

HDI Thruhole Discussion with Yamashita co.

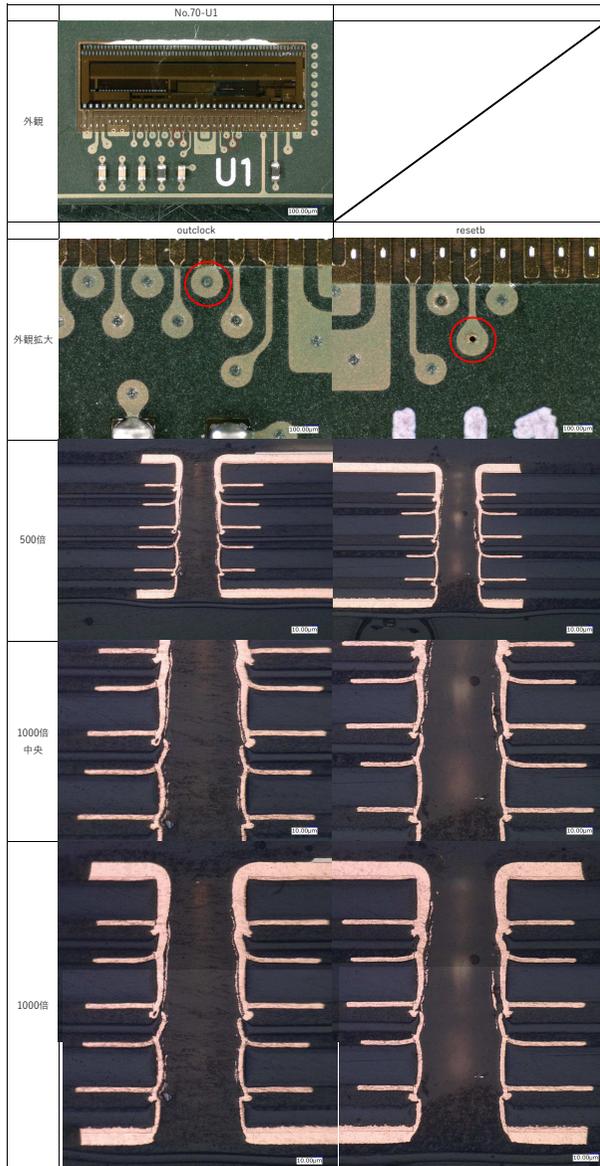
RIKEN/RBRC
Itaru Nakagawa

Contents

Hideto Enyo, Yasyuki Akiba, IN visited Yamashita co. on May 13th

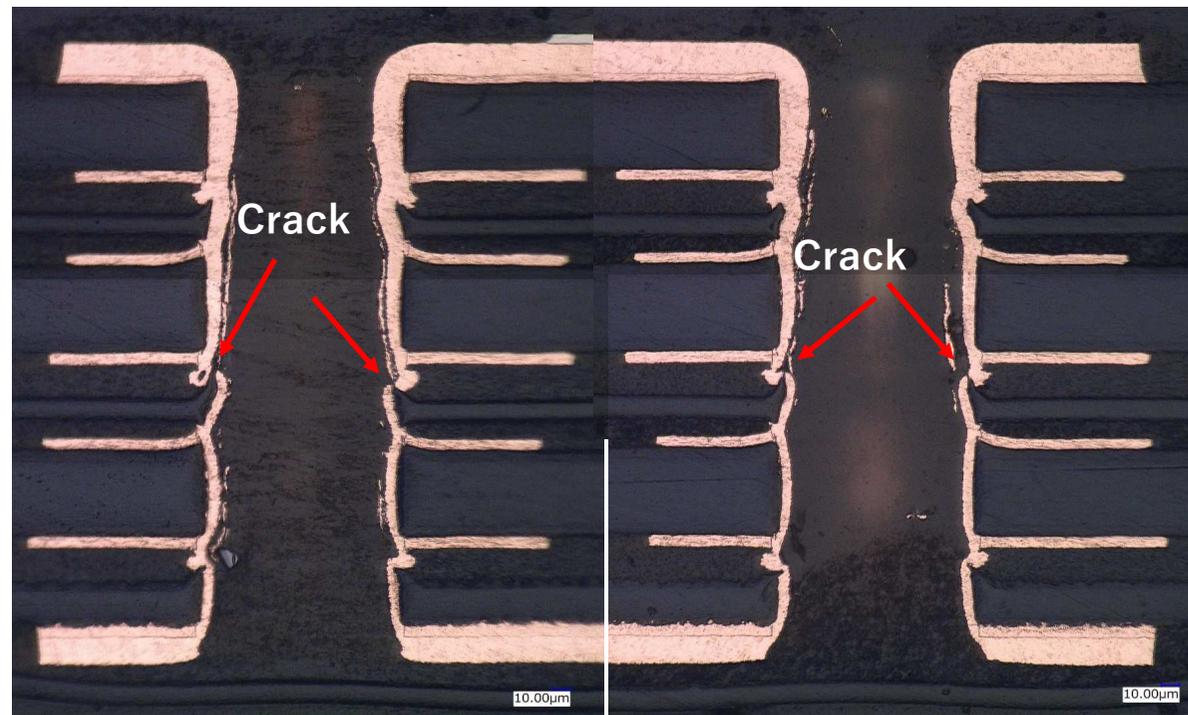
1. Status of thruhole XS inspection
2. Taiwan observation
3. Possible cause hypothesis from Yamashita
4. Improvement Idea and Plan in Thruhole process
5. Production HDI replacement plan and schedule

Delivery Day	Batch	Order #	LOT #	Quantity	HDI Serial No.	Incremented Quantity	Inspection	Inspection Result	Taiwan Observation	
2019/1/23	Preproduction	349670	302382	6						
2019/2/6		349670	302725	4						
2019/9/11		350963	306716	20						
2019/11/20		Exchanged	307469	1						
2020/4/2	Batch-1A	352075	310184	9	1	9	9			
2020/4/2		352075	310185_1	7	10	16	16			
2020/4/2		352075	310185_2	13	17	29	29			
2020/4/2		352075	310186	30	30	59	59	50	4/28	Suspicious
2020/4/28		352075	310188	17	60	76	76	70	3/26	Suspicious
2020/4/28		352075	310189	24	77	100	100	80, 94	3/26	
2020/6/8	Batch-1B	352075	311139	2	101	102	102			
2020/6/8		352075	311587_1	7	103	109	109	105	5/13	6
2020/6/17		352075	311587_2	2	110	111	111			
2020/6/17		352075	311614	15	112	126	126	122	5/13	14
2020/6/24		352075	311615	21	127	147	147	127	5/13	20
2020/7/9		352075	312095	20	148	167	167	(160)		BNL
2020/7/9		352075	312096_1	6	168	173	173			
2020/7/21		352075	312096_2_1	7	174	180	180			
2020/7/28		Batch-1A	Exchanged	312096_2_2	1	24	24	180		
2020/9/28	Batch-2	353110	312532	20	181	200	200			
2020/9/28		353110	312533	16	201	216	216			
2020/9/29		353110	312534	7	217	223	223	(220)		BNL
2020/9/29		353110	312535	14	224	237	237			
2020/9/29		353110	312536	7	238	244	244			
2020/10/27		353110	313304	24	245	268	268	265	5/17	Suspicious
2020/11/27		353110	313673	2	269	270	270			2

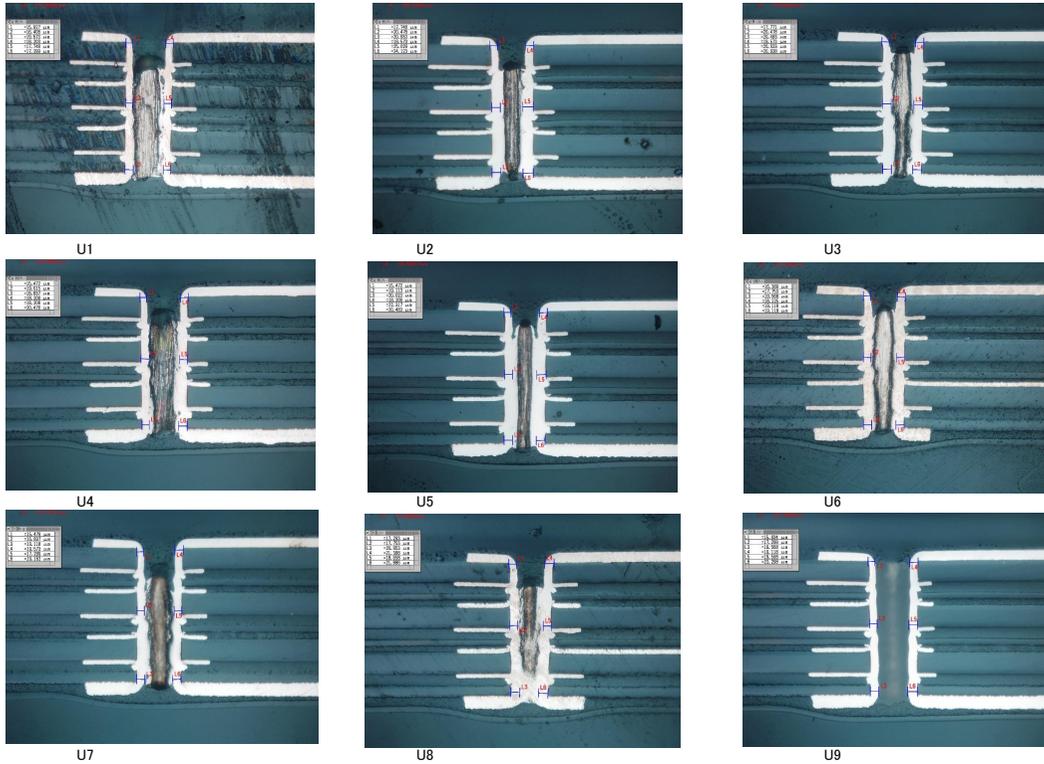


Module-70 Thruhole

- The first HDI inspected thruhole XS
- Cracks in the middle
- Disabled this and next LOT.



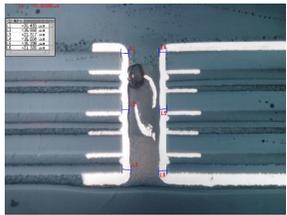
Serial Number 50 Thruhole Inspection



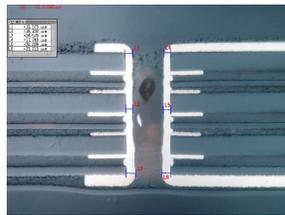
- Report from Yamashita on April 29, 2021.
- 1 thruhole per chip sampling XS inspection showed all OK.

All OK.

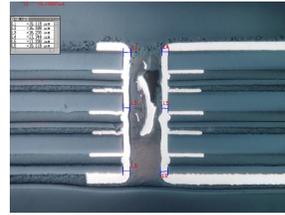
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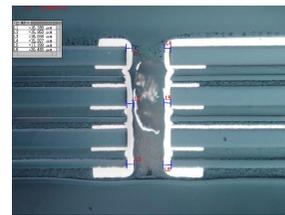
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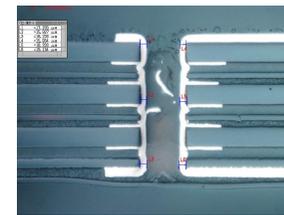
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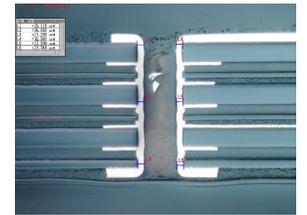
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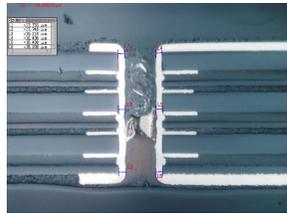
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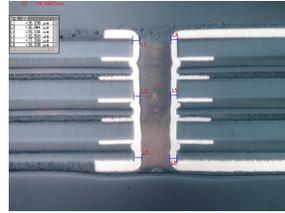
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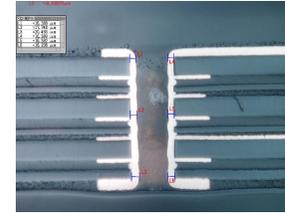
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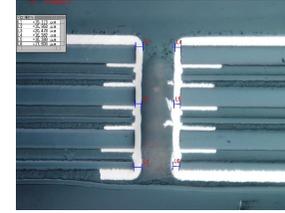
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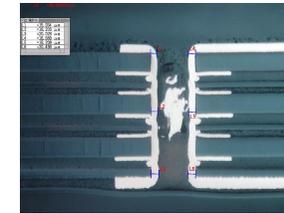
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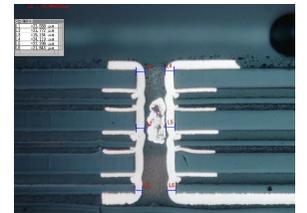
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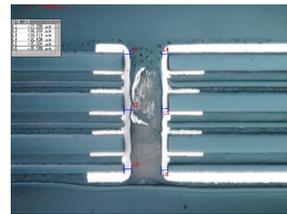
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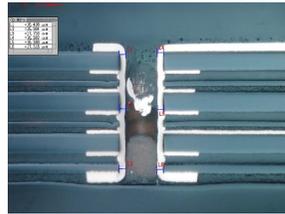
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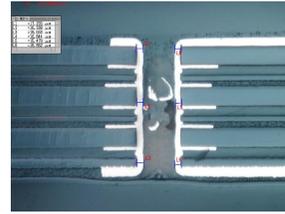
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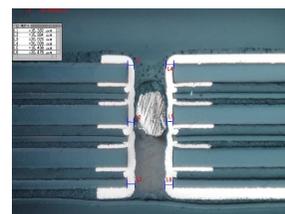
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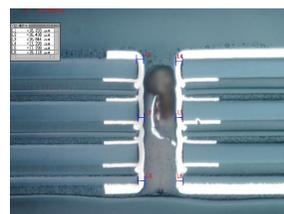
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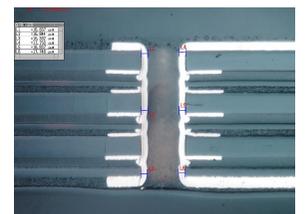
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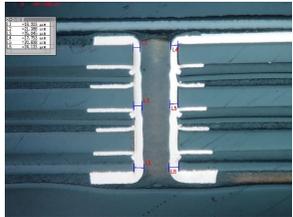
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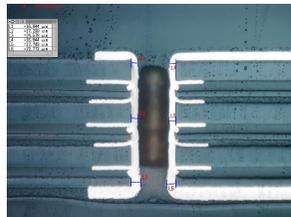
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All OK

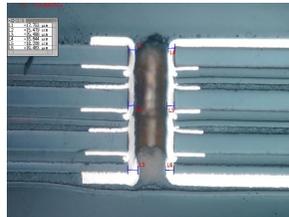
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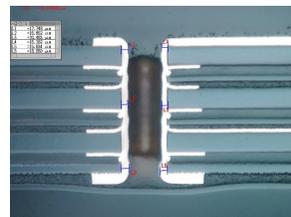
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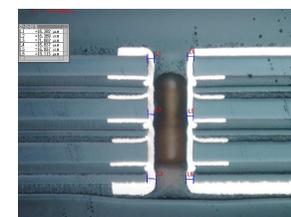
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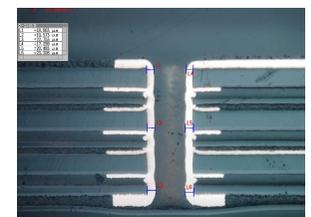
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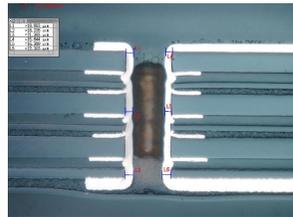
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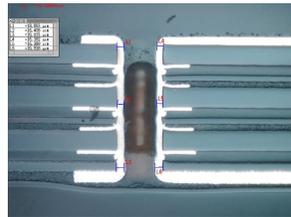
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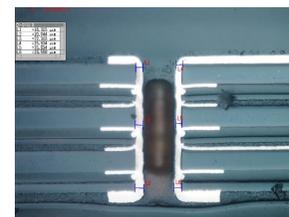
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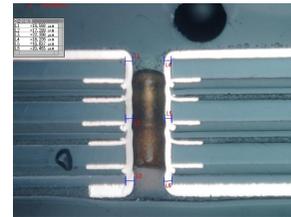
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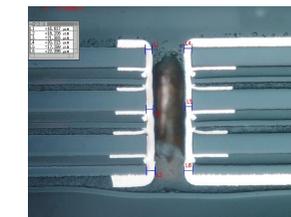
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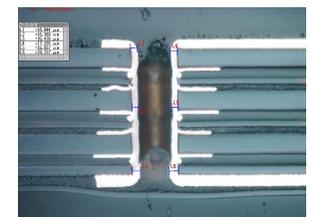
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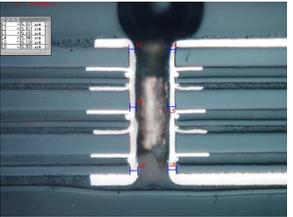
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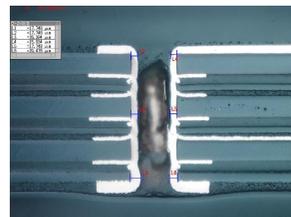
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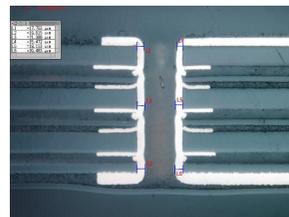
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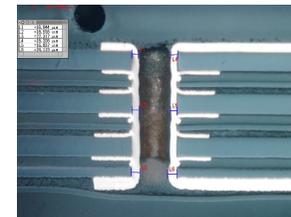
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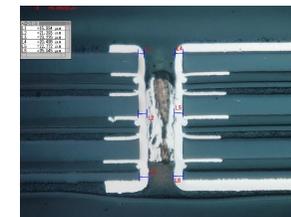
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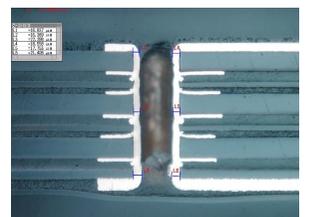
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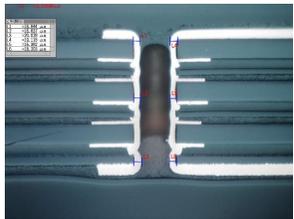
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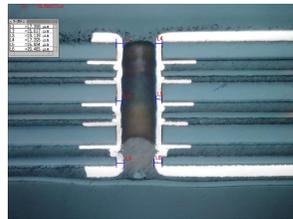
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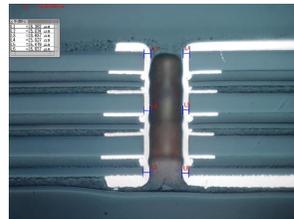
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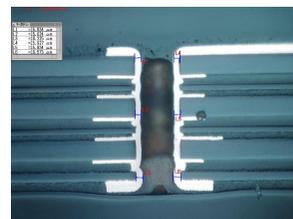
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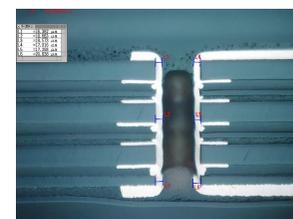
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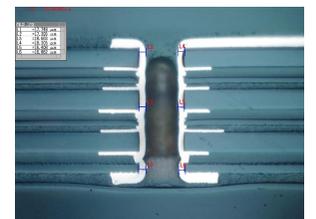
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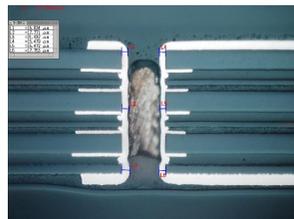
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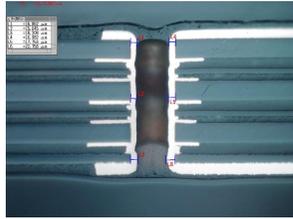
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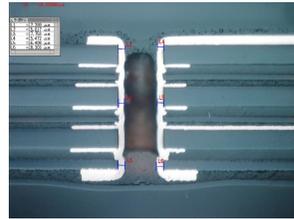
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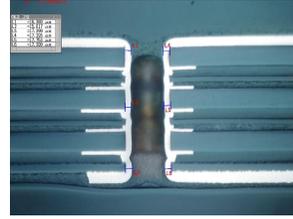
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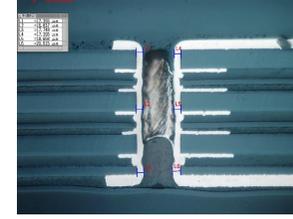
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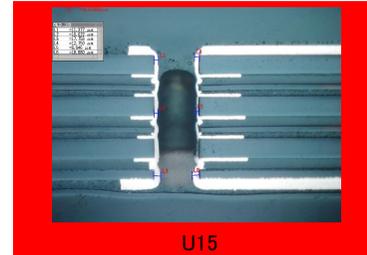
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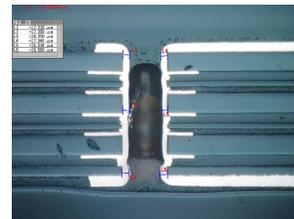
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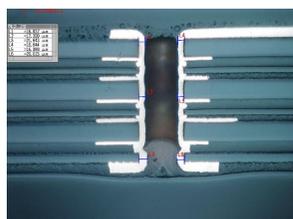
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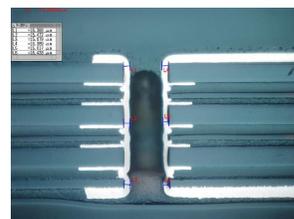
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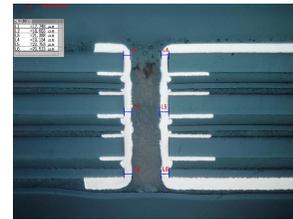
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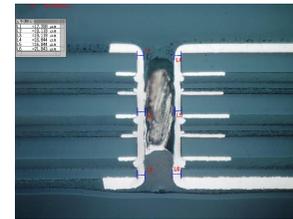
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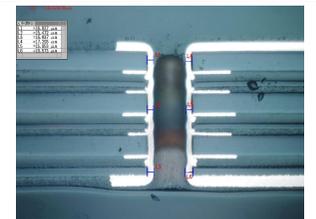
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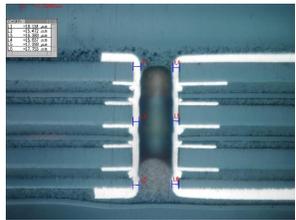
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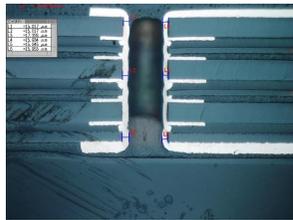
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Found one bad thruhole

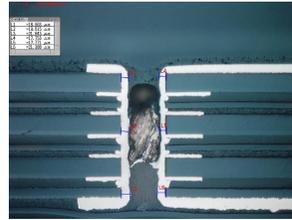
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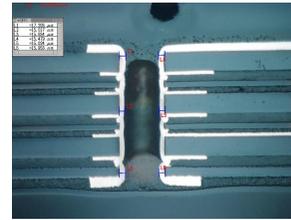
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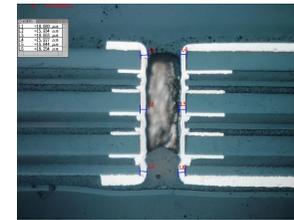
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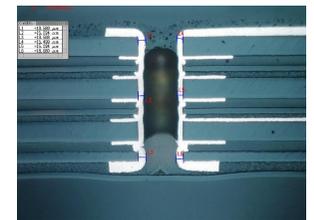
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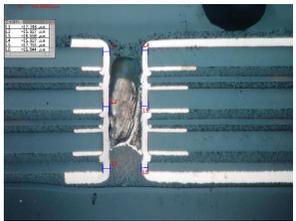
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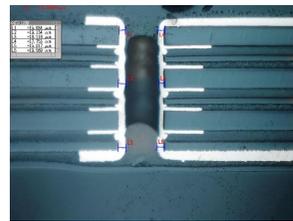
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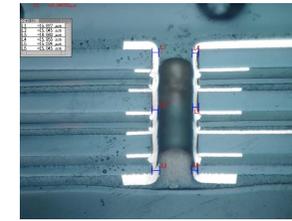
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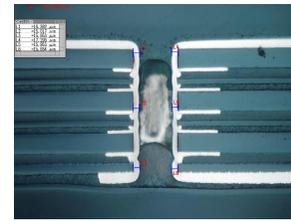
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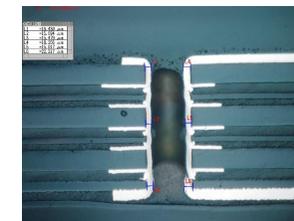
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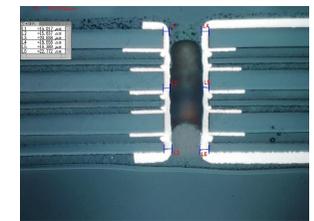
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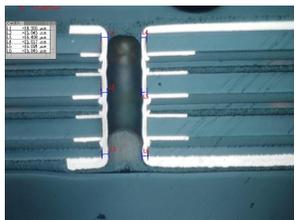
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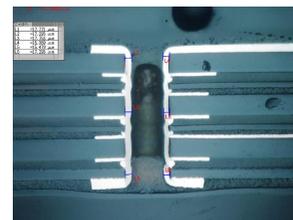
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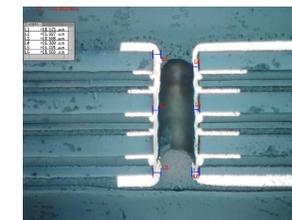
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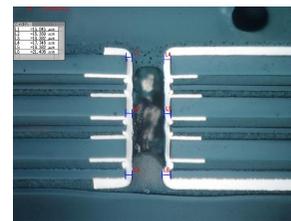
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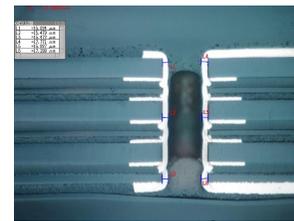
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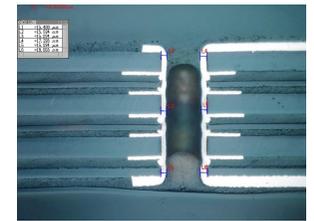
U9



U16



U17



U18

All good

Full reports are available

The screenshot shows a web browser window displaying the sPHENIX wiki page for HDI. The browser's address bar shows 'wiki.bnl.gov'. The page has a navigation bar with 'Page Discussion' and buttons for 'Read', 'Edit', 'Edit source', 'View history', and 'More'. A search box labeled 'Search sPHENIX' is also present. The main content area features the sPHENIX logo and a list of links to various reports and files. A blue arrow points to the link for 'Serial#50' in the first bullet point. The left sidebar contains a navigation menu with categories like 'Main page', 'sPHENIX detector', and 'Collaboration'. The bottom of the page includes a 'Powered By MediaWiki' logo.

SPHENIX

Page Discussion Read Edit Edit source View history More Search sPHENIX

HDI

- Yamashita co.'s Through Hole Inspection Results: [Serial#50](#), [#105](#), [#122](#), [#127](#), [#265](#)
- HDI Pre-Production and Production LOT and Serial Number Mapping File
 - 2021.4.1 Mapping File : [xlsx](#)
- Channel Mapping File:
 - 2020.9.14 Channel Map : [xlsx](#)
- HDI Design Files:
 - Schematics of FVTX's Large-HDI (The schematics for INTT HDI is basically the same as FVTX's) : [pdf](#)
 - 2020.1.30 Production (Strengthen th bias connector):[dxf](#),[pdf](#)
- 
- 2020.1.16 Bias Connector Reinforcement Request: [pptx](#), [pdf](#)
- 2018.11.16 Preproduction (DF18 Connectors are oriented parallel to longitudinal direction):[dxf](#), [garbar](#), [pdf](#), [NetList txt](#), [Component List xlsx file](#)
- 2017.03.29 Preproduction (DF18 Connectors are oriented perpendicular to longitudinal direction):[dwg](#), [pdf](#), [NetList txt](#)

This page was last edited on 19 May 2021, at 12:12.

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Delivery Day	Batch	Order #	LOT #	Quantity	HDI Serial No.	Incremented Quantity	Inspection	Inspection Result	Taiwan Observation	
2019/1/23	Preproduction	349670	302382	6						
2019/2/6		349670	302725	4						
2019/9/11		350963	306716	20						
2019/11/20		Exchanged	307469	1						
2020/4/2	Batch-1A	352075	310184	9	1	9	9			
2020/4/2		352075	310185_1	7	10	16	16			
2020/4/2		352075	310185_2	13	17	29	29			
2020/4/2		352075	310186	30	30	59	59	50	Good	Suspicious
2020/4/28	Batch-1B	352075	310188	17	60	76	76	70	bad	Suspicious
2020/4/28		352075	310189	24	77	100	100	80, 94	bad	
2020/6/8		352075	311139	2	101	102	102			
2020/6/8		352075	311587_1	7	103	109	109	105	Good	6
2020/6/17		352075	311587_2	2	110	111	111			
2020/6/17		352075	311614	15	112	126	126	122	Good	14
2020/6/24		352075	311615	21	127	147	147	127	Bad	20
2020/7/9		352075	312095	20	148	167	167	(160)		
2020/7/9		352075	312096_1	6	168	173	173			
2020/7/21		352075	312096_2_1	7	174	180	180			
2020/7/28	Batch-1A	Exchanged	312096_2_2	1	24	24	180			
2020/9/28	Batch-2	353110	312532	20	181	200	200			
2020/9/28		353110	312533	16	201	216	216			
2020/9/29		353110	312534	7	217	223	223	(220)		
2020/9/29		353110	312535	14	224	237	237			
2020/9/29		353110	312536	7	238	244	244			
2020/10/27		353110	313304	24	245	268	268	265	Good	Suspicious
2020/11/27		353110	313673	2	269	270	270			

Observation in Taiwan (LOT#310186)

	sensor ID	calibration test	HDI pads test (8 pads)	status	X error um (A/B)	Y error um (A/B)	rotate error rad (A/B)	bond	note
		NaN : not yet test G : good G* : good by different set up (in note) B : bad	G : all good serial out 1/1b 2/2b : not test	0 : pad measurement 1 : chip to HDI 2 : sensor to HDI 3 : post-encapsulation 4 : post - thermal cycle	Placing error = HDI-sensor, unit : micrometer				chip bond, sensor bond, post-encapsulation, post-thermal cycle call chip, call sensor, call encap, call thermal PCM : the placing error is corrected manually (Position Corrected Manually)
Pre 001	S14629-01, 1131	G		4				39	
Pre 002	S14629-01, 1132	G		3				0	in NWU
Pre 003	S14629-01, 1139	G		4	47.8/-41.66	18.60/15.33	5.13E-5/-3.21E-5	0	
Pre 004	S14629-01, 1142	G	G	4	-17.5/-12.04	-42.32/-37.76	-1.2e-4/6.7e-5	2	some channels of chip 14 15 are noisy.
first batch									
Module 041	S14629-01, 1134	G		4	84.86/89.53	-11.40/-27.38	4.19E-4/2.91E-4	0	
Module 042	S14629-01, 1135	G		4	44.17/12.76	-0.72/-9.63	8.9E-5/2.16E-4	0	
Module 043		B, U20 U16 empty U15 half entries	20 : slow control in r : 0.58M ohm 16 : slow control in 15 : all good serial out 1/1b 2/2b : good	1					
Module 044	S14629-01, 1136	G		4	77.91/32.73	-21.87/-11.73	6.77E-4/8.6E-4	0	
Module 045		B, U14 empty	14 Outclockb disconnected	1					U10 resetb open and U18, U24 outclk open, fixed by patches to connect opening lines to neighbor chips
Module 046	S14629-01, 1270	B, U5 U7 U15 empty	5 : resetb 7 : BCO clockb 15 : reset	2	20	5			U15 is operational if LVDS is set to 255. Module has been assembled one type A sensor for bonding test. (only assemble type A)
Module 047		B, U17 empty, U24 half entries U17 18 6 empty. U19 half (2021/01/26)	all pads are good for U17 and U24 "all" pads are checked -> all good -----20210126----- 6 : bcoclkb 18 : outclk 17 all good	1					re-bond chip U17 with new bonding parameter -> didn't help
Module 48	S14629-01, 1274	G		4	8.73/2.61	-11.49/3.63	-6.57E-5/5.32E-6	0	
Module 49	S14629-01, 1275	G		4	5.04/-9.87	-3.75/5.57	-6.14E-5/2.42E-4	0	
Module 50				0					shipped to Riken for holes test
Module 51	S14629-01, 1276	B, U2 empty		4	8.77/1.60	1.49/9.71	-7.43E-5/6.35E-5	0	encap call : chan 0 of U12 slightly noisy with bias
Module 52	S14629-01, 1277	G		3	5.19/-4.4	1.16/7.41	-1.49E-5/1.70E-4	0	
Module 53	S14629-01, 1252	G		4	11.38/4.45	-1.93/7.47	-5.47E-5/-3.86E-5	0	chip bond : some chan of some chip were re-bonded (should be no problem)
Module 54	S14629-01, 1251	G		4	7.19/3.15	-2.65/6.95	3.17E-5/-2.78E-5	0	
Module 55	S14629-01, 1250	G		3	7.92/1.96	-3.31/12.51	-1.12E-4/-4.71E-6	0	sensor call : Chan 25 of U4 is empty* sensor call : Chan 24 & 26 of U4 slightly noisy with bias 0 encap call : Chan 25 of U4 is empty
Module 56		B, U13 noisy U 10 empty		1					chip assembly : U13 glue spread, has been cleaned manually correct the sensor placement
Module 57	S14629-01, 1249	G		2	7.98/3.94	9.23/3.83	1.26E-4/-1.34E-4	0	U3 wire bond has been touched, and calibration tested to be good after touched
Module 58	S14629-01, 1248	G		2	6.53/-3.45	1.37/12.13	2.91E-5/1.60E-4	0	
Module 59	S14629-01, 1260	G		2	1.59/6.78	5.89/14.46	2.57E-4/1.06E-4	0	manually correct the sensor placement

LOT#310186

← Inspection good

Observation in Taiwan (LOT#310189, 313304)

sensor ID	calibration test	HDI pads test (8 pads)	status	X error um (A/B)	Y error um (A/B)	rotate error rad (A/B)	bond	note	
	NaN : not yet test G : good G* : good by different set up (in note) B : bad	G : all good serial out 1/1b 2/2b : not test	0 : pad measurement 1 : chip to HDI 2 : sensor to HDI 3 : post-encapsulation 4 : post - thermal cycle					chip bond, sensor bond, post-encapsulation, post-thermal cycle call chip, call sensor, call encap, call thermal PCM : the placing error is corrected manually (Position Corrected Manually)	
	B, 15 test in total : all bad : U1 U2 U4 U6 U8 U9 U14 U16 U17, 3 times bad : U3 U15 6 times bad : U5 Entries of good chips slightly less ~300 ====NCU==== U1 U2 U4 U6 U8 U9 U11 U14 U17 ====NWU====	U1 : resetb, outclk U2 : outclkb U3 : reset, slow controlinb U4 : outclkb U5 : outclk U6 : bcoclkb U8 : outclkb U9 : reset, outclkb U11 : slowcontrolin U14 : slowcontrolin, bcoclkb U15 : reset U16 : resetb U17 : outclk	LOT#310189					Placing error = HDI-sensor, unit : micrometer	
Module 070			1					in NWU	
Module 071	S14629-01, 1137	G	G	4	5.35/-7.83	-21.56/-39.9	-6.43e-5/3.09e-4	0	PCM
Module 072	S14629-01, 1145	NaN	G, For U7 and U15 "all" pads are checked -> all good	2	3.295/-9.121	1.043/4.843	-2.13E-4/-1.16E-5	5	chip to HDI : U7 & U15 half entries the pad of U7 and U15 have been tested after chip assembly (including serial out)and they are all good If we test with different conversion cable the half entries chip can be different
Module 073	S14629-01, 1141	G	G	4	8.66/-2.4	19.2/-9.68	-7.82E-5/2.5E-5	5	call : calibration good with shield, PCM
Module 074	S14629-01, 1148	B U13 empty	G	4	-3.04/-2.34	17.18/-2.01	1.68E-4/-1.17E-4	33	call : channel 112 of U18 is a little bit noisy (with shield) call post encapsulation : U13 empty call thermal cycle : U13 empty
Module 076	S14629-01, 1138	G	G	4	7.35/1.1	12.62/13.41	-1.6E-4/-5.73E-5	57	PCM
Module 077	S14629-01, 1147	G	G	4	-11.72/-7.05	10.17/9.76	-3.58E-4/-1.17E-4	0	chip : sensor side of U12 has a little glue spread PCM
Module 078	S14629-01, 1146	G	G	4	12.151/6.872	-9.175/-0.578	-2.80E-4/-1.52E-4	0	one type A guard/bias ring pads un-bounded
Module 079	S14629-01, 1157	G	G	1					
Module 024	S14629-01, 1157	G	G	4	8.17/-0.35	1.58/5.42	-1.3E-4/7.67E-5	0	U26 was touched by 連勝, tested to be good
second batch									
Module 245	S14629-01, 1140	B, U3 two-channel noisy, U22 empty, U10 half entries	U22 : bco clockb U10 : serial out 2	1					tested Dec 4th, U10 has half entries; with new power scheme of ROC, U10 has full entries 2020/12/22 : I tested 245 with LVDS 255, but it didn't help on chip 22
Module 246	S14629-01, 1140	G	G	4	46.4/43.1	8.2/11.4	-1.66E-4/-6.02E-5	6	APWR and AGND shorted on U22 chip, replaced
Module 247	S14629-01, 1143	G	G	4	-19.53/-10.09	-44.93/-86.53	-2.78e-5/1.23e-4	6	all good, except 6 unbonded channels some channels of chip U2 U3 are noisy
Module 248	S14629-01, 1143	B, chip U16 is empty after re-assemble the chip	U16 : out clckb r: 60ohm	1					U16 had replaced
Module 251	S14629-01, 1159	B, chip U18 is empty, U17 and U20 have very big noise U15 has small noise.	G						
Module 252	S14629-01, 1273	B, chip U23 is empty, U5 is noisy.	G	1					
Module 253	S14629-01, 1159	G	G	4	4.68/-1.22	-2.22/5.43	-6.43E-5/-1.08E-5	0	
Module 254	S14629-01, 1273	G	G	4	3.96/0.39	-6.39/8.29	-3.5E-5/-3.73	0	
Module 255	S14629-01, 1159	G	G	4	10.24/4.17	-0.3/6.1	-9.4E-4/-7.4E-4	0	call sensor : some channels of chip 25 are accidentally touched, calibration result : good post-encap : wire is touched
Module 256	S14629-01, 1152	G	G	4	3.07/-1.85	-4.69/1.19	-1.3E-4/7.6E-6	0	
									LOT#313304

← Inspection bad

Observation in Taiwan (LOT#313304)

	sensor ID	calibration test	HDI pads test (8 pads)	status	X error um (A/B)	Y error um (A/B)	rotate error rad (A/B)	bond	note
		NaN : not yet test G : good G* : good by different set up (in note) B : bad	G : all good serial out 1/1h 2/2h : not test	0 : pad measurement 1 : chip to HDI 2 : sensor to HDI 3 : post-encapsulation 4 : post - thermal cycle	Placing error = HDI-sensor, unit : micrometer				chip bond, sensor bond, post-encapsulation, post-thermal cycle cali chip, cali sensor, cali encap, cali thermal PCM : the placing error is corrected manually (Position Corrected Manually)
Module 257	S14629-01, 1151	G	G	4	6.8/-4.34	-4.1/4.23	-6.55E-5/-4.15E-5	0	post-encap : wire is touched encap cali : is bad Thermal cali : all good
Module 258	S14629-01, 1150	G	G	4	0.28/3.55	-1.26/5.71	-9.73E-5/-1.8E-4	4	leave the type B pick up tool on the sensor after pick and place.
Module 259	S14629-01, 1149	G	G	2	6.51/5.71	-1.35/10.85	-1.41E-4/-7.09E-5	0	
Module 260		B chan 0 ~ 31 of U4 are bad	G	1					
Module 261	S14629-01, 1154	G	G	4	11.78/-3.33	-3.12/5.21	-1.05E-4/-4.58E-5	0	
Module 262	S14629-01, 1144	B, chip U12 is bad	G	4	4.82/-14.74	3.56/2.84	3.38E-4/-1.29E-4	6	chip cali : first and last test are all good, rest tests : U12 empty (in status 1) sensor cali (with bias) : chip 1, chan 19 empty. Thermal cali: chip U12 bad
Module 263	S14629-01, 1155	G	G	4	7.69/-9.48	-2.15/4.81	-1.2E-4/1.4E-4	0	
Module 264	S14629-01, 1156	B, chan 126 U3 empty. 125 & 127 noisy (w/ bias) chan 95, 125 of U16 empty. 96, 117, 124, 126, 127 of U16 noisy (w/ bias)	G	4	1.24/-7.31	-3.26/3.99	-5.1E-5/7.5E-6	5	Encap glue on sensor Encap cali : bias voltage current: 10uA (short on typeB, has checked still don't know the reason) Thermal cali : high bias current : ~13uA. 5 We manually damage the wire bond of U16 try to fix the high bias problem. -> 5 channel disconnected

LOT#313304

Module 265

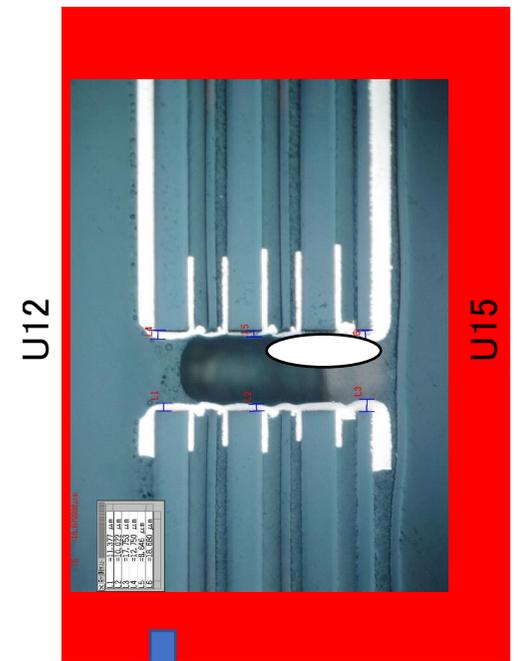
← Inspection good

Discussion

- Although some open thruholes observed in Taiwan, all 26 thruholes inspected in Yamashita showed good quality for the HDI from the same LOT.
- There are 1500 thruholes per HDI and 26 sampling inspection is not sufficient to come across bad thruholes. What we learned is just the upper limit of the bad thruhole rate.
- Given the fact large effort to inspect XS of thruholes and consuming time, we shouldn't continue this sampling inspection for a little gain.

Cause of bad thruhole

- Low quality drilling process.
- Residual etching liquid in multiple soft etching process made the copper plating thinner.
- Left over bubble in the thruhole prevented the copper plating on the upper part of the thruhole.
- Often the case the trouble is caused by the tight aspect ratio (100 μm diameter vs. 450 μm depth.)



Dipping to etching liquid

How to improve?

- Low quality drilling process.
 - Review drilling parameters and optimize again.
- Residual etching liquid in multiple soft etching process made the copper plating thinner.
 - Consider coating surface for easier exhale of etching liquid from a thruhole.
- Left over bubble in the thruhole prevented the copper plating on the upper part of the thruhole.
 - Likely some bubble is generated by swirl of etching liquid in the plating tank. Try to use alternative production line which is considered to be relatively rather swirl free.
- Often the case the trouble is caused by the tight aspect ratio (100 μ m diameter vs. 450 μ m depth.)
 - There is no way to improve this rather than changing the design. This is not the intrinsic solution though, try to apply 30~60% thicker copper plating in increase the survival rate.

Where we are?

- Yamashita has hypotheses though, they haven't been able to find the smoking gun yet.
- Yamashita continues to inspect Module-70 adjacent thruholes to see any geological trends.
- However, we decided to move on for replacement fabrication without waiting for these further investigation.
- Requesting heat cycle before their all-channel conductivity check to reduce the rate to pass their QA. In other word, we'll let fragile copper plating break and force them to fail the QA to prevent bad HDI to be delivered.
- Proposed heat cycle: $-45\sim 125^{\circ}\text{C}$ for 144 cycles (ramp time & interval 2 minutes, respectively) is under negotiation. Can be moderate the condition.

Replacement Plan and Schedule

- 100 HDI's to be produced at Yamashita's cost for now.
- Approximately 20 HDI's per LOT are to be processed and to be delivered for each LOT.
- Thicker copper plating is to be tested by the end of May. The first LOT will be delivered to RIKEN by June 28th.
- Requesting heat cycle for all HDI's before delivery. Under negotiation.
- We will proceed open line check as Itaru proposed in May 5th Meeting and provide feedback to Yamashita to keep improving the fabrication quality.
https://indico.bnl.gov/event/11410/contributions/48374/attachments/34114/55521/210506_HDIThurholeEvaluation.pdf
- We will throw out all HDIs in the LOT if we find more than 2 open lines.
- Yamashita will continue improvement reflecting our feedback and keep processing LOTs beyond 100 HDIs until we assemble 112 good ladders.