GODDARD SPACE FLIGHT CENTER

Test Lab Report Summary

Report Number:	Q20102DPA	*Project:*	SORCE
Part Type:	Microcircuit	*System:*	
Part Number:	RT54SX16-1CQ208BX3	*Initiated Date:*	03/15/02
Date Code:	0101 (1), 0113 (1)	*Report Date:*	03/29/02
Manufacturer:	Actel	*Investigator:*	C. Greenwell (562)
Generic Number:	RT54SX16	*Requester:*	T. Perry (562)
Purchase Spec:	Mfg. 883 Flow	*Approval / Date:*	

Destructive Physical Analysis (DPA) was conducted on two parts per GSFC S-311-M-70. Figures 1 through 8 show external and internal construction features. Figures 21 and 22 show typical die metallization features.

The devices met the requirements of GSFC S-311-M-70; however, the following observations are noted.

Internal examination revealed intermetallic halo visible around several of the gold ball bonds in SN 003 (dc 0101) (see Figures 9 and 10). As observed, no conditions were deemed to violate MIL-STD-883 Method 2010, Paragraph 3.2.1.4(k) inspection criteria – no device shall be acceptable that exhibits "*Intermetallic formation extending radially more than 0.1 mil completely around the periphery of that portion of the gold bond located on metal*." Similar optical inspection of SN 004 (dc 0113) revealed no evidence of the intermetallic halo condition (see Figure 11).

SEM inspection (before and after bond strength testing) revealed the extent of intermetallic halo around the bonds in SN 003 (see Figure 12). A few of the bonds in SN 003 also had evidence of 'watermelon stripes" or otherwise visible grain boundaries, similar but less pronounced than those documented in Failure Analysis Q20024FA (see bottom two images in Figure 12). Some intermetallic was revealed at locations around some of the bonds in SN 004 (see Figure 13).

While no actual failures occurred, bond strength testing per 883-Method 2011 Condition D produced uniquely different results for the two devices. In SN 003, of 223 wires tested (one wire was inadvertently broken prior to testing), 220 broke somewhere along the wire span and three broke at the ball neckdown area (HAZ - heat affected zone) (see Figure 14). Span and neckdown breaks are both very common, but the ratio of one to the other is usually not so one sided. The average breaking load for all these wires was 5.78 grams-force (g-f), with a Std Dev of 0.35. The wires in SN 003 measured nominally 1.0 mil; per 883-Method 2011, the corresponding minimum break force is 2.5 g-f.

Bond strength testing SN 004 resulted in 219 of 224 wires breaking at the ball neckdown, a somewhat unusual event (see Figure 14). The remaining five bonds lifted, pulling areas of the die bond pad metallization with them (see Figures 15 through 20). This is an unusual occurrence. The five lifts occurred at loads of 6.7, 8.1, 8.7, 9.7 and 10.6 g-f. All five lifts left significant amounts of intermetallic on the bond pads. The average breaking load for all the wires in SN 004 was 10.28 g-f, with a Std Dev of 0.89. The wires in SN 004 measured nominally 1.3 mil; with a corresponding minimum break force of 3.0 g-f.

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Summary of Analysis:

	Date Coder	0101	0113
	Serial Number	003	004
External Examination			
1. Markings - legibility and correctness		A	A
2. Integrity of package seals		A	A
3. Condition of external leads and plating		A	A
4. Overall package condition		A	A
Radiographic Examination			
5. Die bonding material and die alignment		A	A
6. Package seal integrity		A	A
7. Presence of foreign material		A	A
8. Lead dress (if revealed)		A	A
Acoustic Microscopy Inspection			
9. Condition of material interfaces (delaminations)		A	A
10. Condition of molding material (voids, cracks)		A	A
Internal Examination (including cross-section)			
11. Presence of foreign material		A	A
12. Mechanical condition of die		A	A
13. Wire bonds and lead dress		A*	A*
14. Die bonding material		A	A
15. Condition of die surface		A	A
16. Condition of metallization		A	A
17. SEM Examination		A	A
Bond Strength			
18. Strength		A	A
19. Metallization adherence		A	A*
Die Bond Strength			
20. Strength		N/P	N/P

(* = Refer to comments, A = acceptable, U = unacceptable, N/A = not applicable, N/P = not performed)

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Appended Photographs:

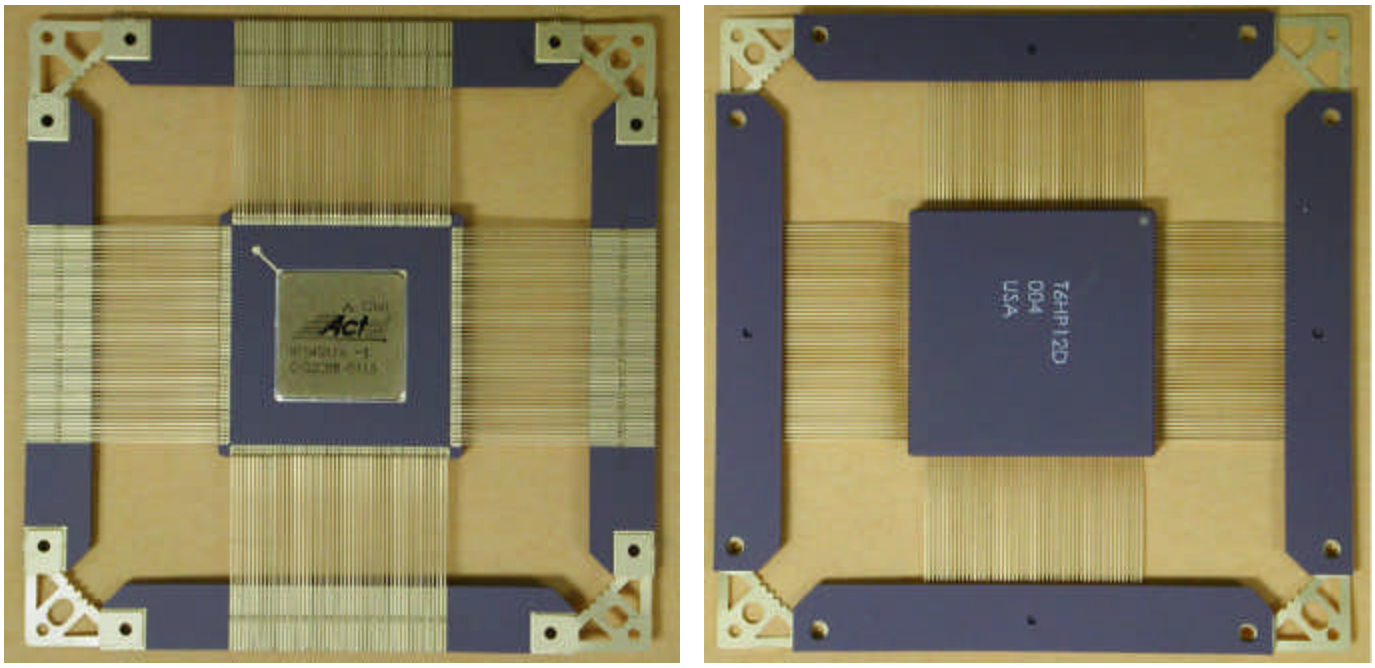

Figure 1. External top and bottom views of the RT54SX16-1CQ208BX3 dc 0113 device. Part markings on the dc 0101 devices were identical except for the date code and '003' in place of '004' on the bottom side.

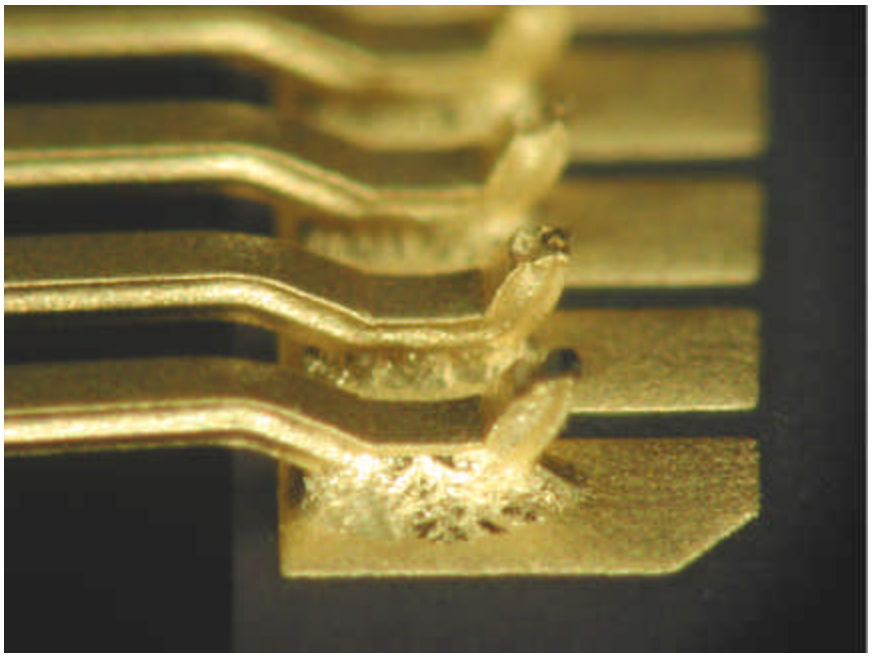

Figure 2. Close-up view shows details of the external lead attach.

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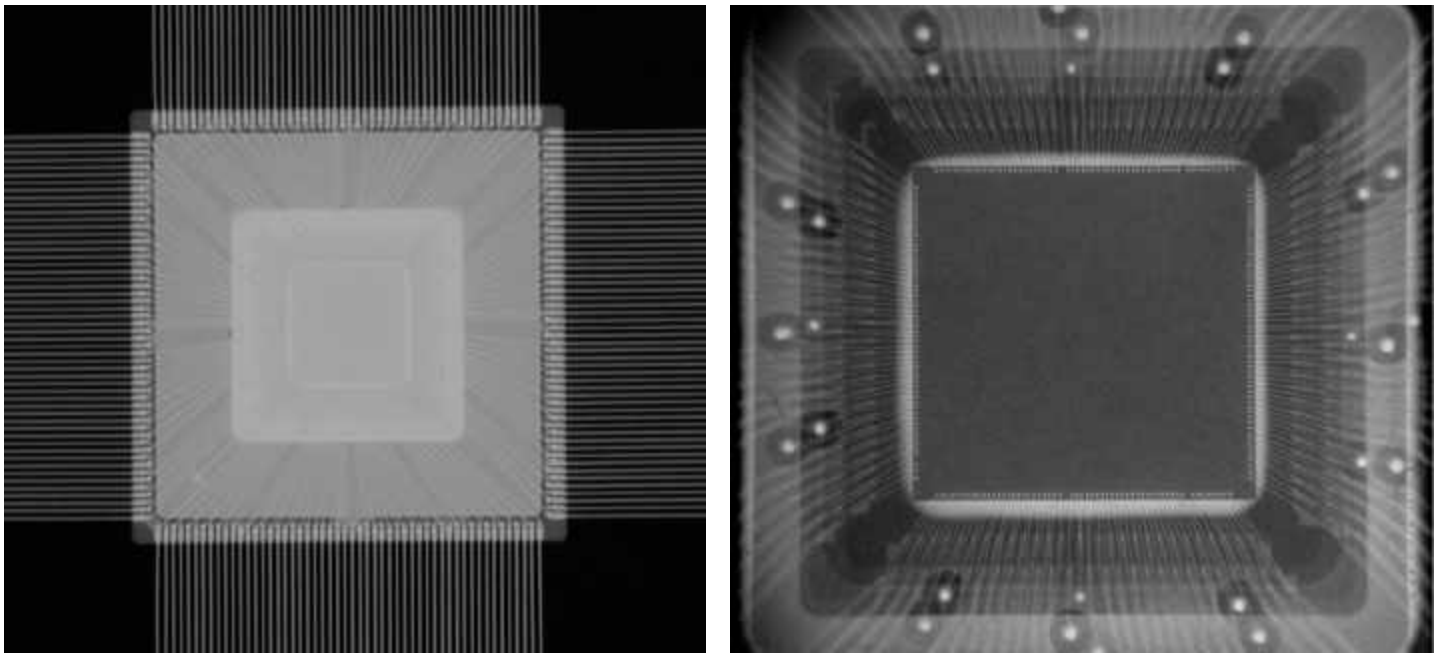

Figure 3. Radiographic images of the RT54SX16 devices. Right image is a close-up of the cavity area. Both devices appeared basically identical.

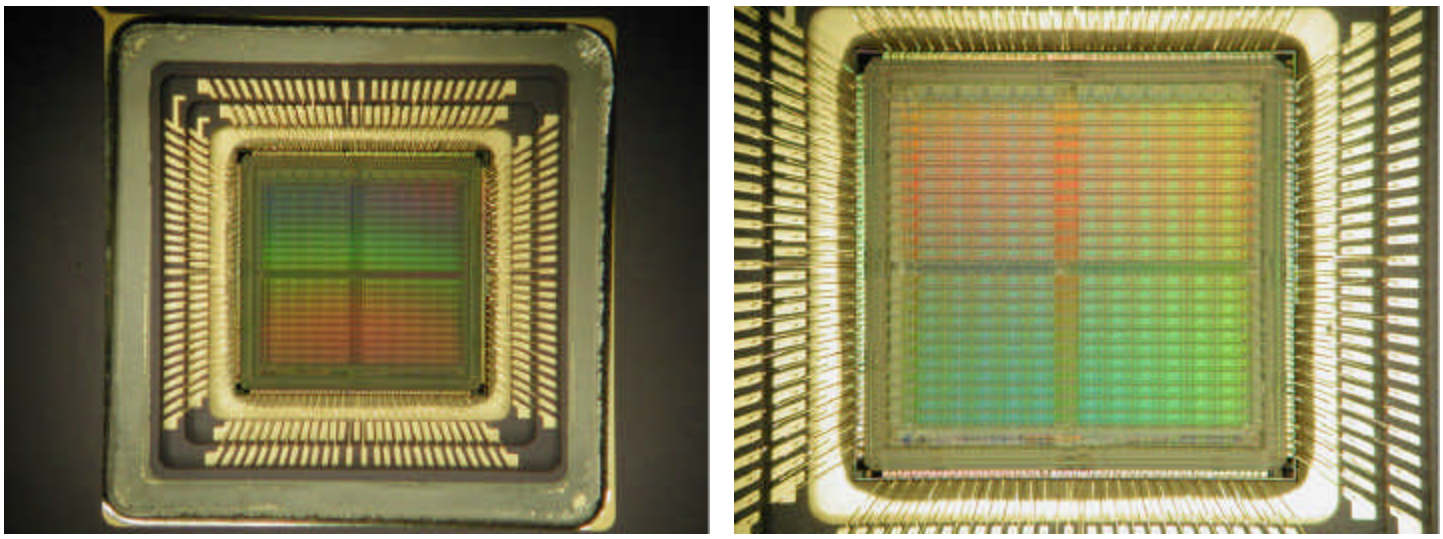

Figure 4. Internal views of SN 003 (dc 0101) device.

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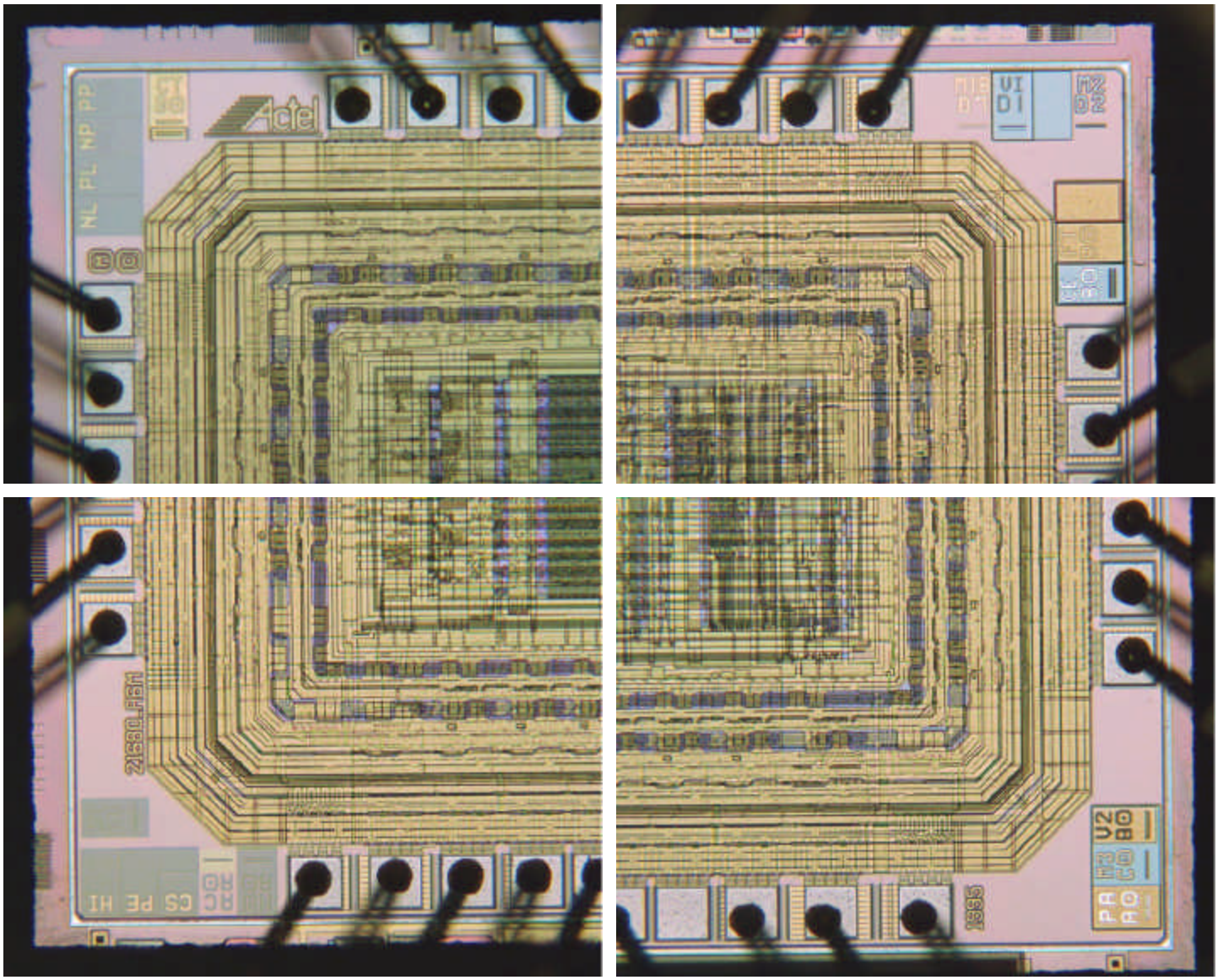

Figure 5. Relatively high magnification images show all four corners of the SN 003 (dc 0101) die. An entire die view at this magnification would be six pages wide.

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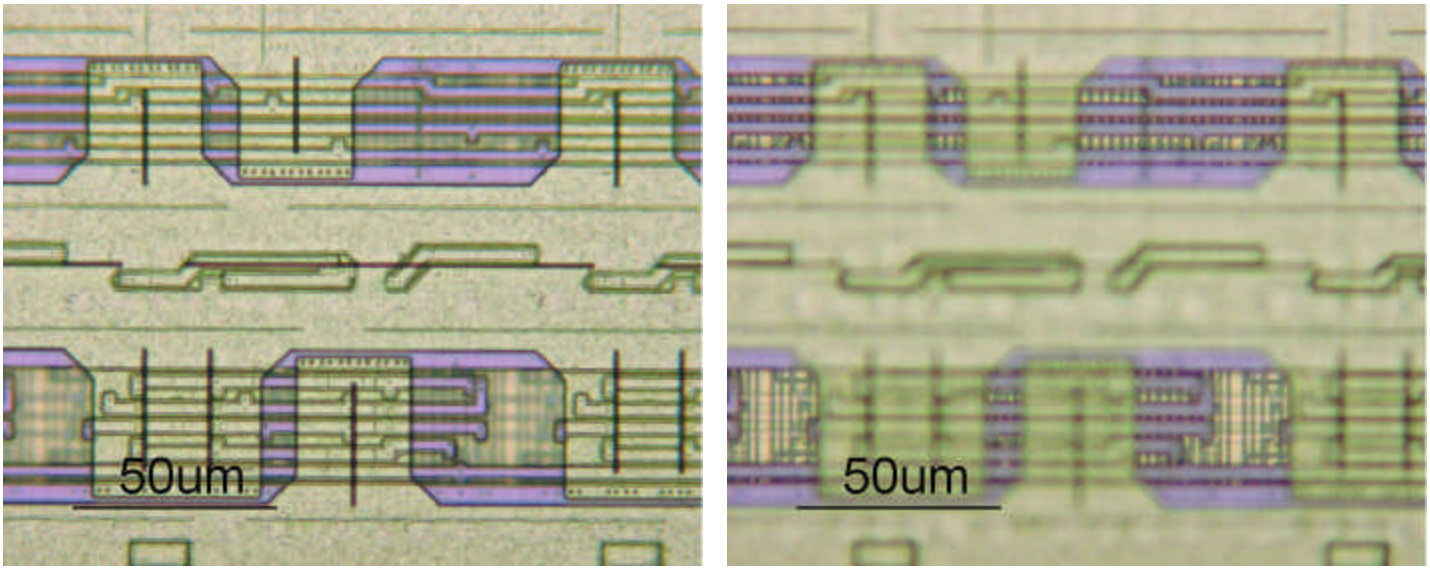

Figure 6. High magnification images of SN 0003 show typical die features. These images or of the same area focused at different planes. The die has a relatively high vertical structure; three metal layers.

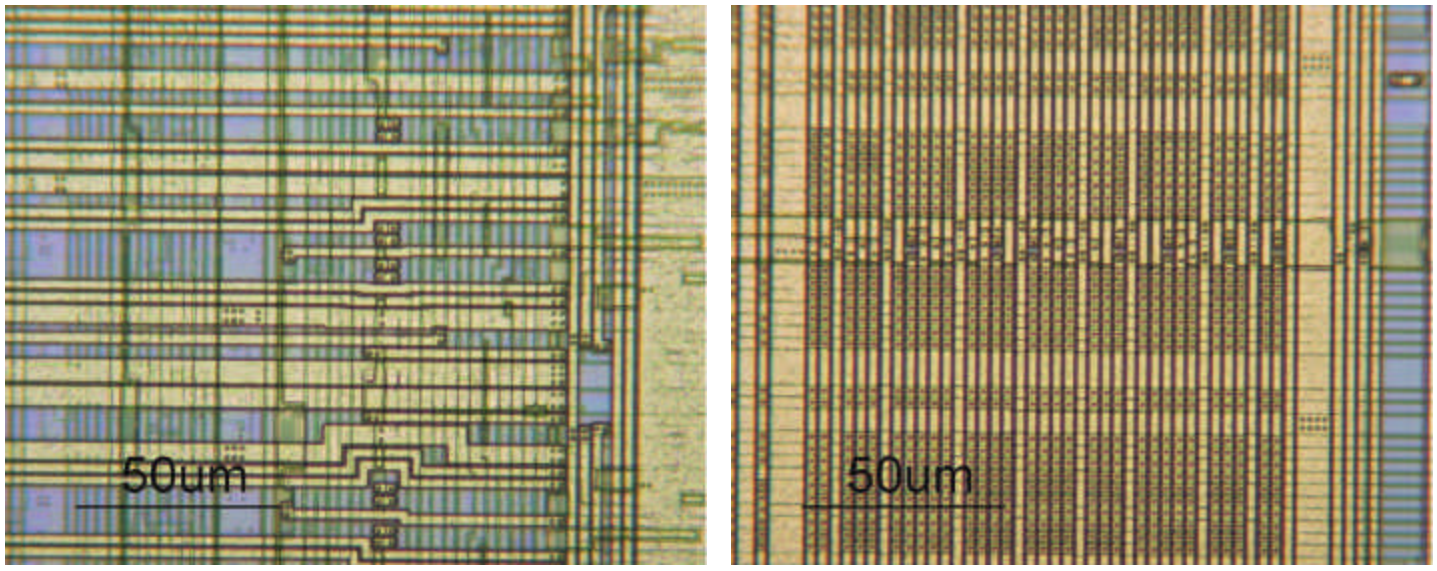

Figure 7. High-mag optical images show typical die features on SN 004 (dc 0113).

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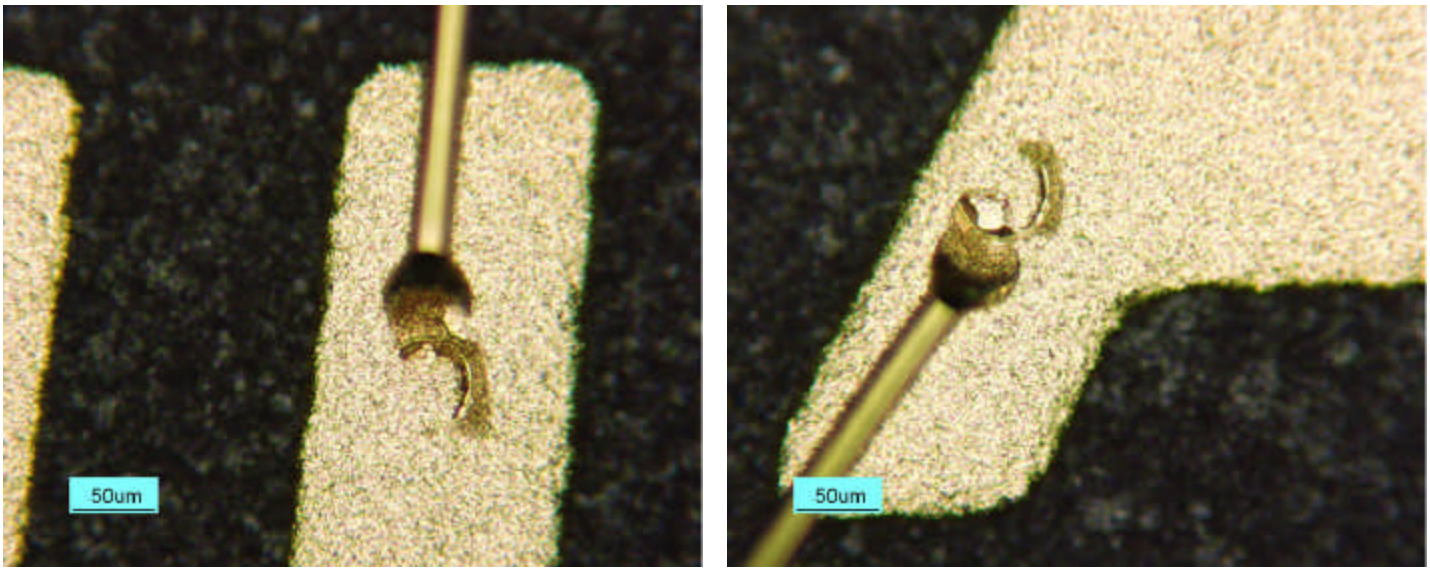

Figure 8. High-mag optical images show worst-case lead frame bonds in SN 003. Lead frame bonds in SN 004 were very similar.

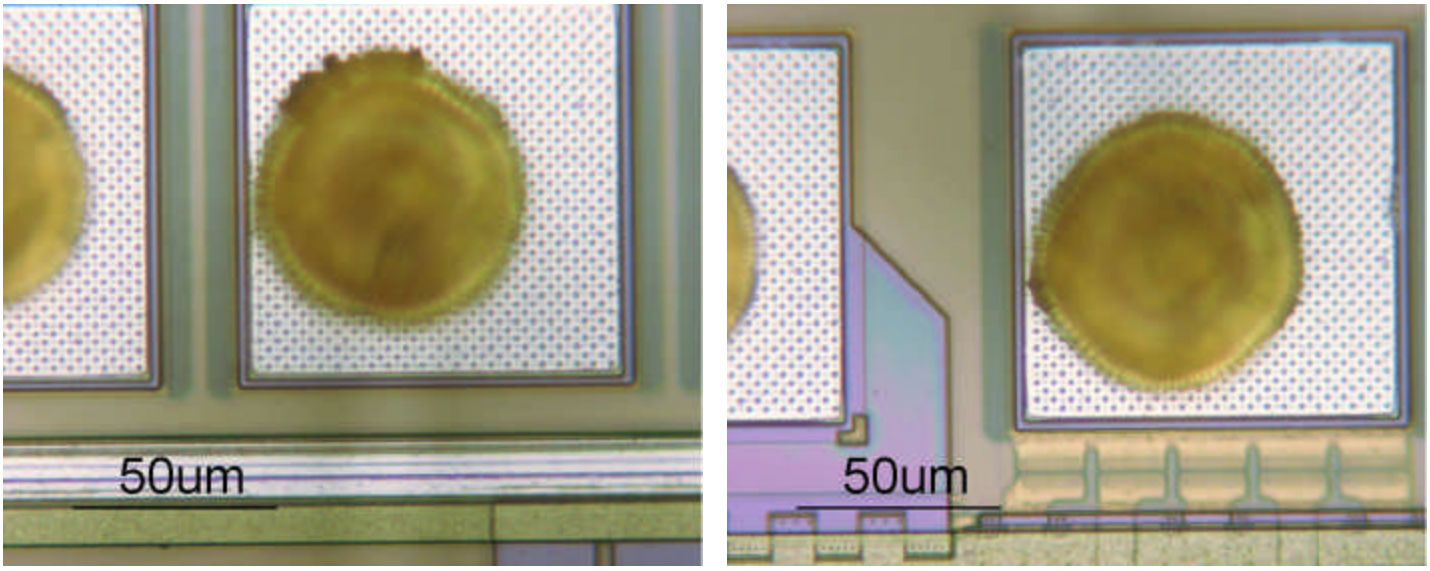

Figure 9. High-mag optical images of SN 003 show gold ball bonds with discernable indications of intermetallic around portions of the bond periphery.

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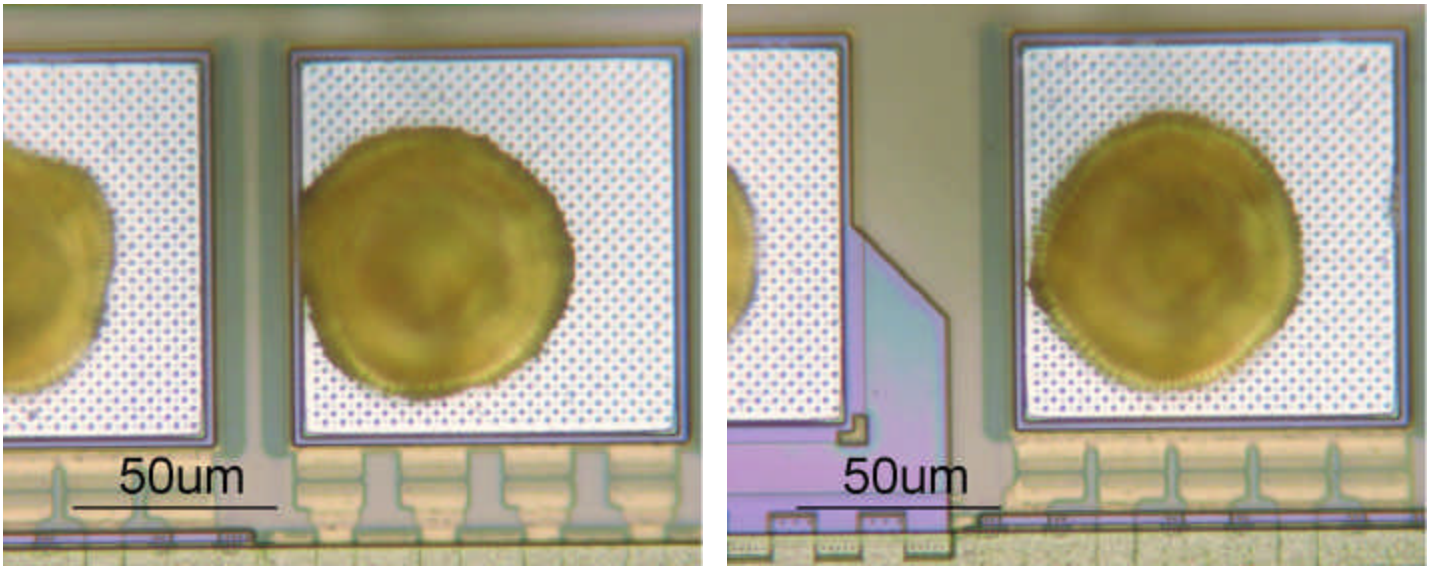

Figure 10. High-mag optical images of SN 003 show typical gold ball bonds. The halo of intermetallic is discernable around these bonds.

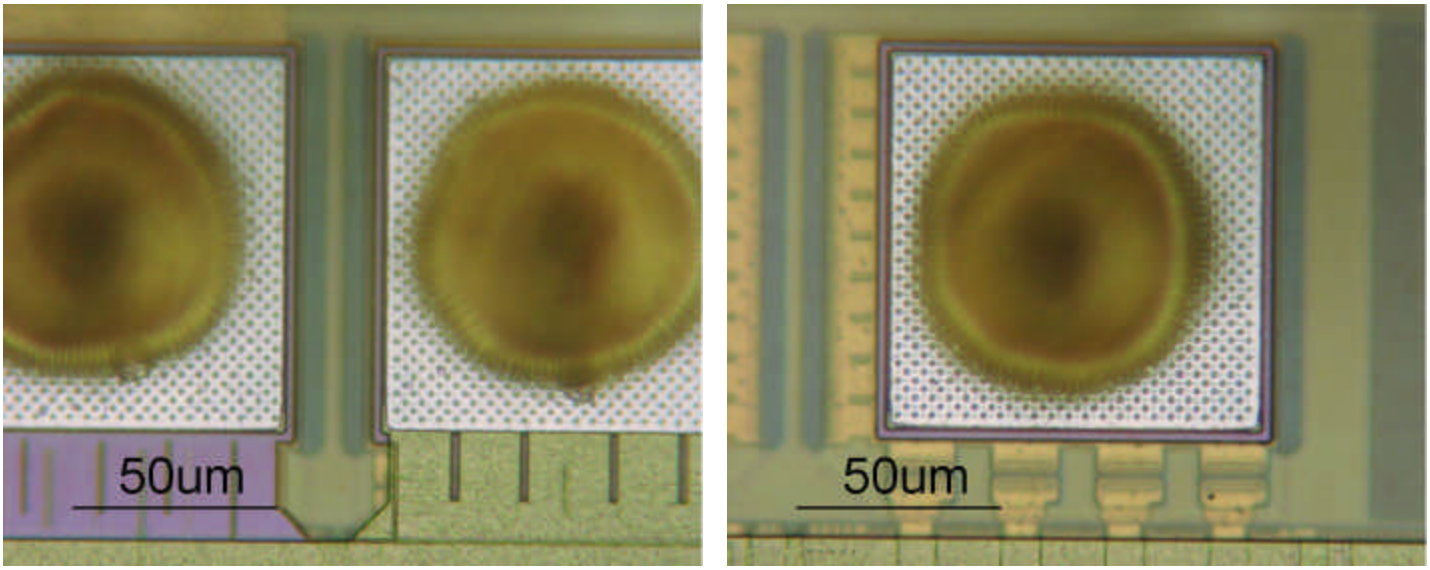

Figure 11. High-mag optical images of SN 004 (dc 0113) gold ball bonds. This device did not exhibit optically-visible evidence of intermetallic halo around the bonds. The features visible in the left two bonds at approximately the six o'clock position are wafer probe damage; very normal features.

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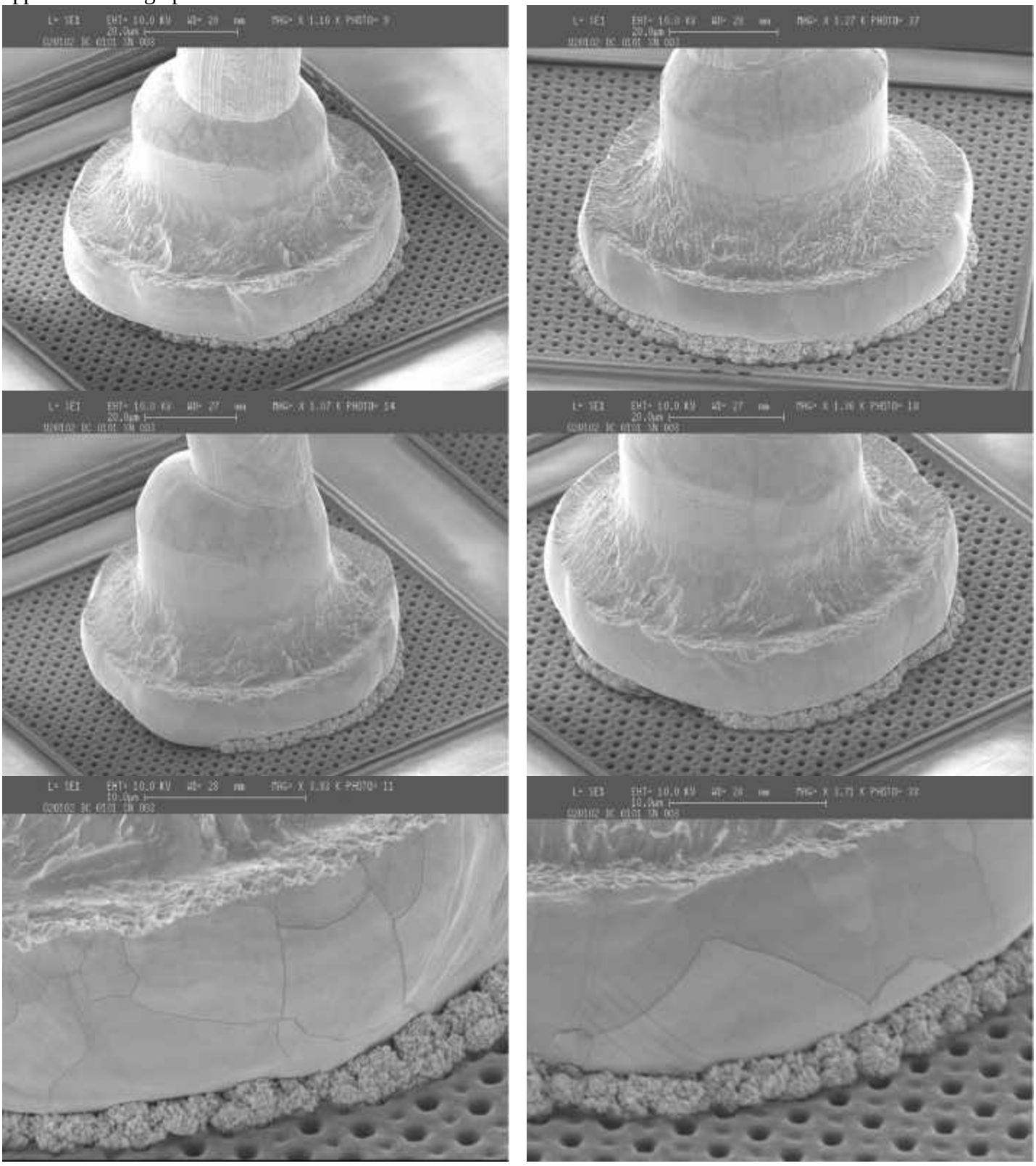

Figure 12. SEM images of SN 003 showing detailed views of ball bond intermetallics.

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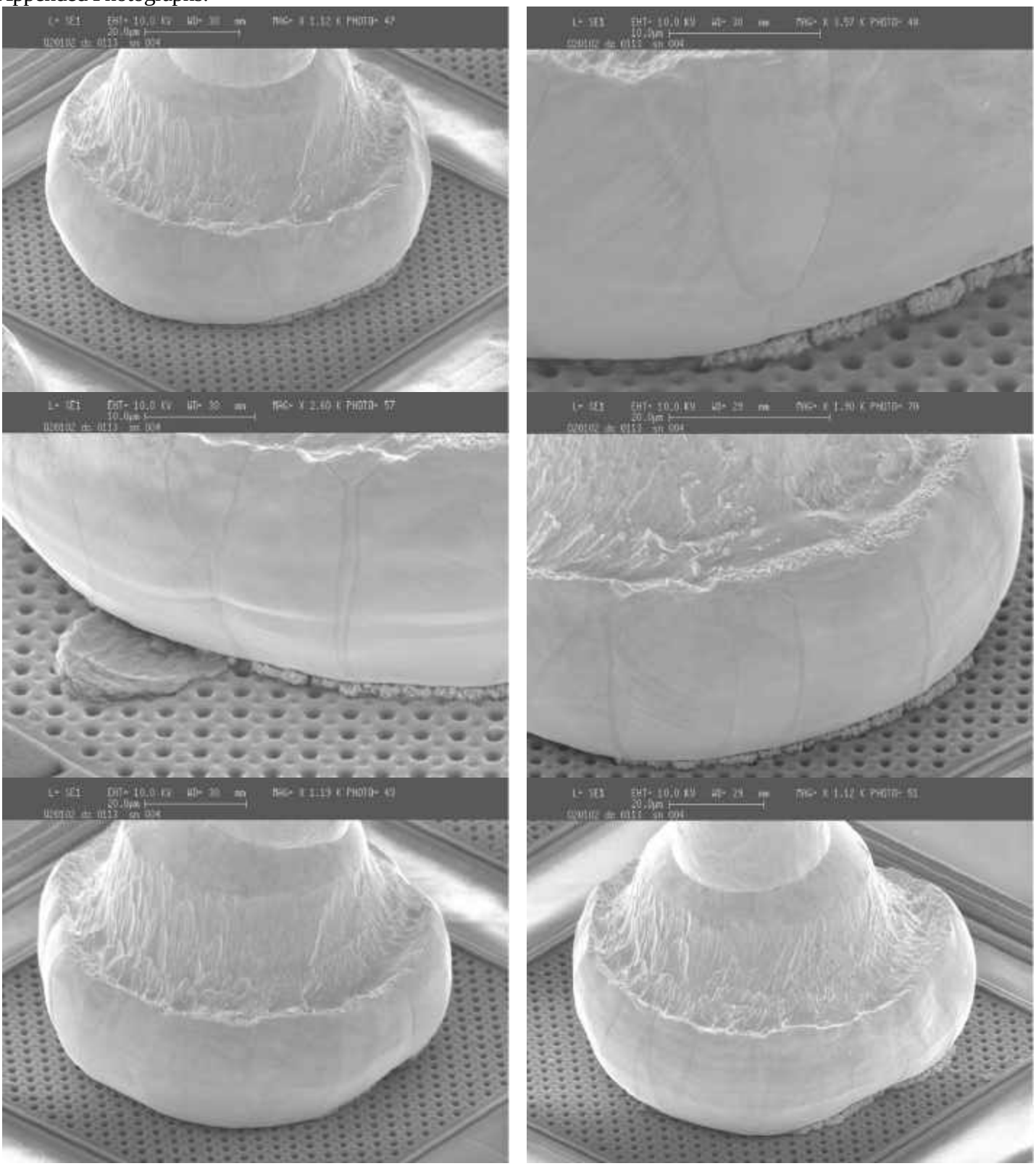

Figure 13. SEM images of SN 004 ball bonds. Significantly less intermetallics are present in this device.

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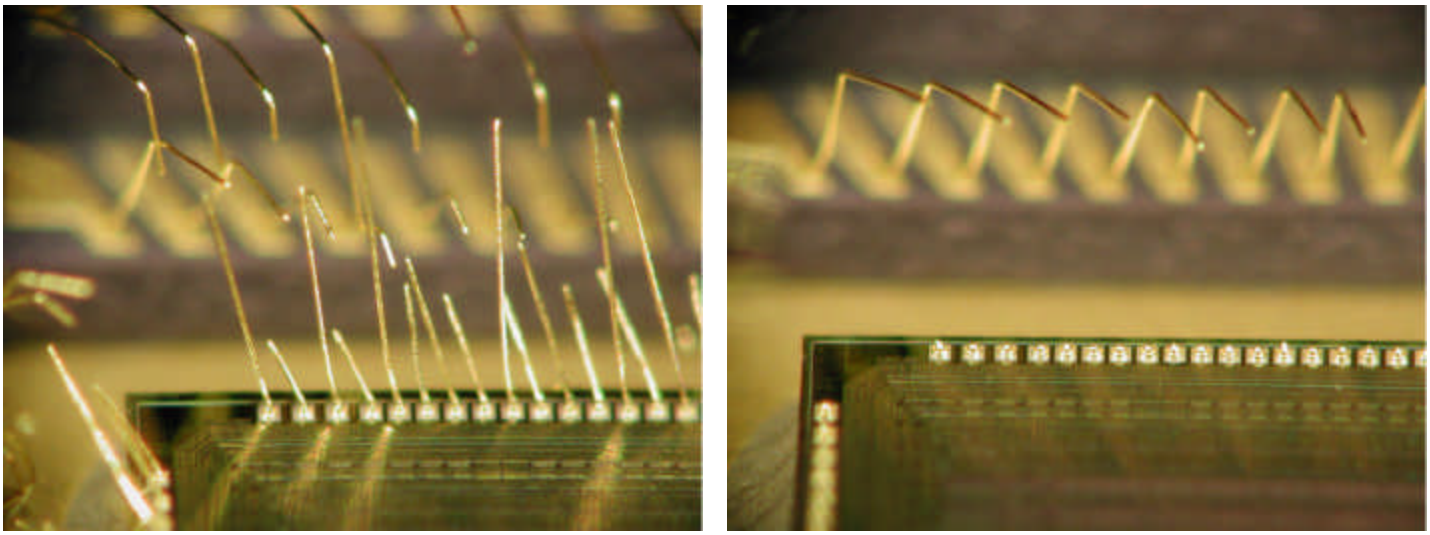

Figure 14. Optical images show bond pull results for SN 003 (left) and SN 004 (right). Except for three neckdown breaks (at the ball), all the wires in SN 003 broke somewhere along the wire span with an average of 5.78 grams-force. In SN 004, all wires except five broke at the ball neckdown (heat affected zone) with an average of 10.28 g-f. There are 224 wires in each device.

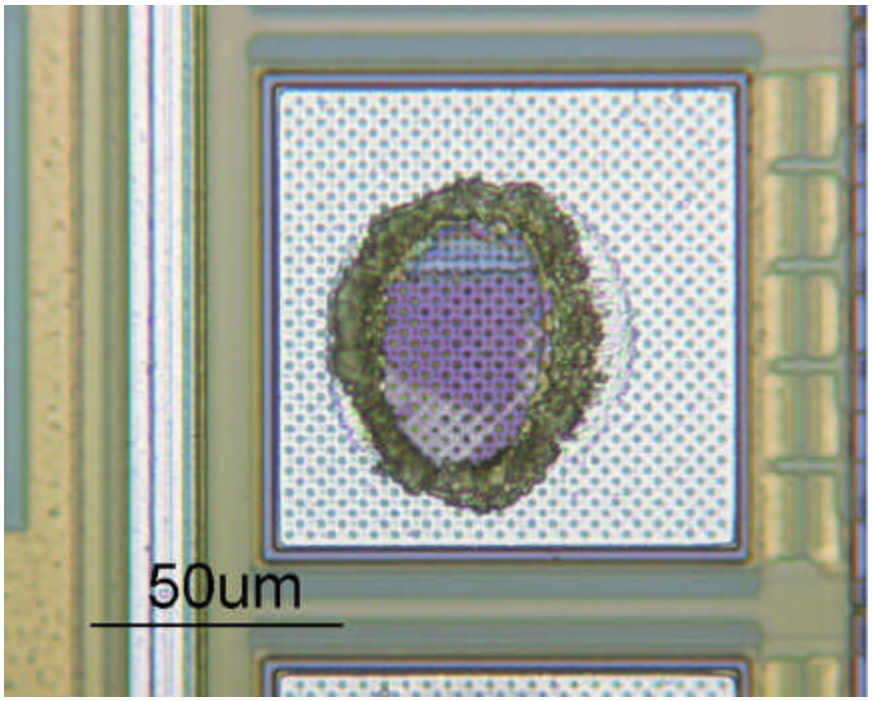

Figure 15. High-mag optical image shows bond pull test result for a wire in SN 004. This bond lifted metallization from the die with an applied load of 10.6 g-f. Note the significant halo of intermetallic remaining on the pad.

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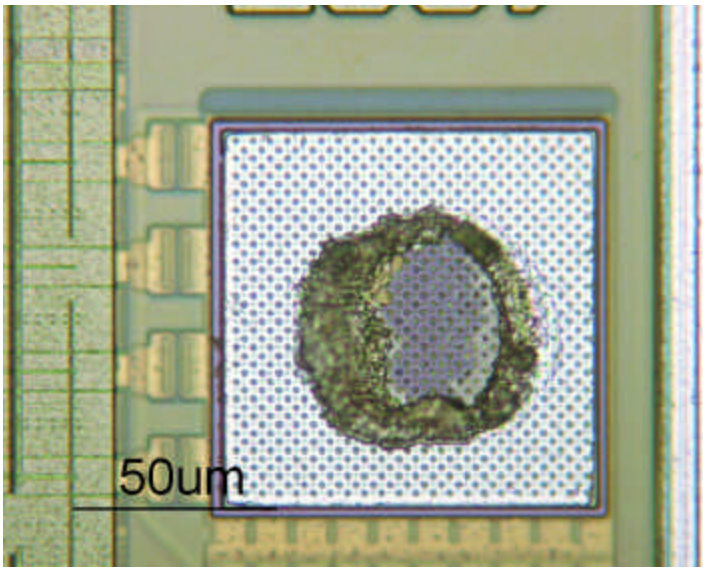
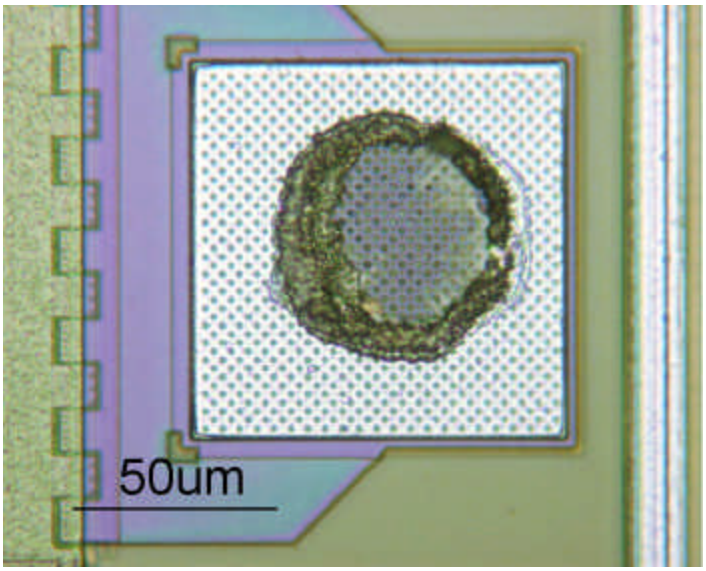
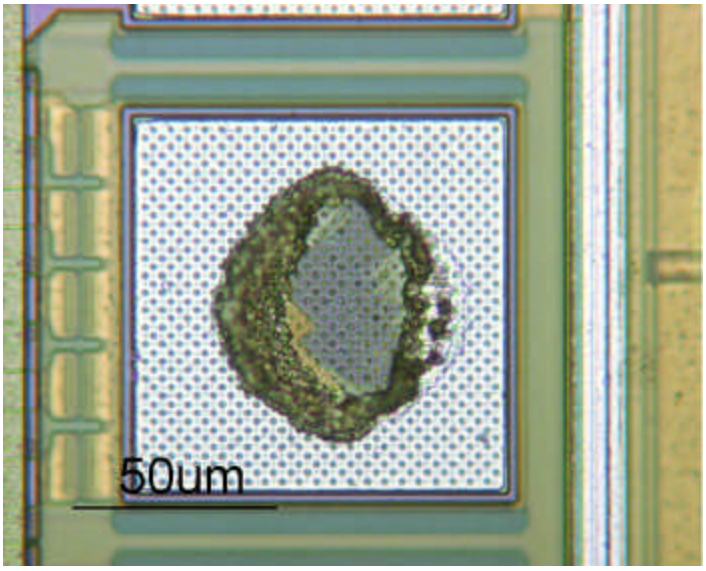


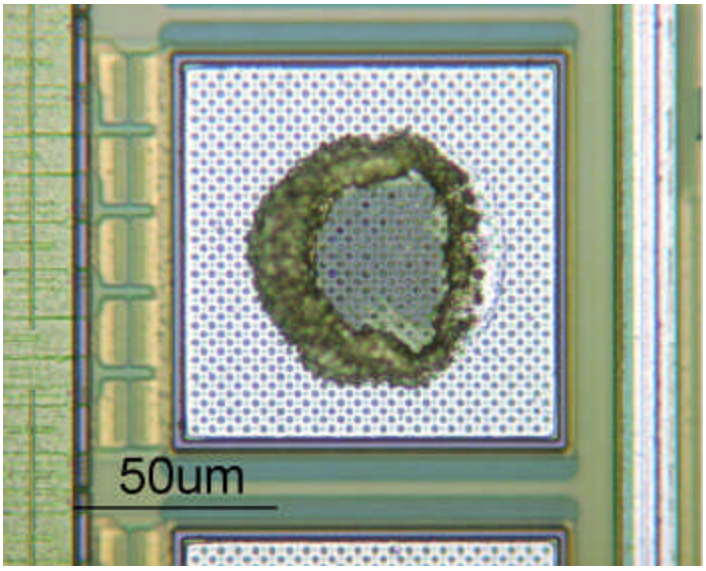
6.7 g-f



8.1 g-f



9.7 g-f



8.7 g-f

Figure 16. High-mag optical images of the remaining four bond lifts in SN 004.

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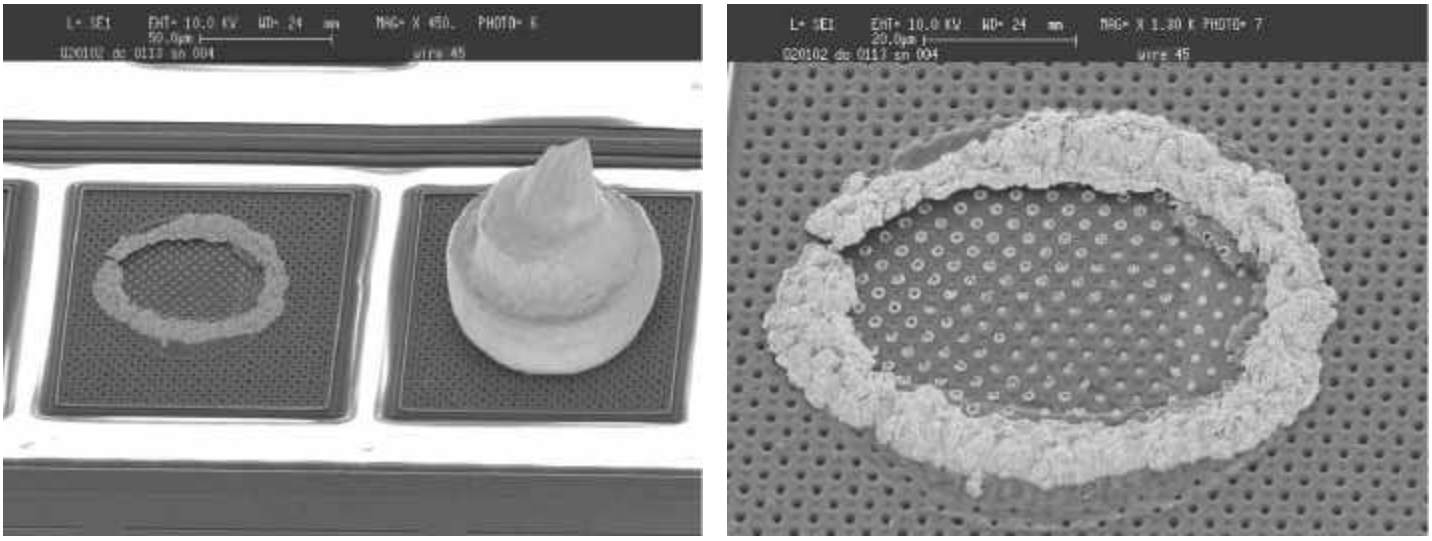

Figure 17. SEM micrograph images shows results of the bond that lifted at 10.6 g-f.

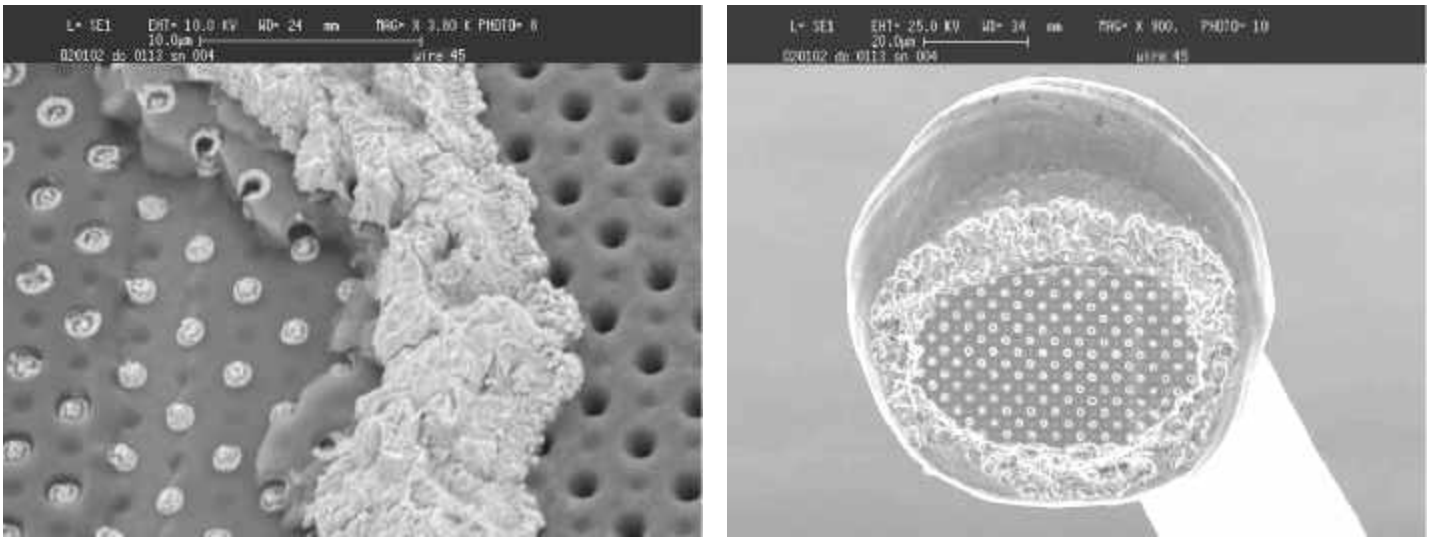

Figure 18. SEM images show a close-up area of the pad shown above and the corresponding underside of the ball that lifted from this pad.

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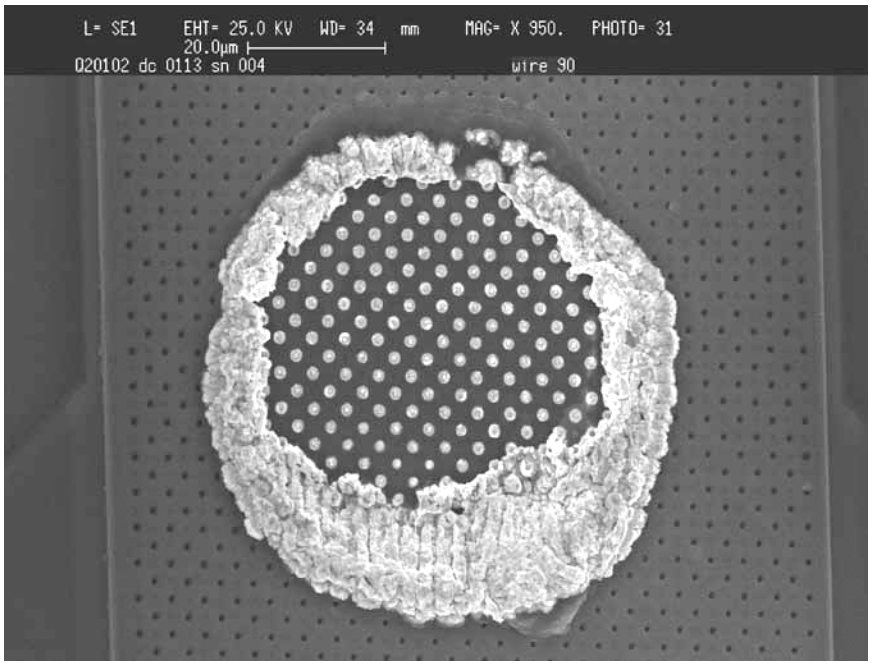

Figure 19. SEM image shows pad area for wire that lifted at 8.1 g-f. Note the 'straight line' pattern in the intermetallics, particularly noticeable in the wider bottom half of the halo.

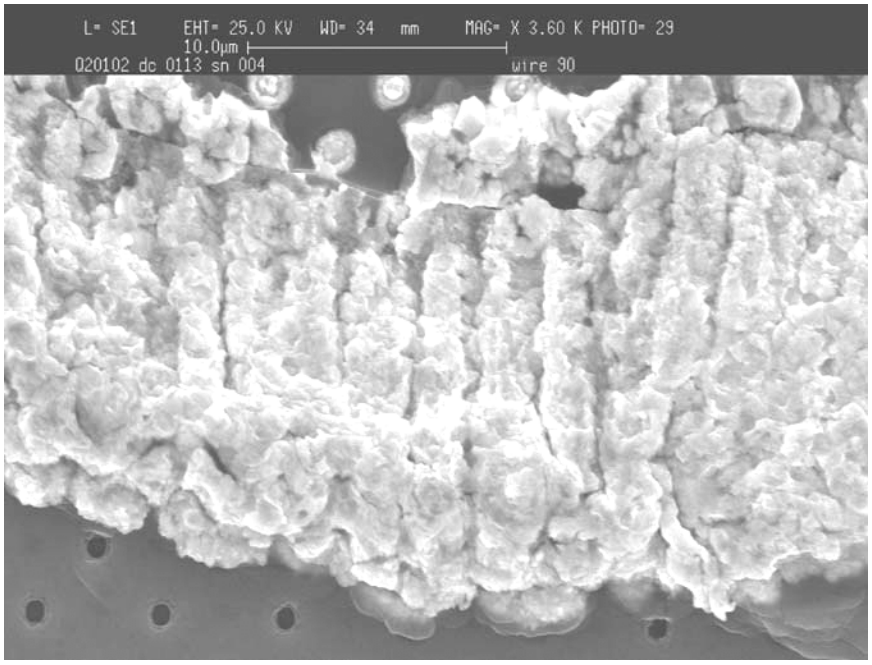

Figure 20. Close-up SEM image of the area indicated above. It is not known what these features indicate.

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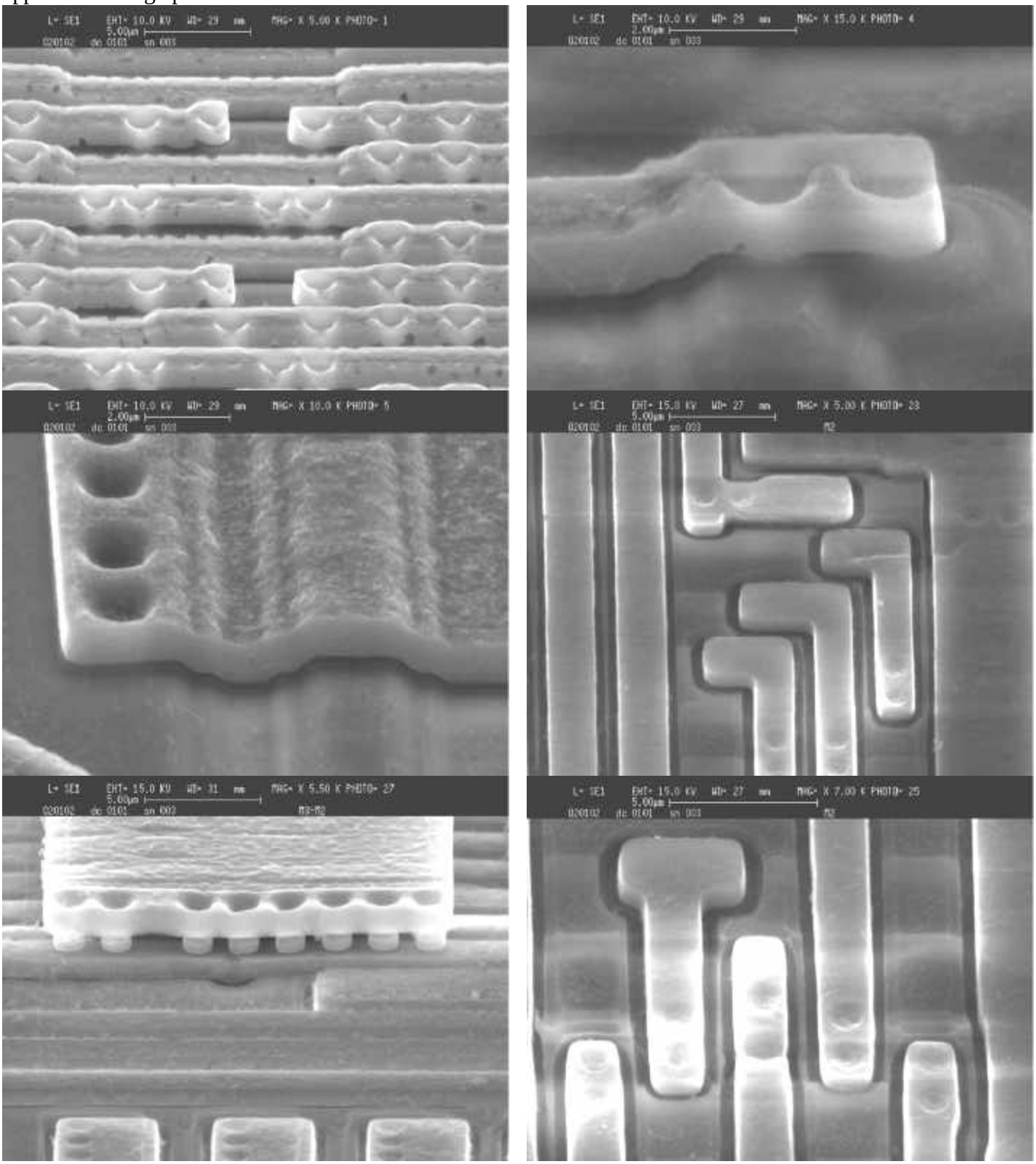

Figure 21. SEM images of die metallization on SN 003.

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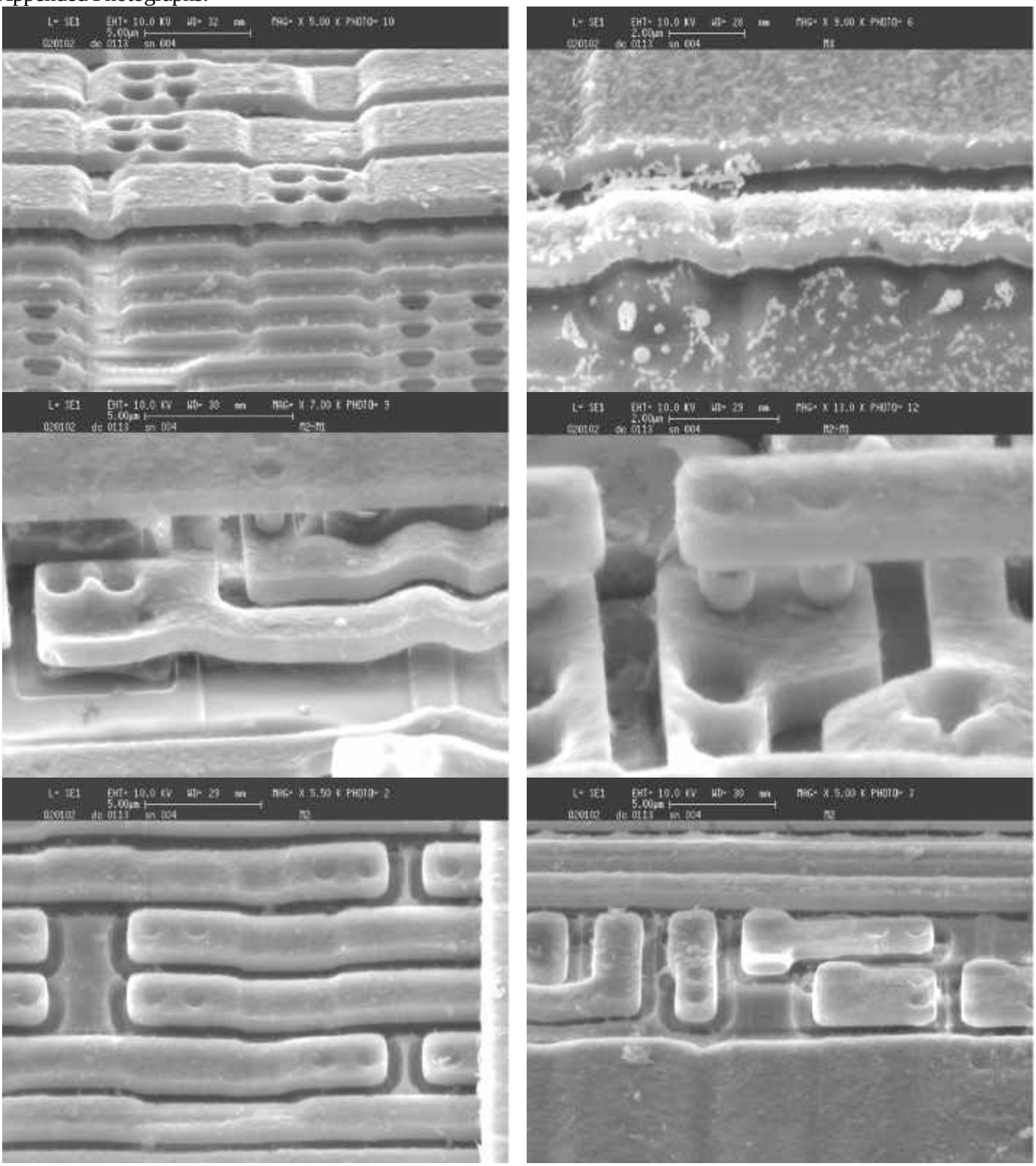

Figure 22. SEM images of die metallization on SN 004. Etch artifact is visible in several areas.