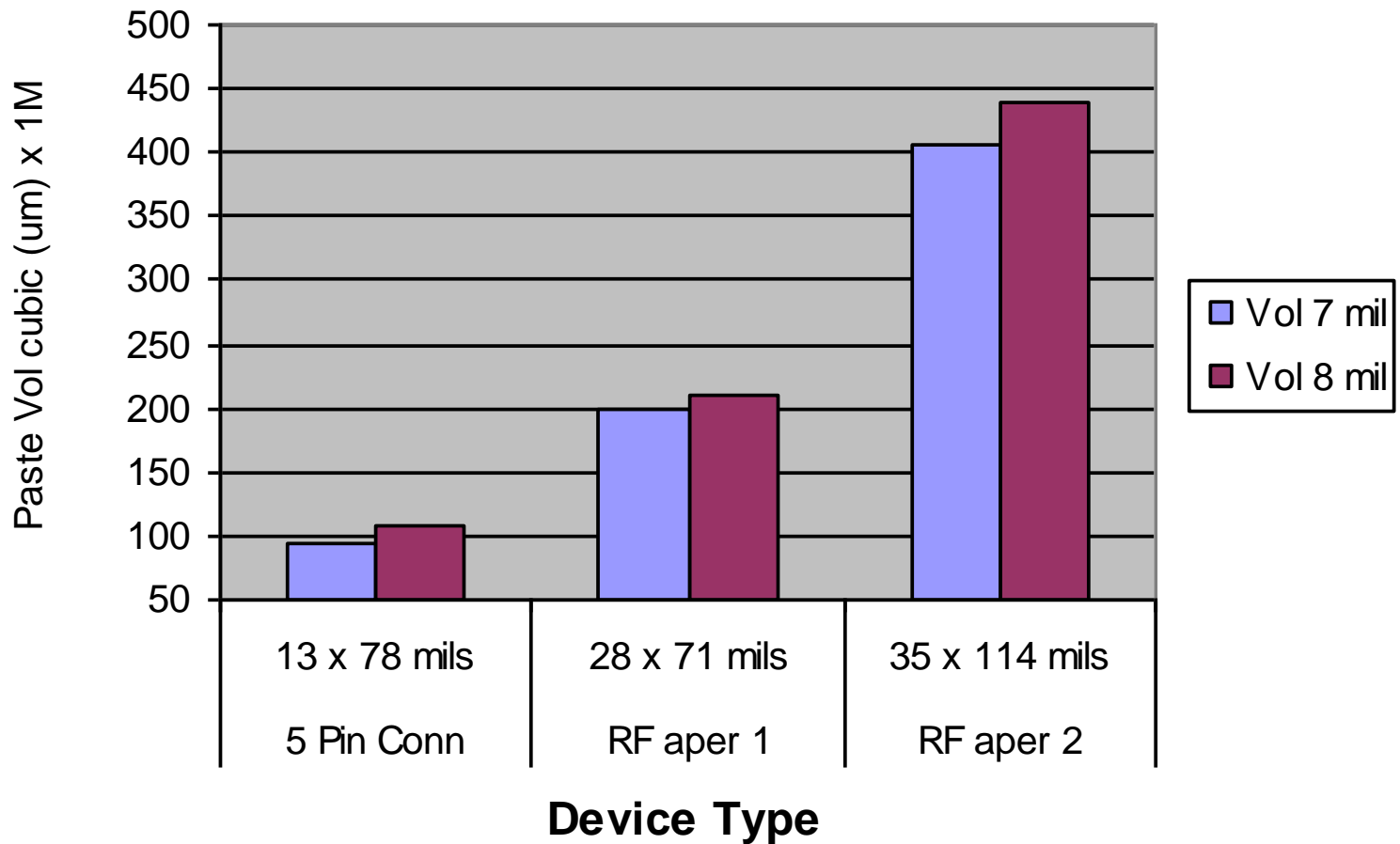
## % Std Dev Comparison 2 mil thick Stencil vs. 3 mil thick Stencil



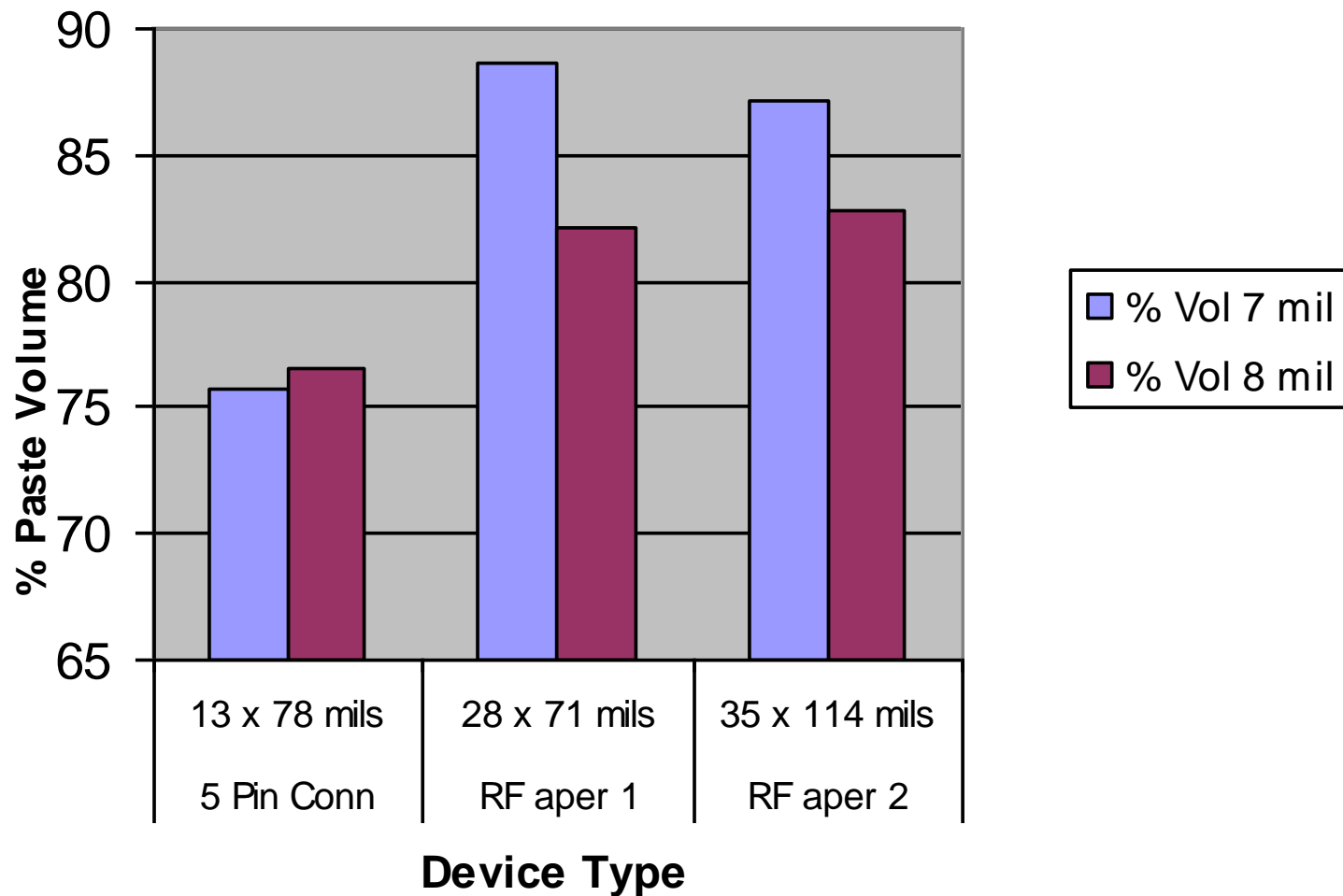
## Height Comparison 2 mil thick Stencil vs. 3 mil thick Stencil



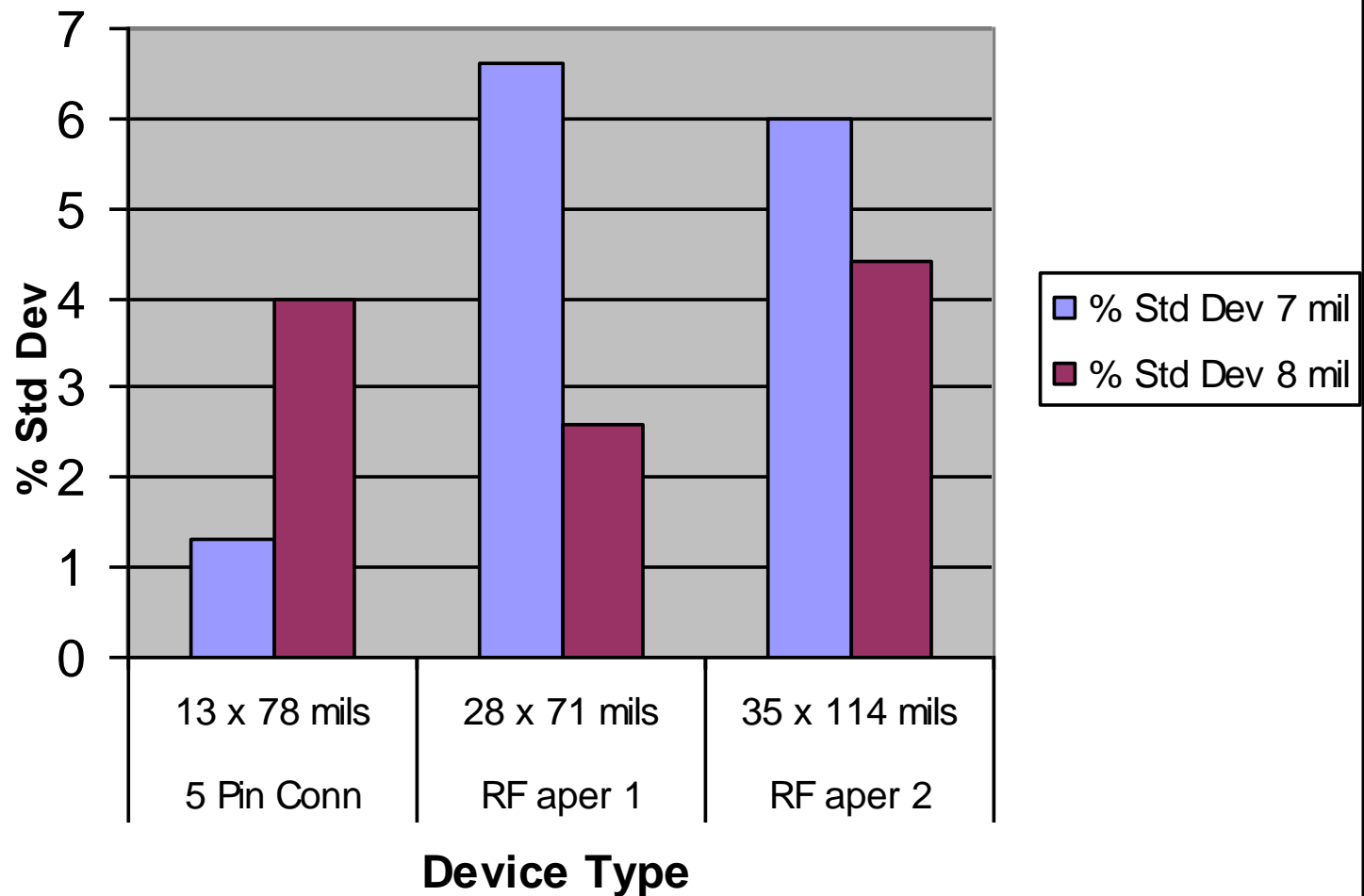
## Paste Volume Comparison 7 mil thick Stencil vs 8 mil thick Stencil



## **% Paste Volume Comparison 7mil thick Stencil vs. 8 mil thick Stencil**

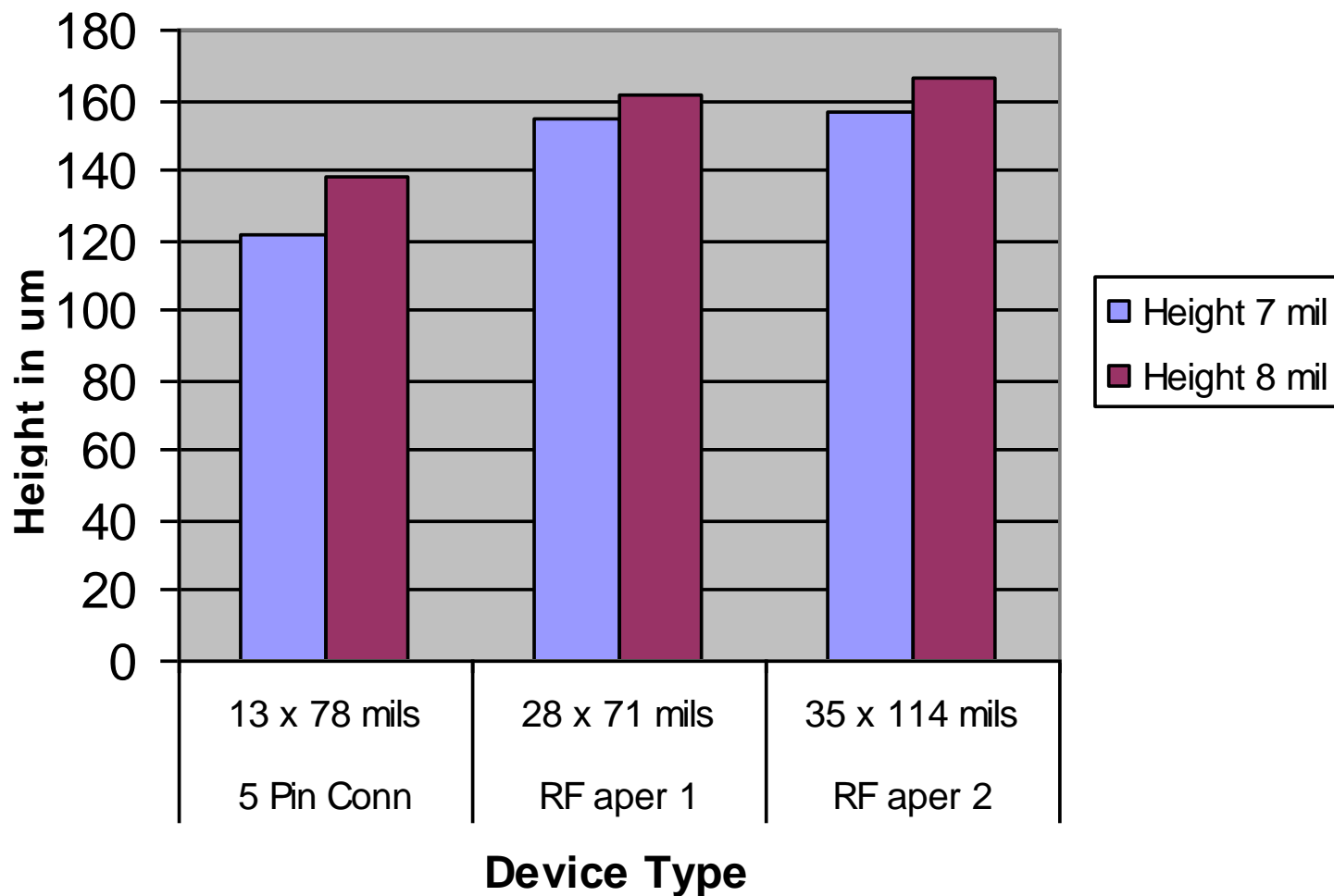


## % Std Dev Comparison 7 mil thick Stencil vs. 8 mil thick Stencil





## Height Comparison 7 mil thick Stencil vs. 8 mil thick Stencil

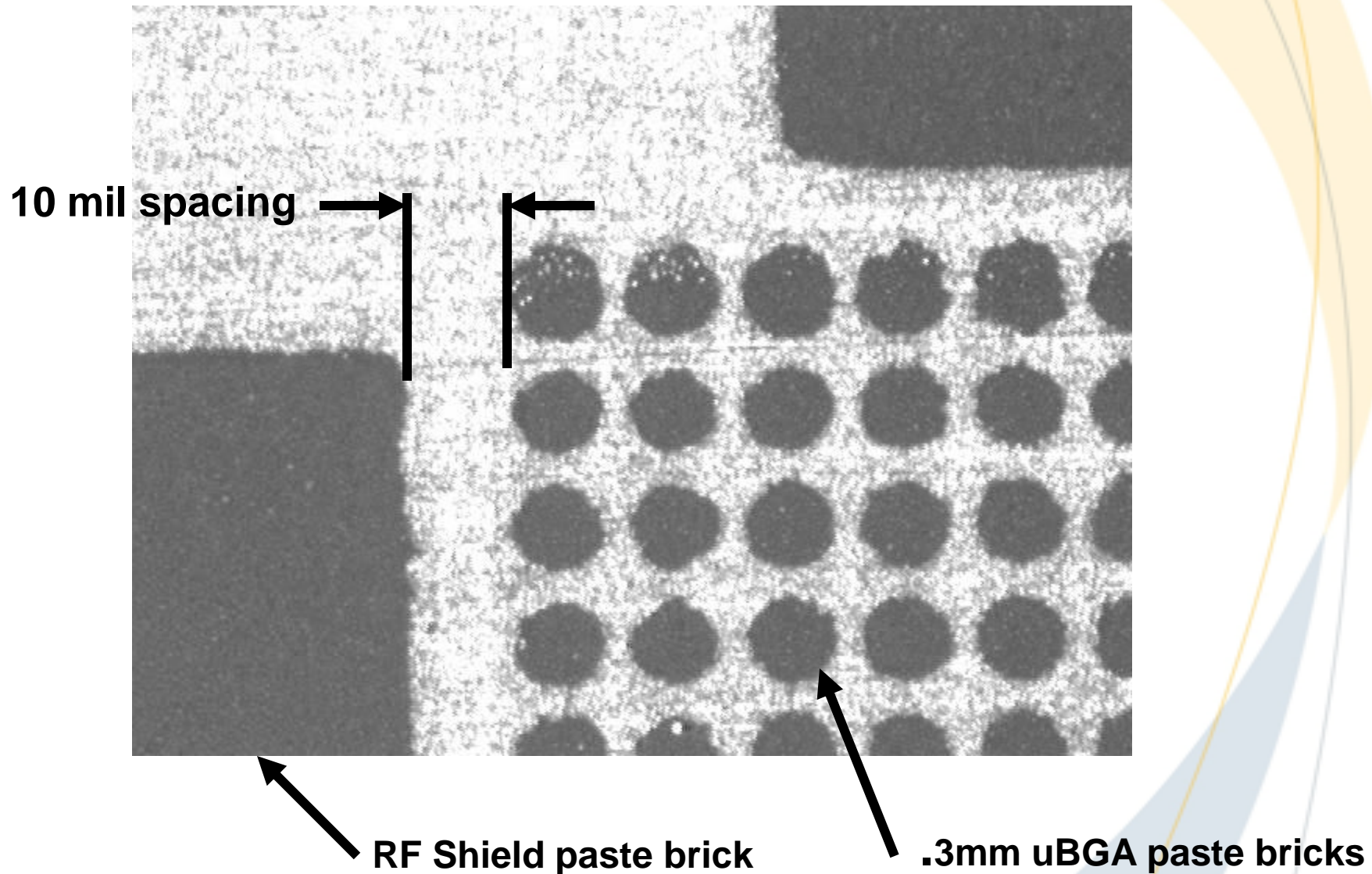


**Print Results using 2 mil thick stencil for 1<sup>st</sup> print  
then 5 mil thick stencil for 2<sup>nd</sup> print  
with a 3 mil deep relief pocket**

1<sup>st</sup> Print (2 mil stencil) then 2<sup>nd</sup> Print (5 mil stencil)

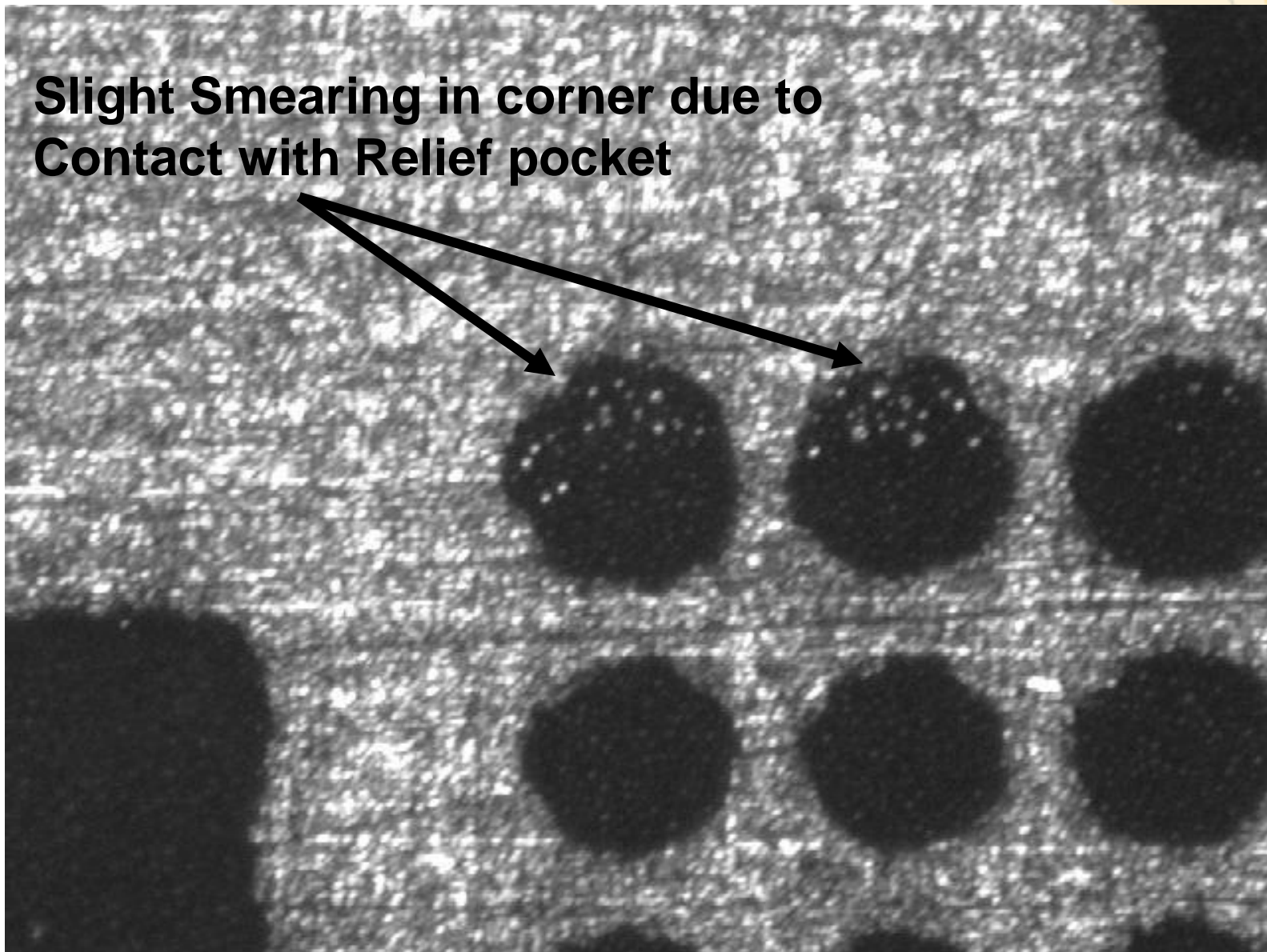
Observe to see if there is any paste smear  
when the spacing between apertures in the two  
stencils is 10 mils.

# Solder Bricks 1<sup>st</sup> Stencil 2 mil, 2<sup>nd</sup> Stencil 5 mils with 3 mil relief pocket for Image 1



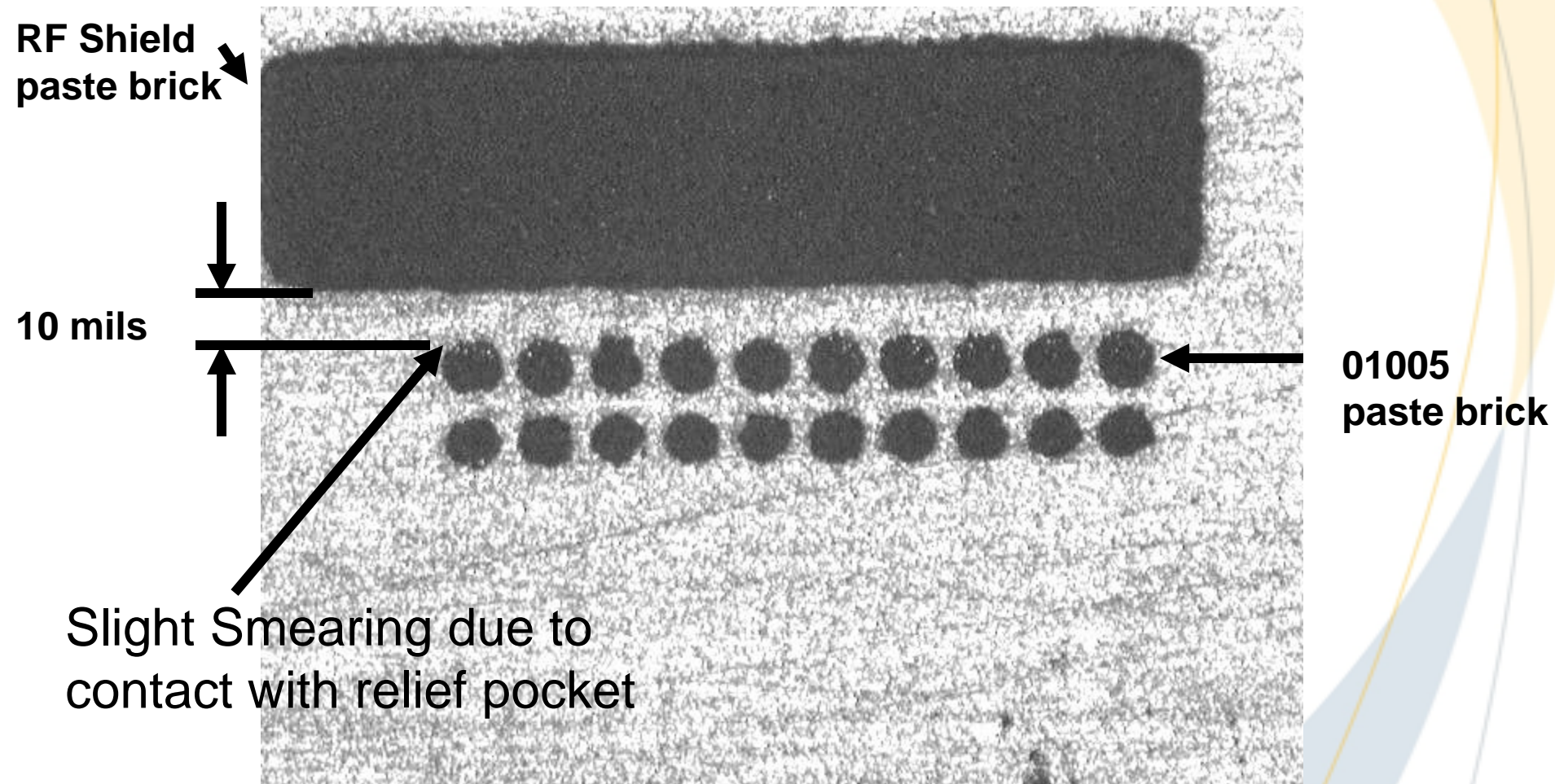
## Magnified view of previous slide showing smearing of .3mm pitch solder brick

**Slight Smearing in corner due to  
Contact with Relief pocket**





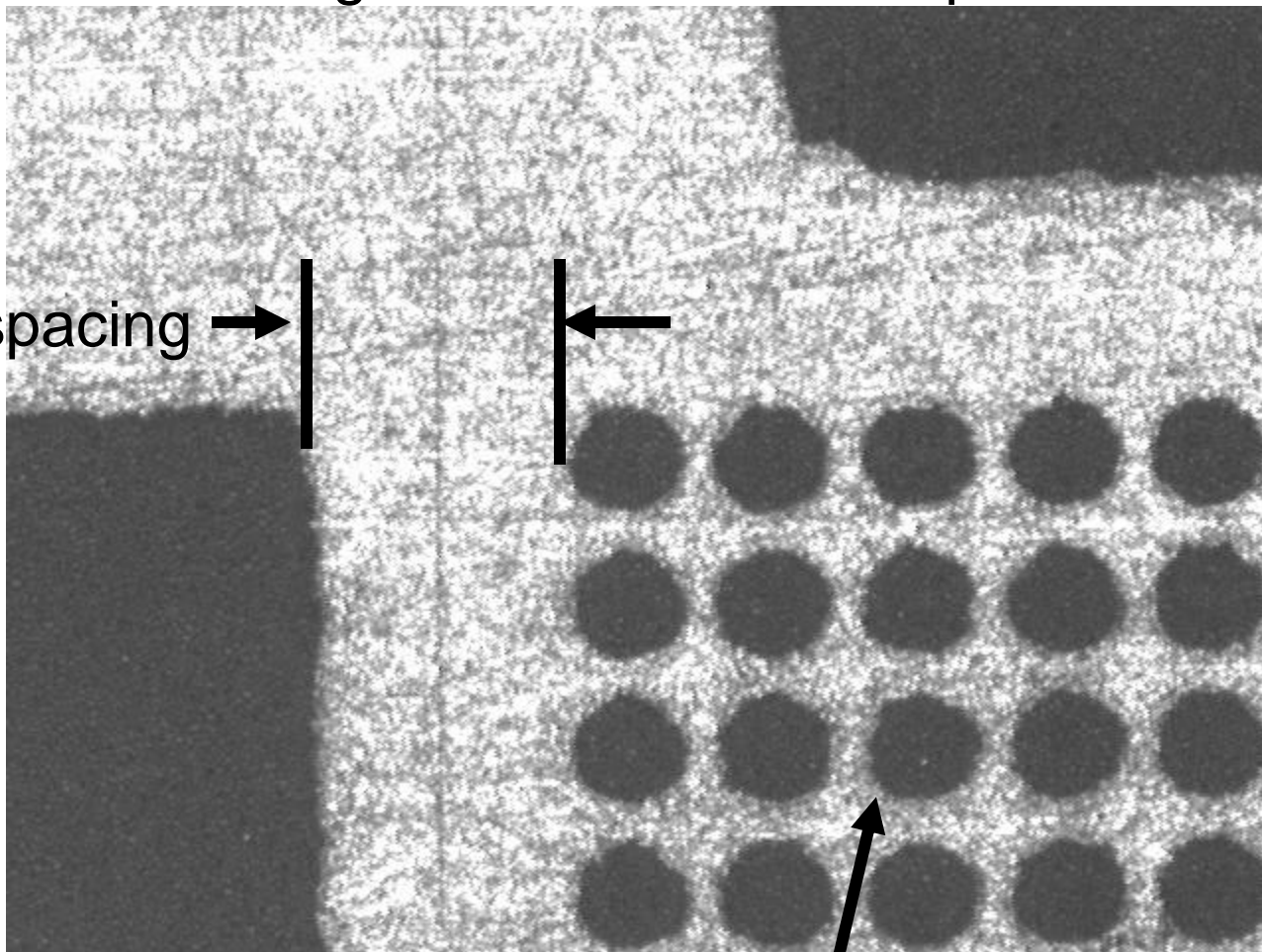
## Solder Bricks 1<sup>st</sup> Stencil 2 mil, 2<sup>nd</sup> Stencil 5 mils with 3 mil relief pocket for Image 1



**Solder Bricks 1<sup>st</sup> Stencil 2 mil, 2<sup>nd</sup> Stencil 5 mils  
with 3 mil relief pocket for Image 2**

No sign of smeared solder paste bricks

20 mil spacing →



RF Shield paste brick

.3mm uBGA paste bricks

## Conclusion / General Design Guidelines / Future Work

### Conclusion Primary:

- The “Two Print Stencil Process” is effective for applications where 01005 or .3 mm pitch uBGA’s coexist with RF shields and SMT connectors, which require larger paste brick heights.
- The “Two Print Stencil Process” demonstrates solder paste heights Of 40 um and 140 um can be printed on the same PCB prior To Placement
- Ten mil spacing between apertures in the 1<sup>st</sup> print stencil and the 2<sup>nd</sup> print stencil produced only marginal smearing of the 1<sup>st</sup> print solder paste bricks.



## **Conclusion Secondary:**

- A 2 mil thick E-FAB stencil provided higher paste transfer efficiency than a 3 mil thick E-FAB stencil.
- The Standard Deviation of a 2 mil thick E-FAB stencil was significantly lower than a 3 mil thick E-FAB stencil.

## General Design Guidelines

### Minimum Spacing between apertures in 1<sup>st</sup> and 2<sup>nd</sup> stencil

- 10 mils (250um) – lower limit with slight paste smear
- 20 mils (500um) no sign of paste smearing
- 15 mils (375um) not tested but highly suspect no smear problem

### Minimum relief pocket height for clearance of 1<sup>st</sup> print paste brick

- 1<sup>st</sup> print stencil thickness + 1 mil (25um)

### Thickness of 1<sup>st</sup> stencil

- Determined by Area Ratio and Paste volume required

### Thickness of 2<sup>nd</sup> Stencil

- Determined by height and volume of solder brick required  
[ 5 mil (125um) to 10 mil (250 um) ]

## Future Work

Test on live cell phone board to determine design of relief pocket

Background:

Present test had relief pockets positioned in close proximity to RF shield apertures and determined the minimum spacing. The relief pocket itself encompassed the entire device area of either the array devices or the chip devices. The largest relief pocket was .270" x .270" for the .4 mm pitch uBGA. There was no support issue for this design when the squeegee blade traveled over the relief pocket.

## Future Work continued

- Determine the maximum size of a relief pocket before the 2<sup>nd</sup> Print stencil bows to make contact with the 1<sup>st</sup> print paste brick.
- Determine the smallest support pillar in a relief pocket and how close it can be positioned to a printed solder paste brick. (For example, if the relief support pillar is 10 mils in diameter and spaced 3 mils from an aperture there would need to be a minimum of 16 mil open area between apertures somewhere on the PCB).