X-Ray Inspection of Flip Chip Assemblies

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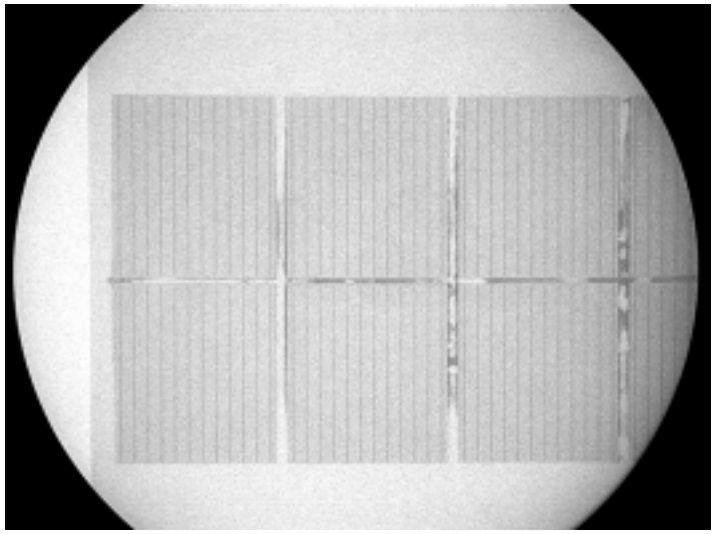
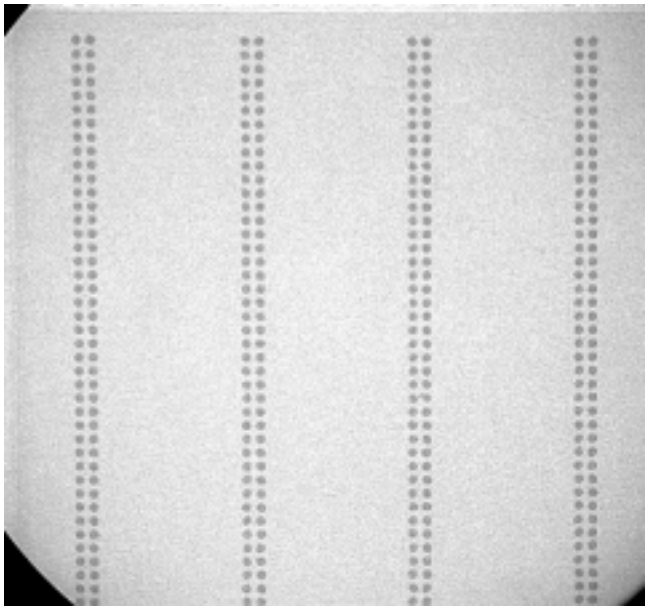
LBNL

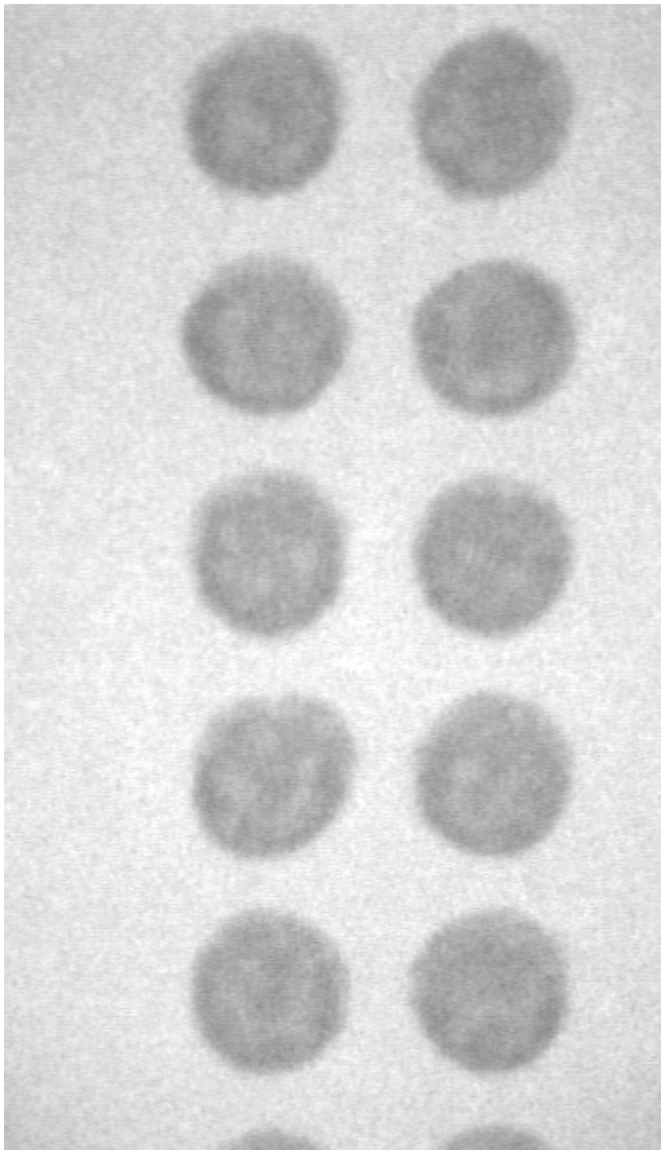
X-Ray Source

- X-Ray inspection from X-Tek
  - Model VTX
    - 2 micron resolution
    - 1800 X magnification
    - Large area, precision x-y table, with rotation
  - www.xtek.co.uk
  - Inspection services offered
    - Local office near LBL
    - Allow us to use equipment after short training to do inspection.
    - They will also do inspection
  - Very easy to use

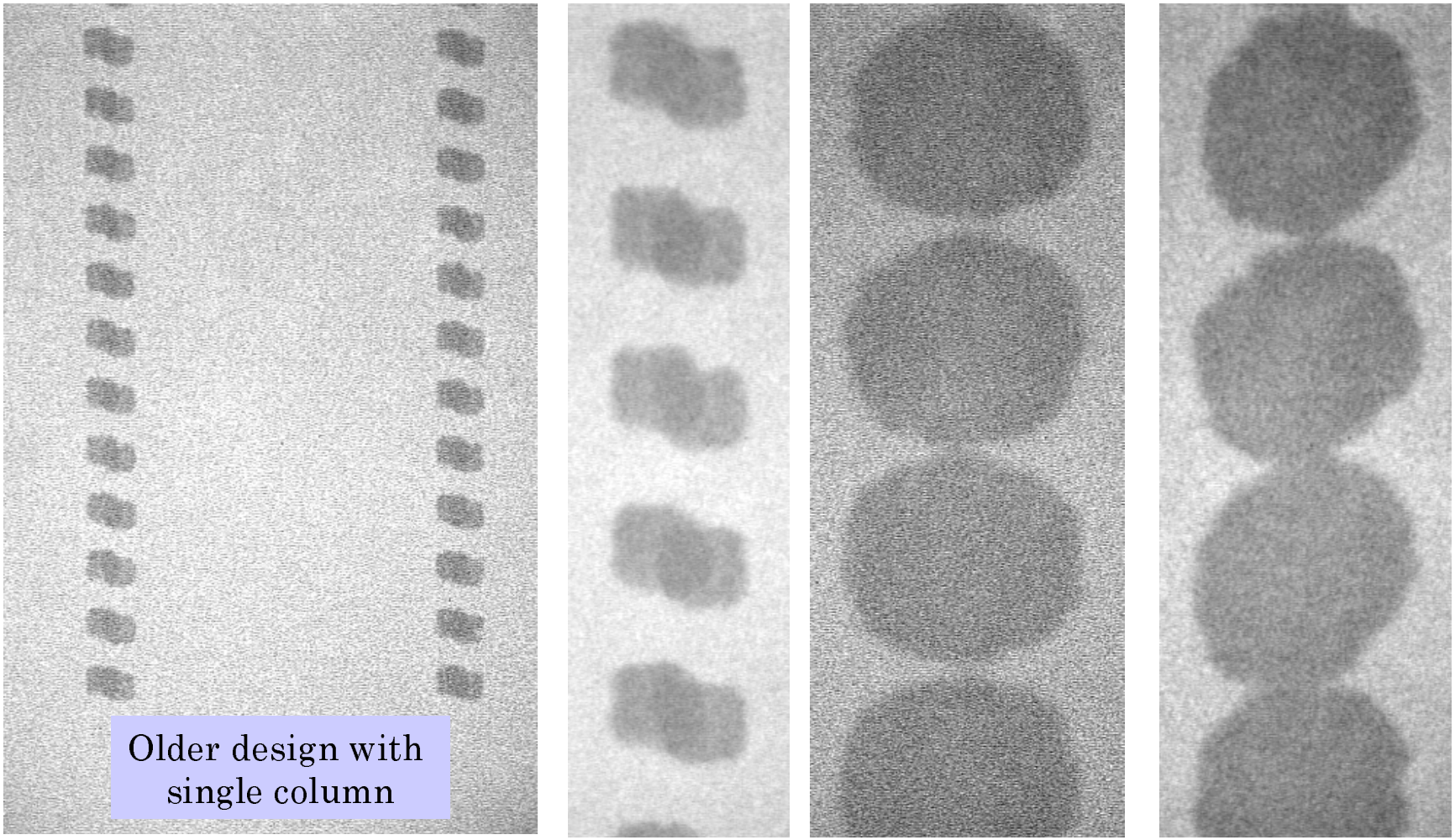
Seiko Solder Bump Dummy 16-Chip Module





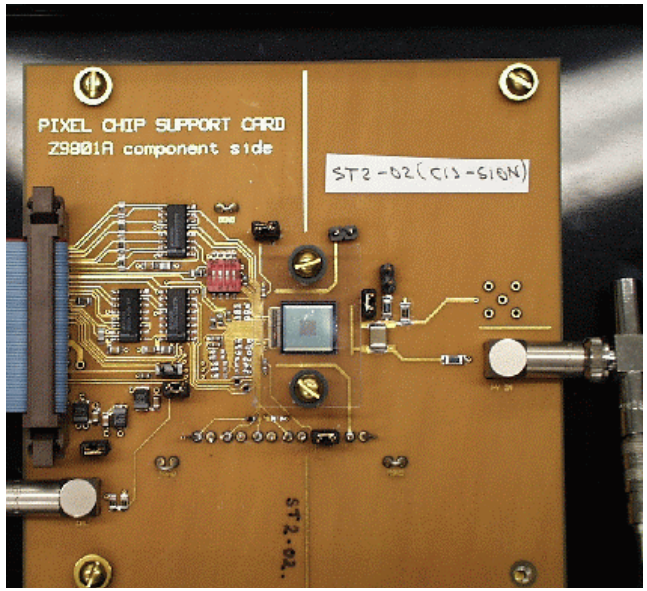


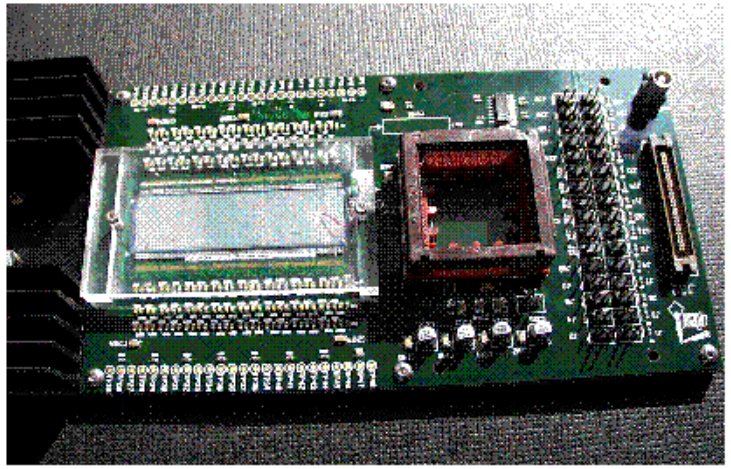
Boeing Indium Bump Dummy 16-Chip Module



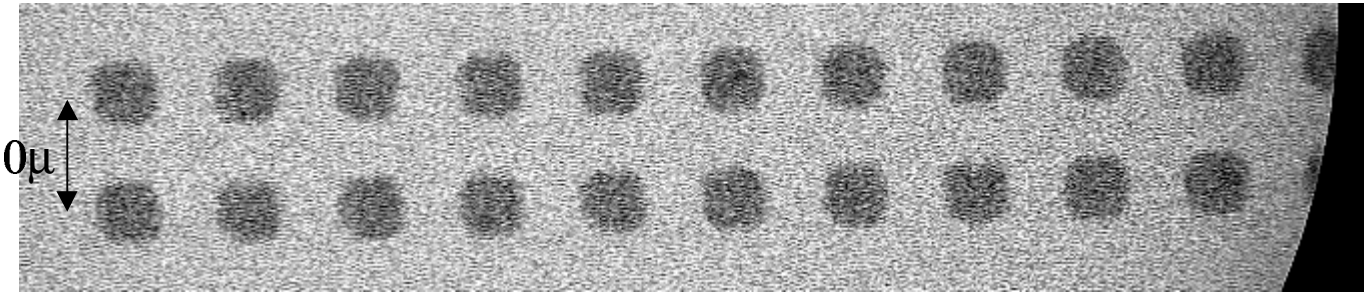
Active Devices

- Bare die(indium bumps)
- Unmounted single-chip assembly(both solder and indium)
- Single-chip assemblies on PC boards
- Full 16 chip module on PC board and aluminum plate

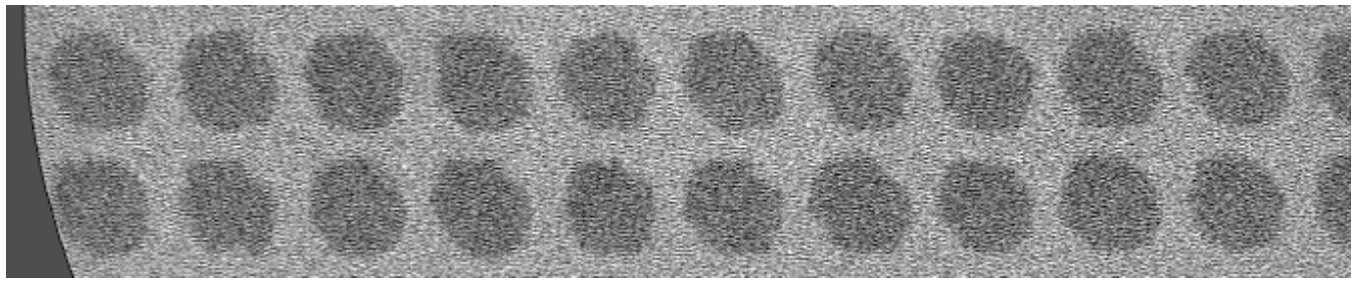




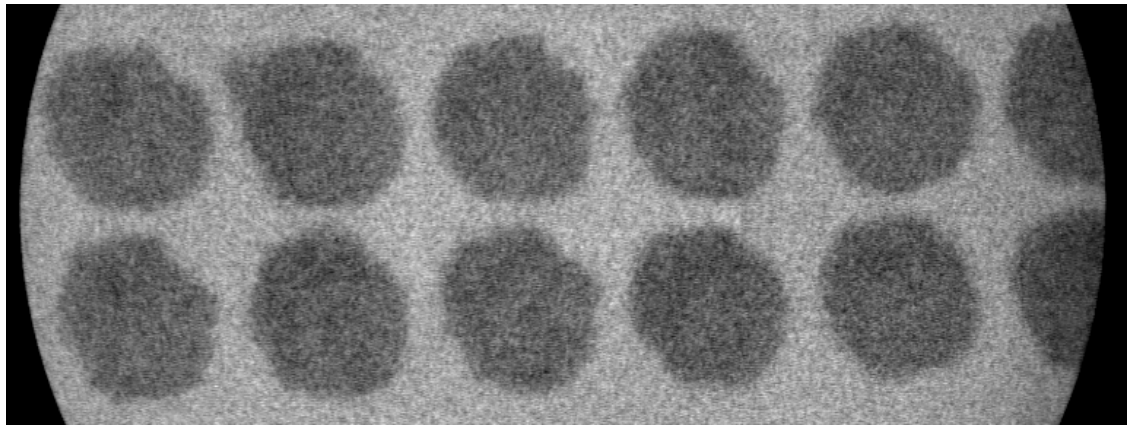
Bare Die and Single-Chip Assembly(Indium Bumps)



Bare indium die before flip-chip assembly

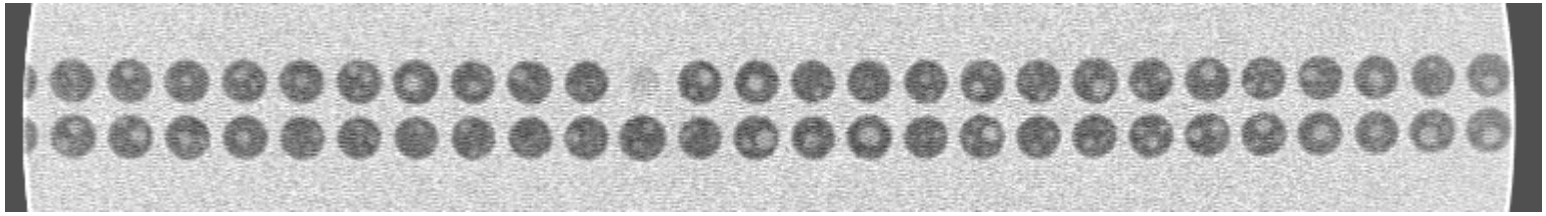


Single-chip assembly with indium(SCP)

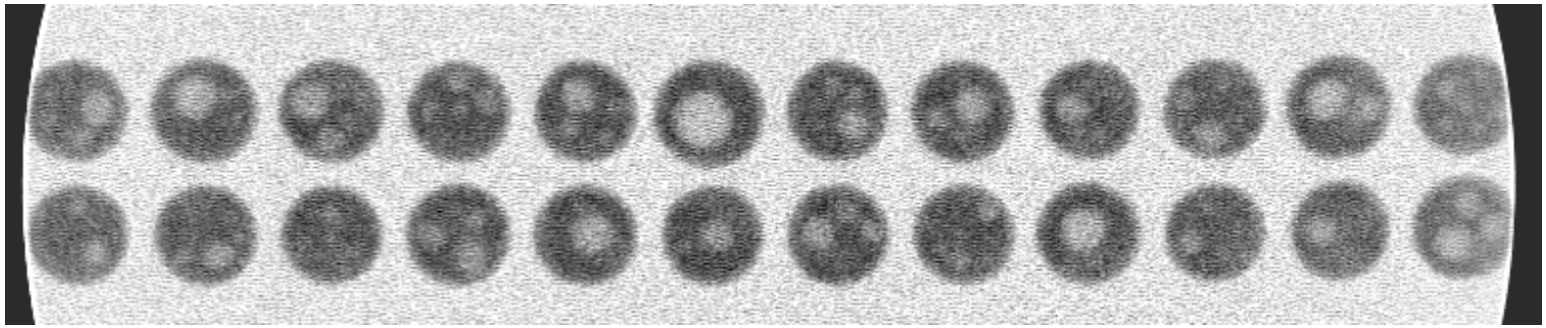


Same as above but higher magnification

Single-Chip Assembly(IZM Solder Bumps)



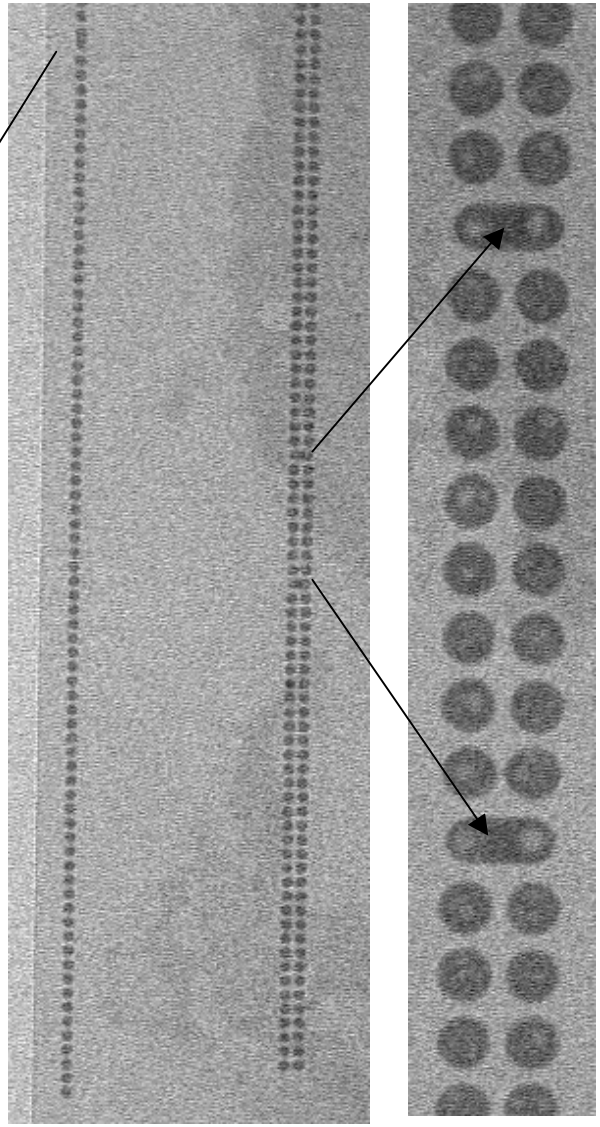
Region with missing bump



Higher magnification - notice voids

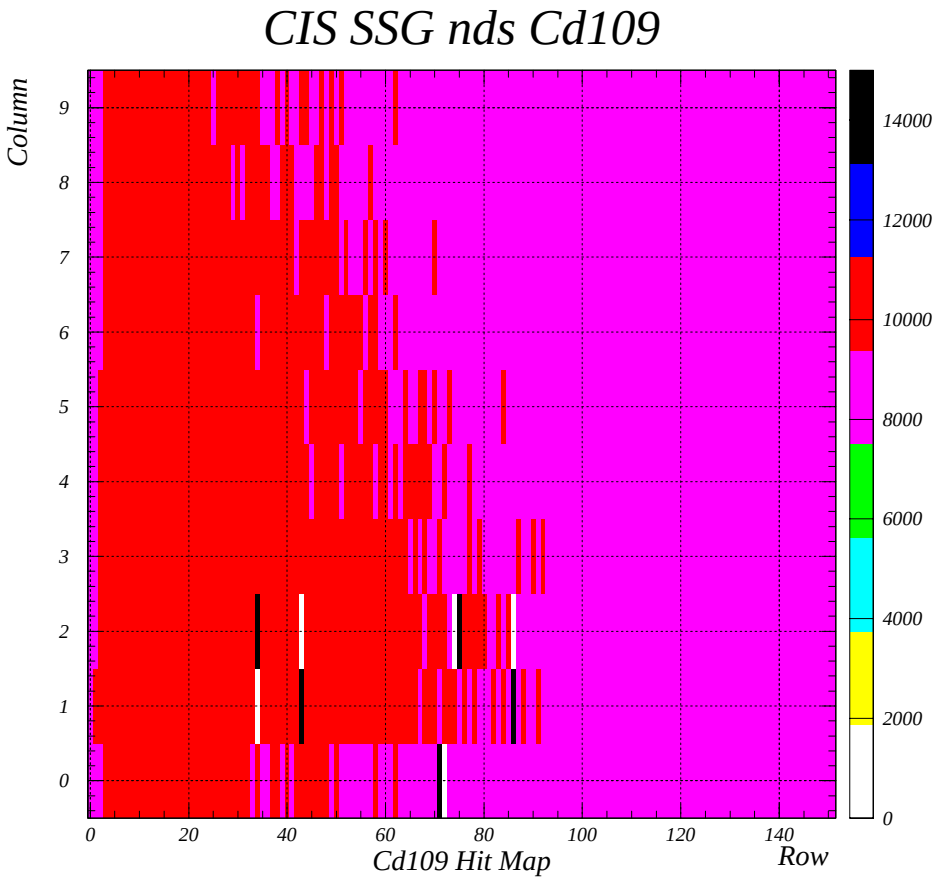
Active Devices - SSG(Solder Bumps)

Column 0



Column 0 and 1-2

Column 1-2

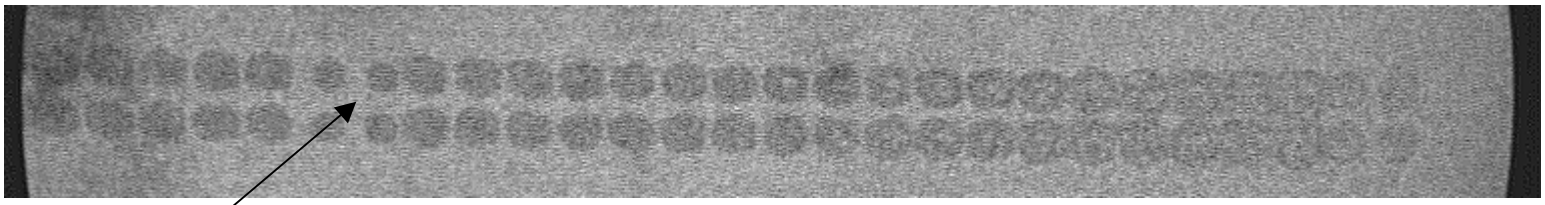


Complete correlation between pairs of dead and double rate channels with bridged bumps

Active Devices - S80(Indium Bumps)

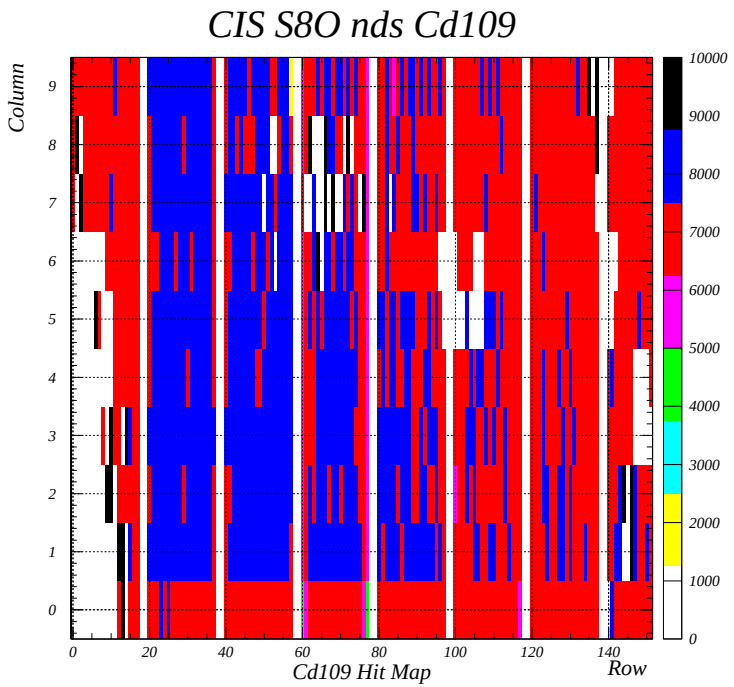
Column 0
Rows near 0

Merged bumps



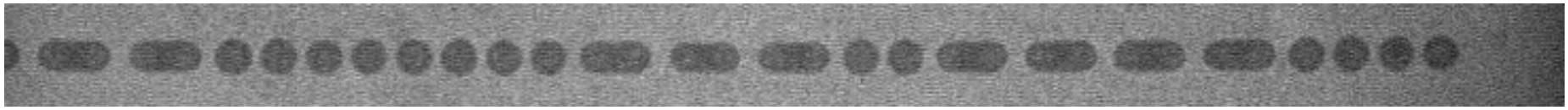
Columns 1-2
Rows near 0

Unattached region

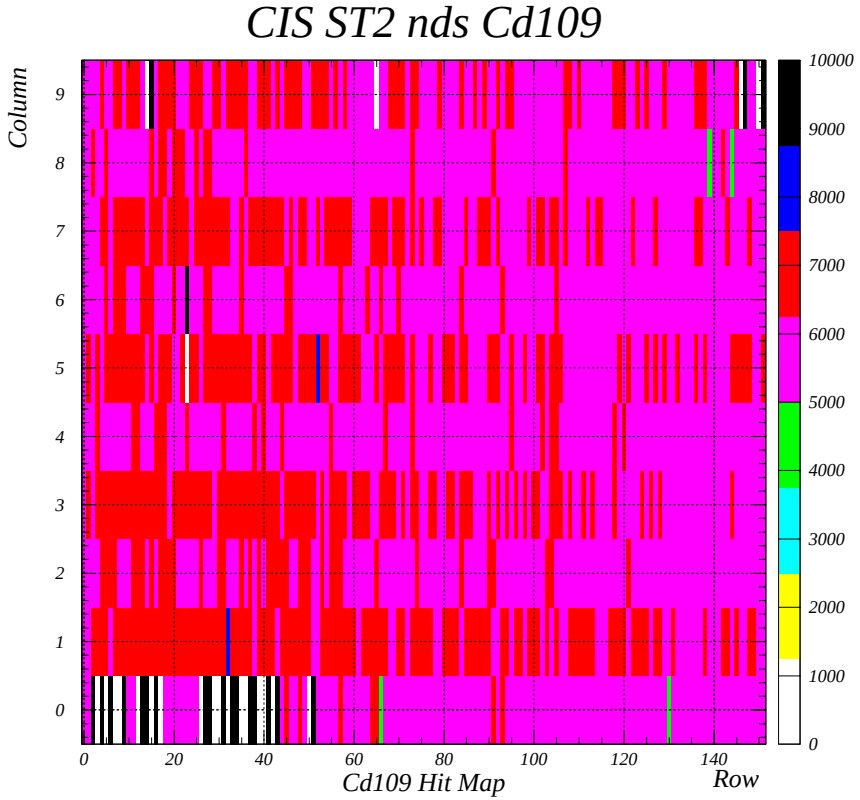


M. Gilchriese -February 1999

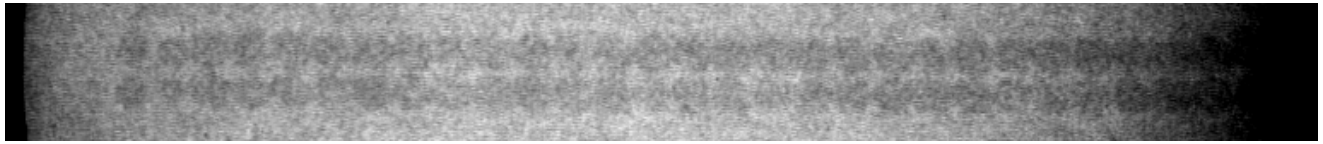
Active Devices - ST2(Solder Bumps)



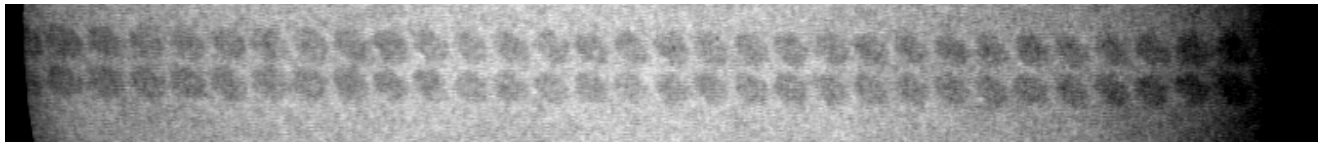
Merged bumps in column 0



Module(Indium Bumps)



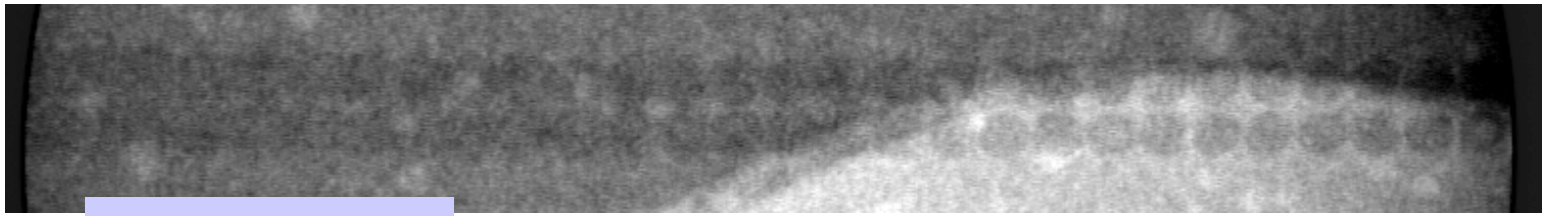
Chip 4 column 3-4 bad region



Chip 4 column 3-4 good region

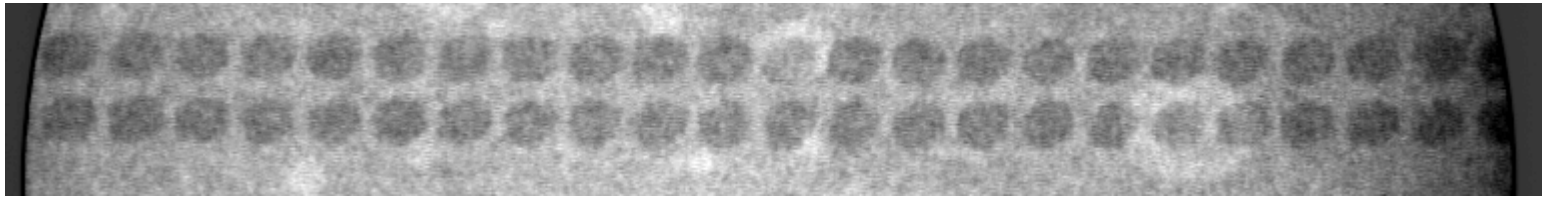
- Resolution not as good with module on top of aluminum plate
- But still clear correlation between dead channels and regions of merged/bridged bumps
- Simple mechanical modifications to support would be needed to improve resolution - mill out hole in plate.

Diamond Devices



CDS62
columns 7- 8

Merged bumps

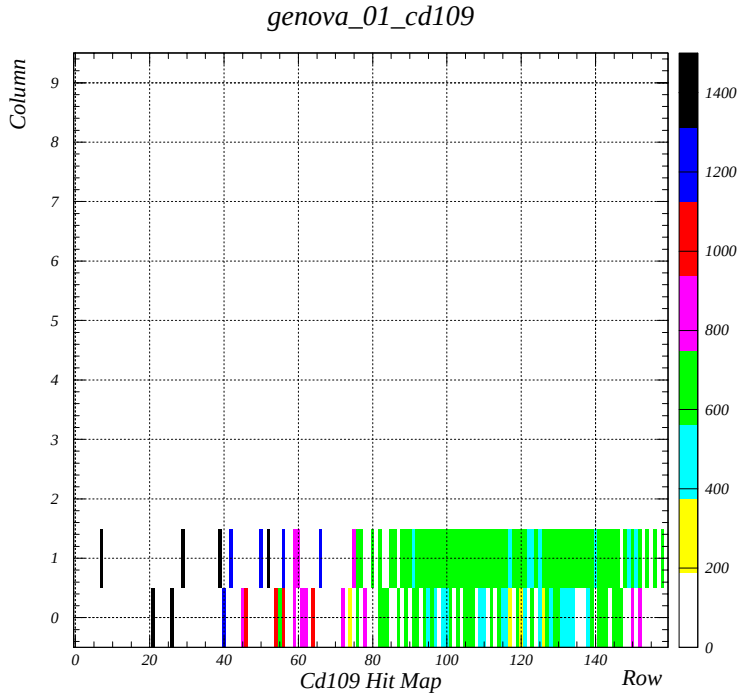


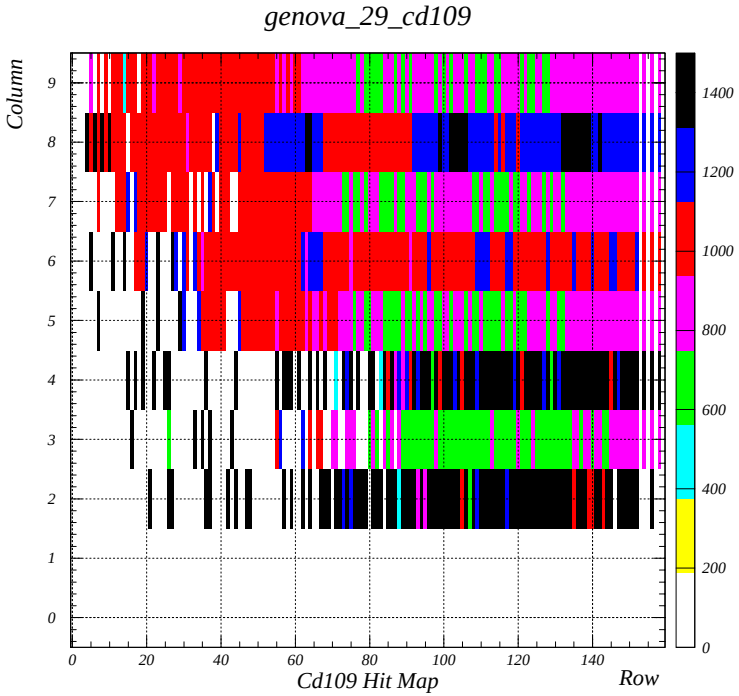
CDS62
columns 3-4

- Two diamond assemblies - CDS61 and CDS62
- Both show same feature of region of merged bumps near center of die.
- Diamond not flat - local region. Need to measure flatness before bumping.
- There was some indication of this already from person doing original lithography for photoresist.
- However, this does not readily explain why most(almost all) of channels are not responding. Most of bumps look OK away from center.

Alenia/Genoa Assembly

- Single chip assembly with indium bumps from Alenia and flip-chip assembly at Genoa. Mounted PCB. Glued on and type of glue makes X-ray contrast poorer.
- Alenia indium bumps are about 50% of height of Boeing indium bumps
- Assembly is noisy, unstable - not clear why. Also seems to have regions of dead channels. Hard to do all of chip with source.

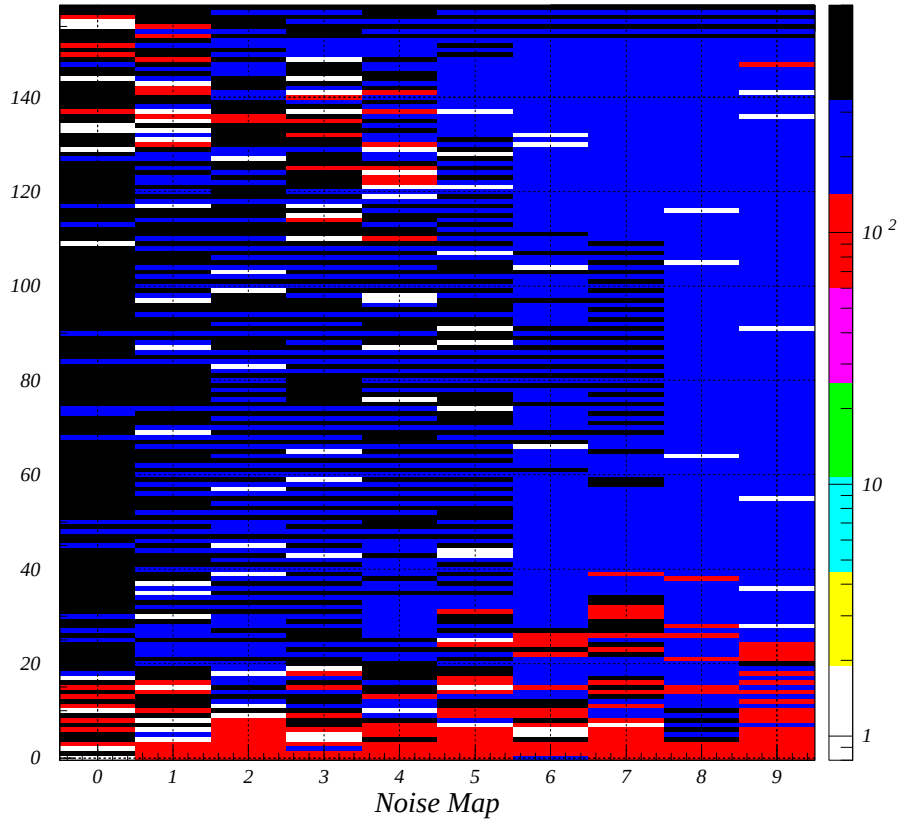




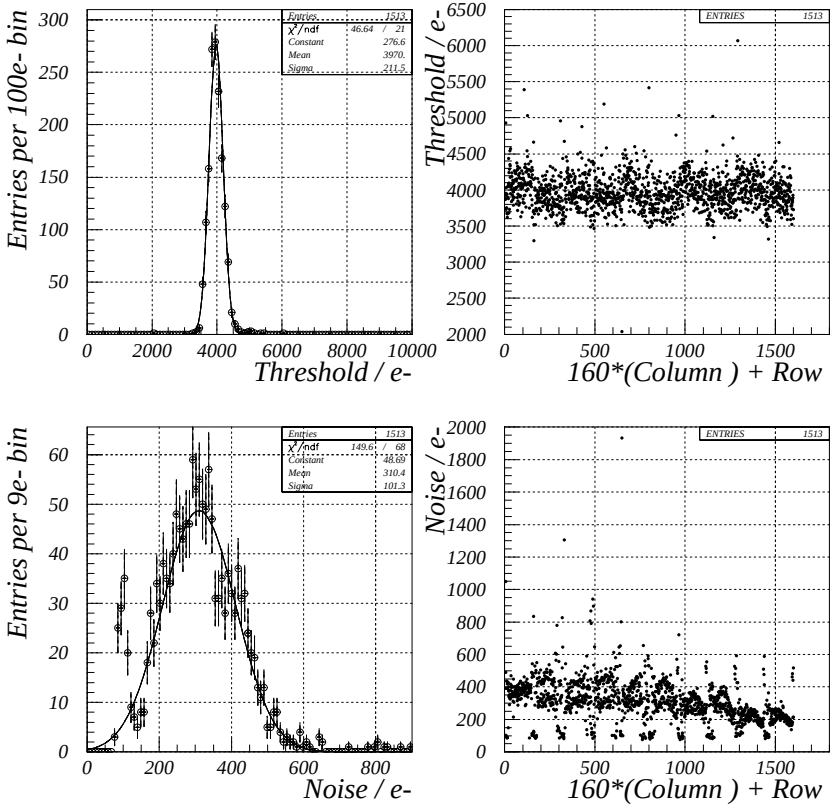
Alenia/Genoa Assembly

- Noise measurements. Correlation? Lower noise for unconnected channels.. Maybe.

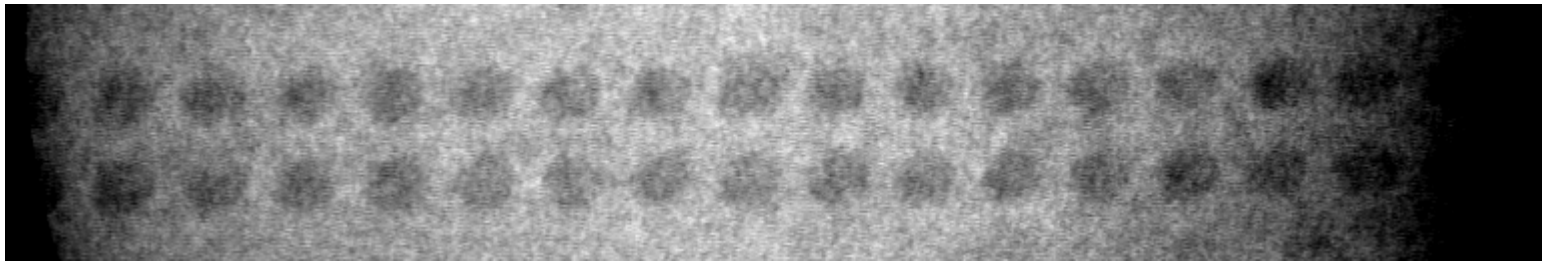
genova_2880



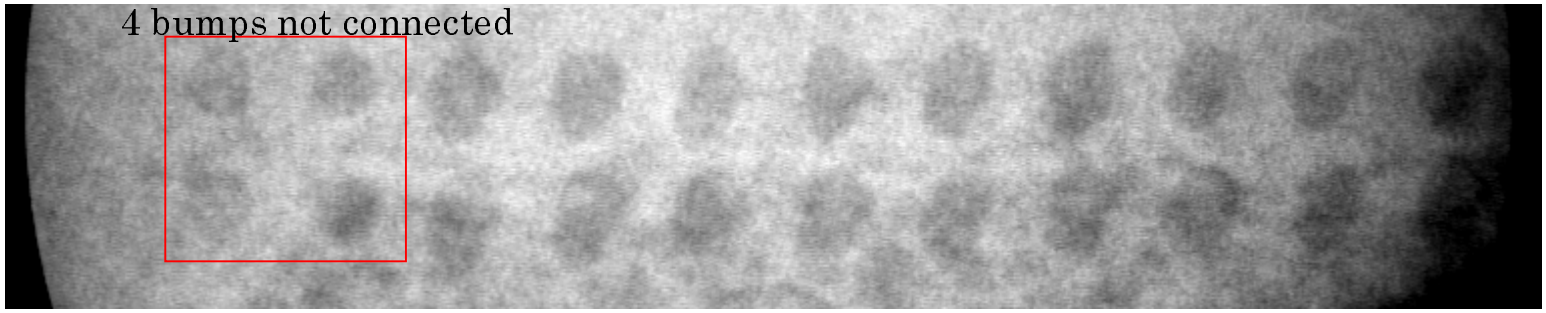
genova_2880



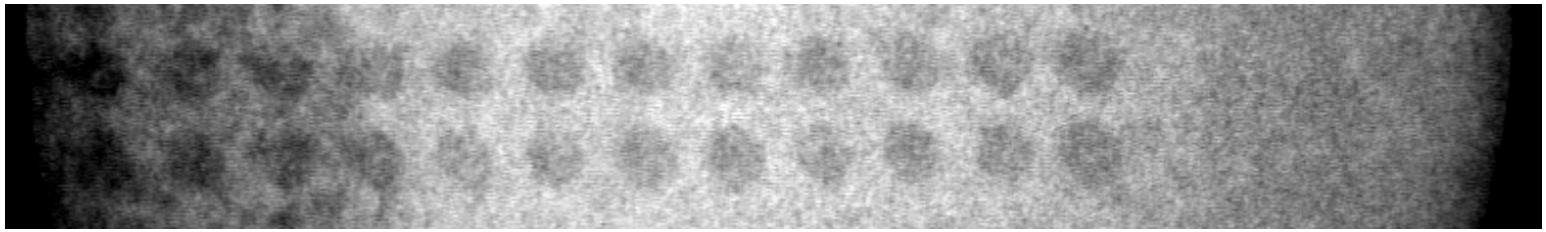
Alenia Assembly X-Ray



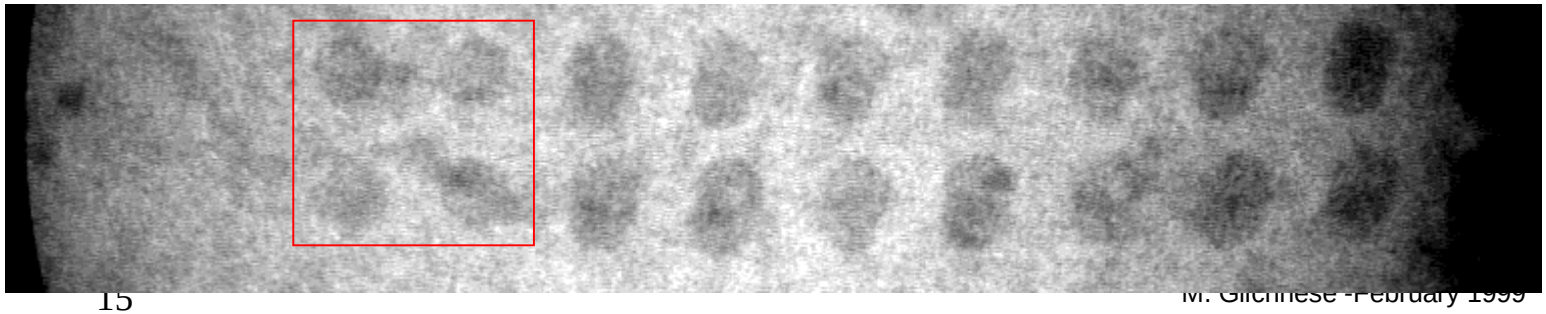
Column 1-2
Near row 120
Working region



Column 5-6
Near row 0
“Dead” region
Misregistered?



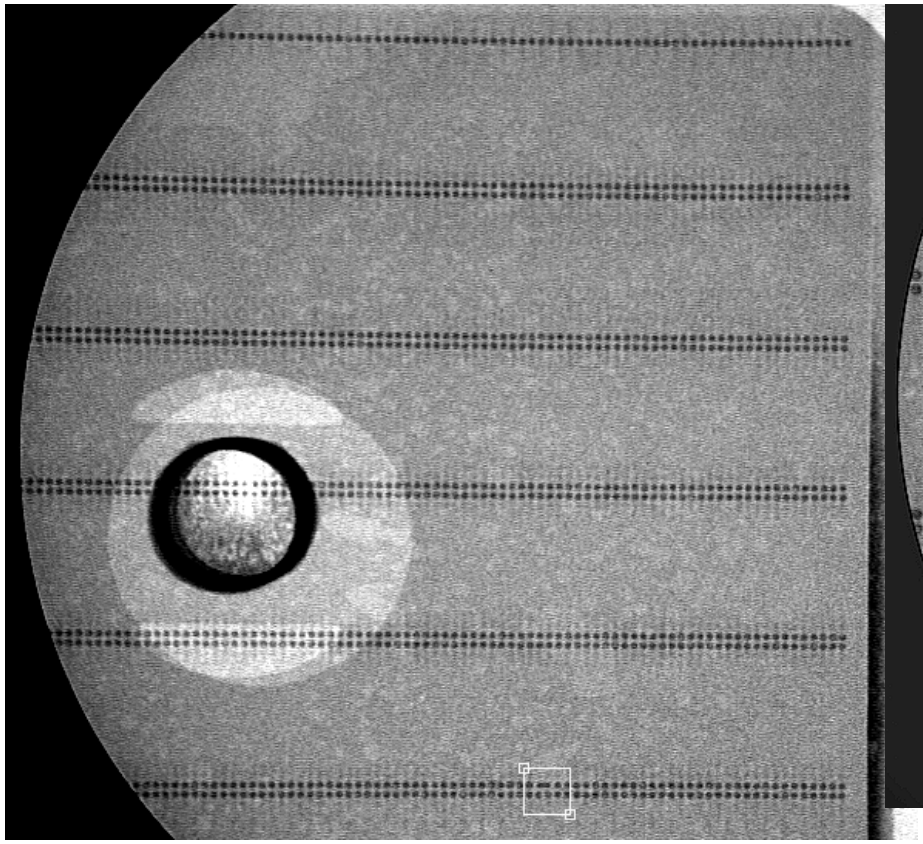
Column 5-6
Near row 160
Working region
Mag. Changed
from above



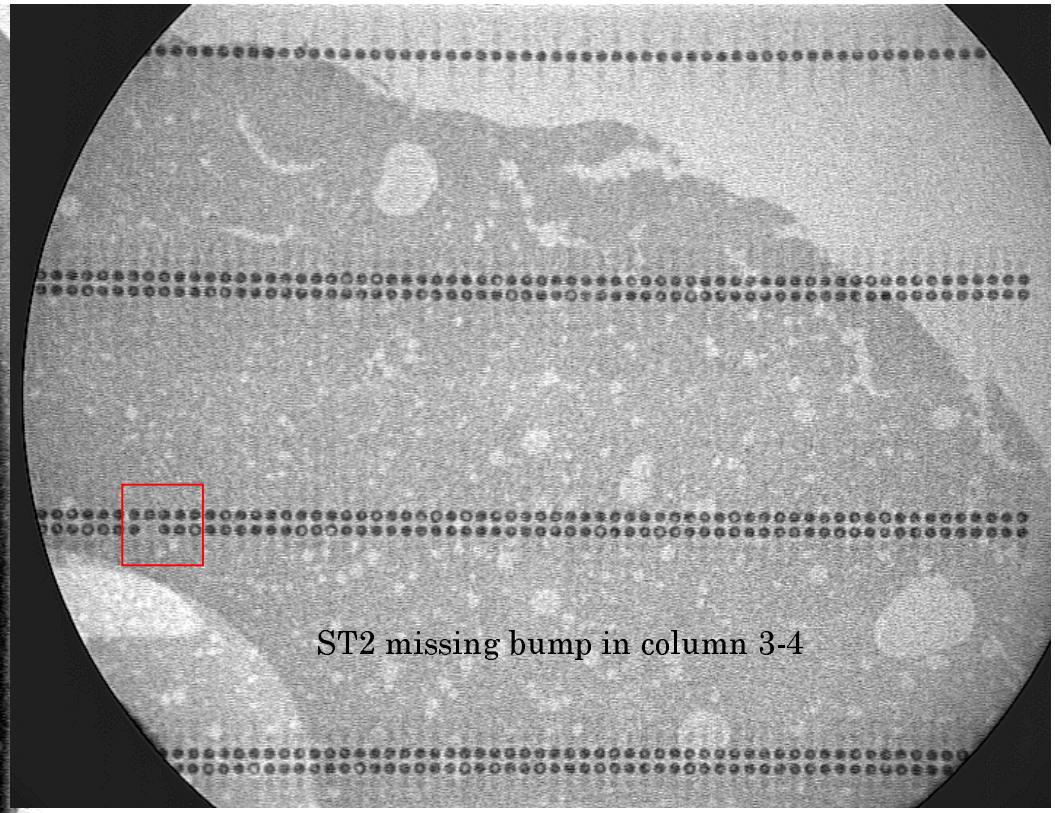
Column 7-8
Near row 0
“Dead” region
Misregistered?

MCM-D Assemblies

- ST1 and ST2 assemblies.
- Missing bumps and bridged bumps observed - need to be correlated with source scan. Bridged bump seen correlated with dead channel in calibration,

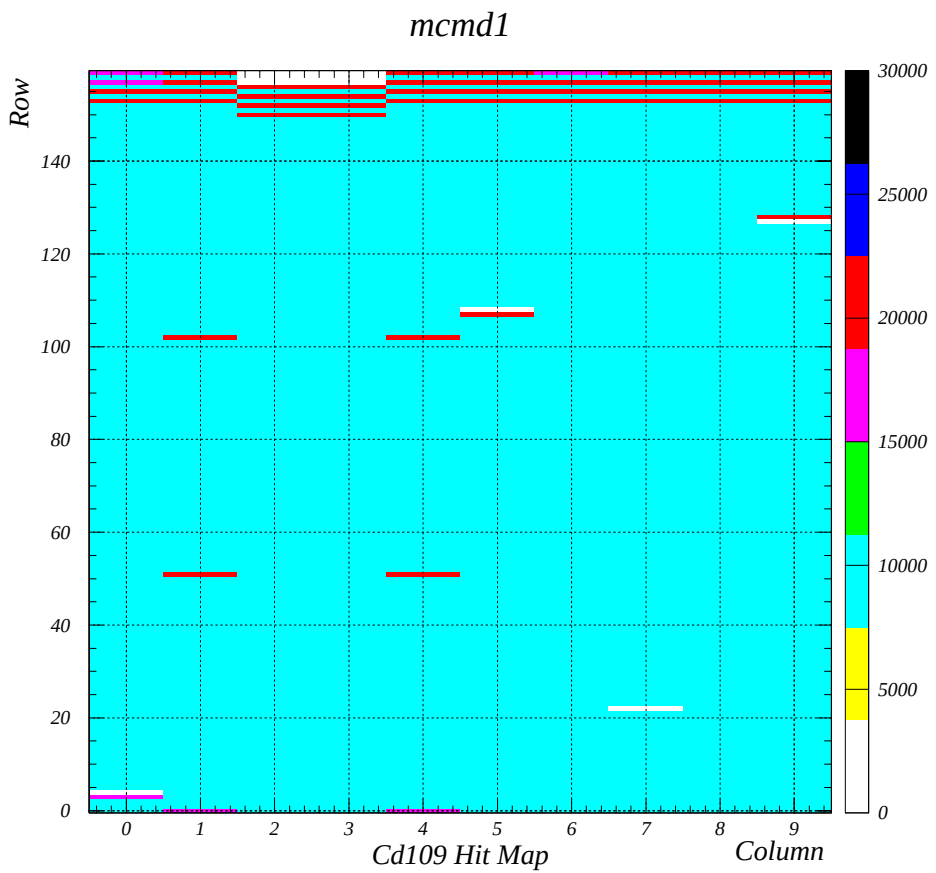


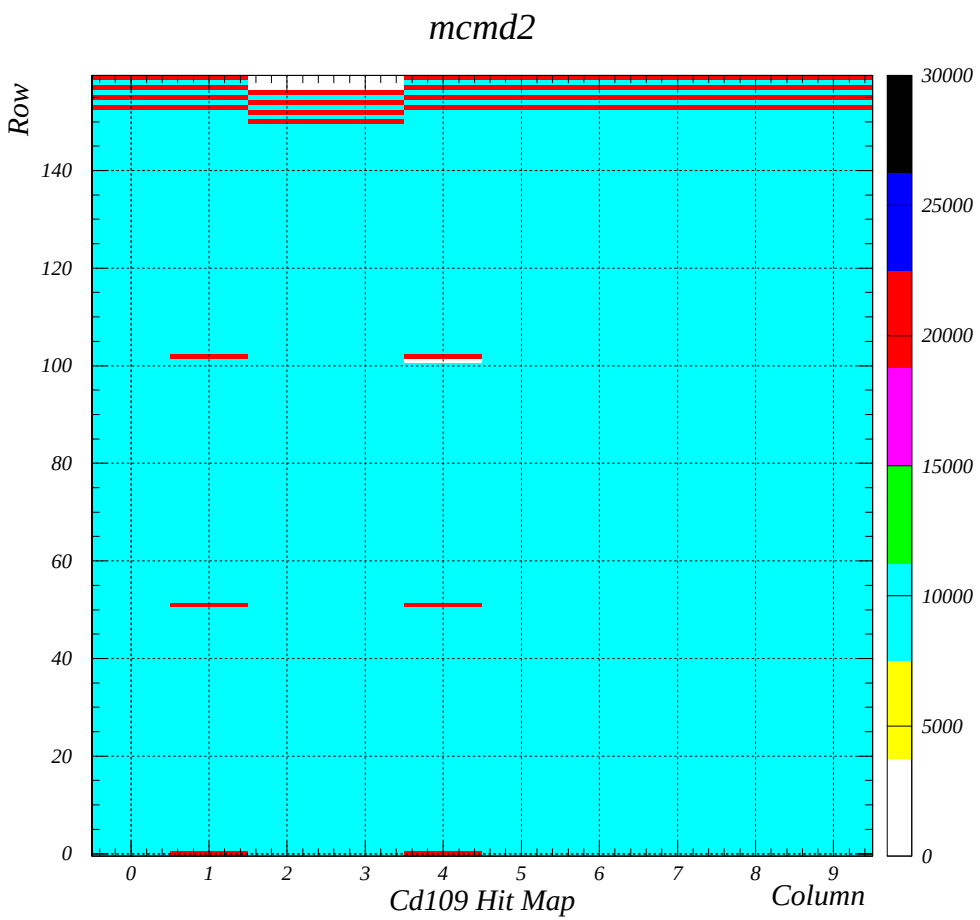
ST1 - note bridge bump in column 9



ST2 missing bump in column 3-4

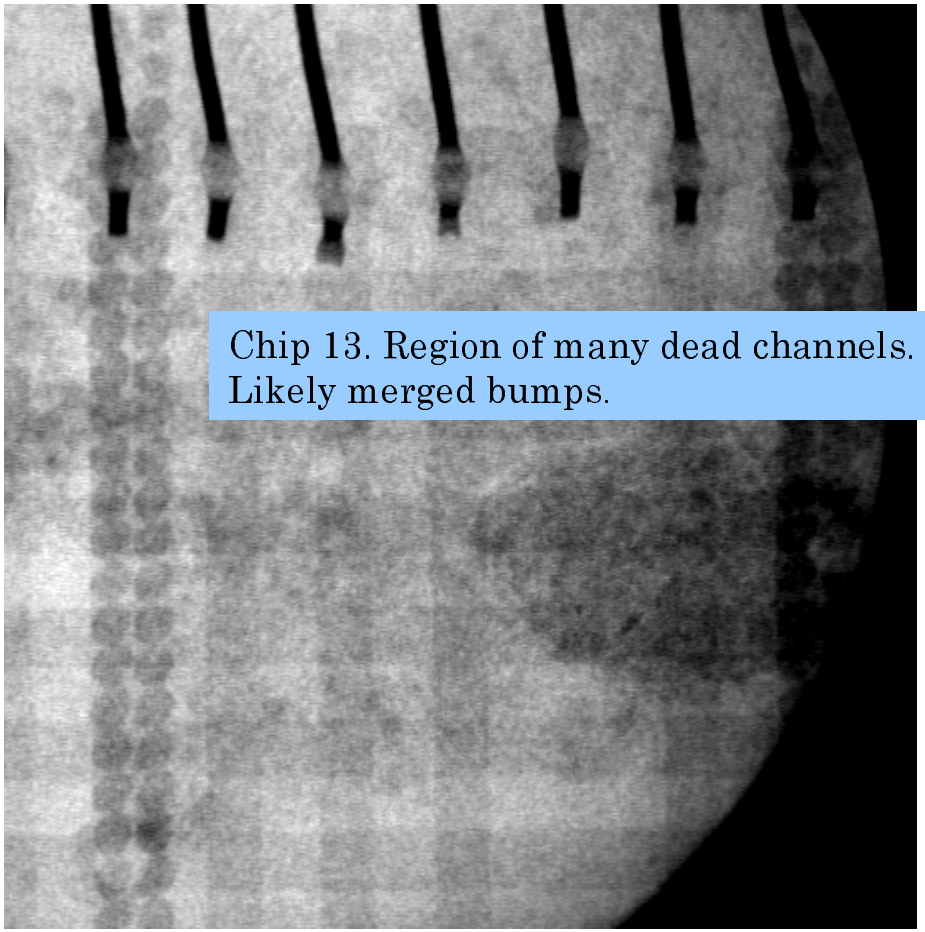
MCM-D Source Maps



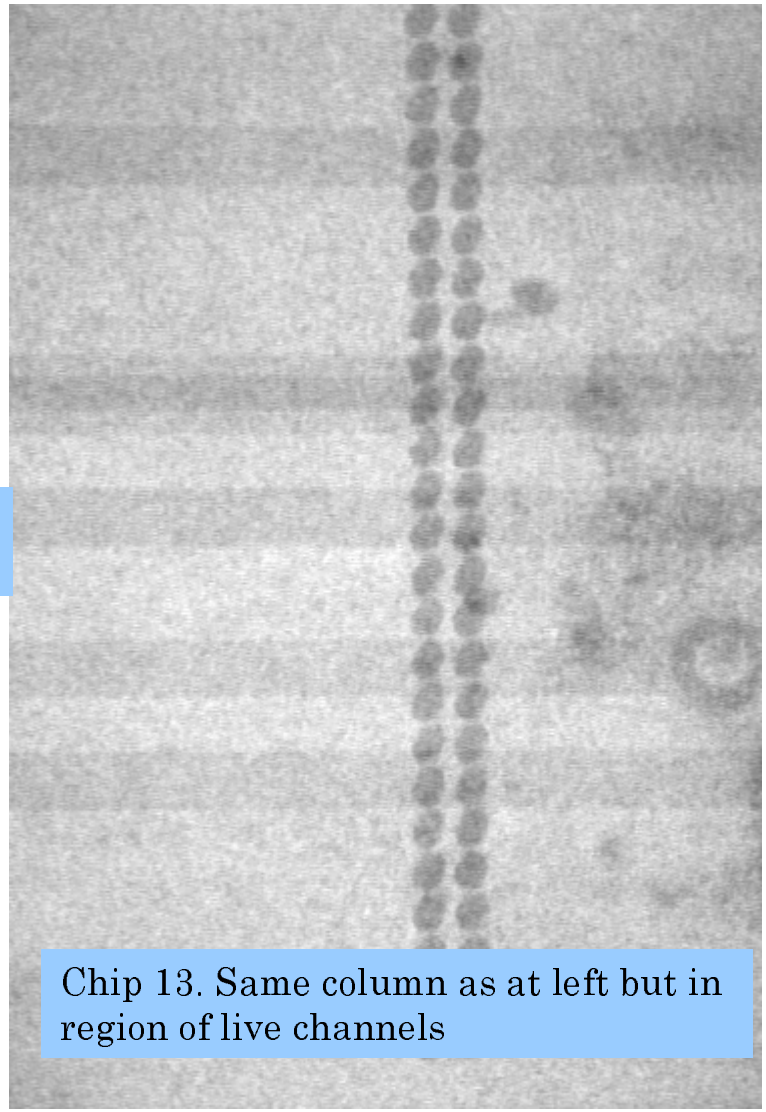


Flex Module

- Boeing indium bumps. Mostly see dead regions correlated with merged bumps. Still need to do more correlation with source scan.



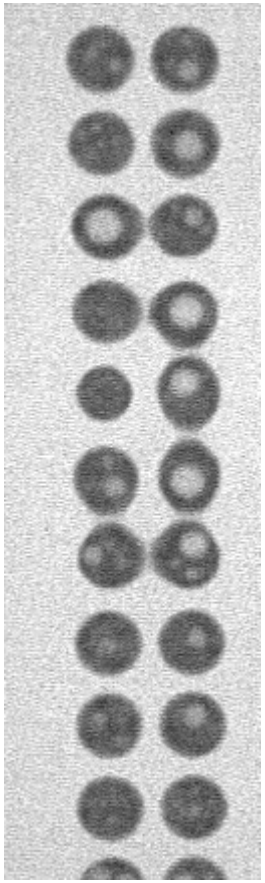
Chip 13. Region of many dead channels. Likely merged bumps.

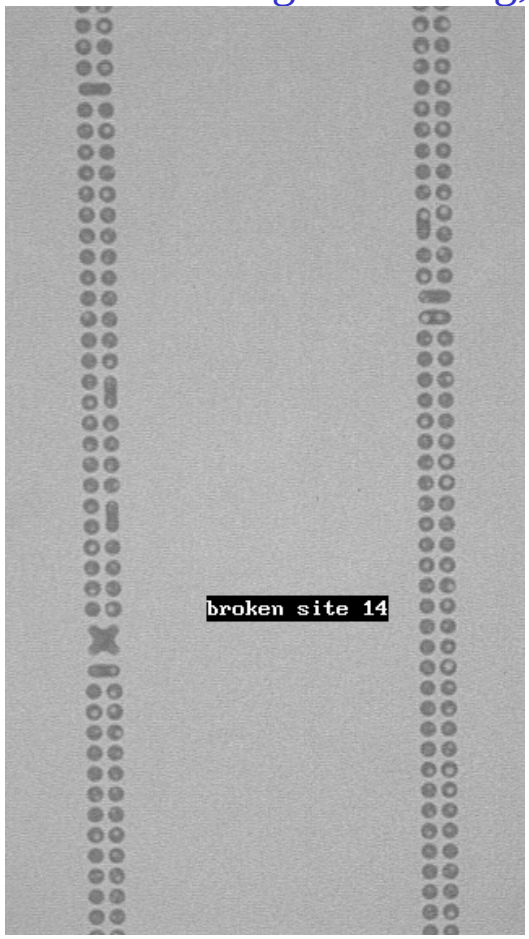


Chip 13. Same column as at left but in region of live channels

IZM Bare Modules

- Looked at module broken during shipment and undamaged module. Both are bare.
- Scanned for bridges and missing. May miss some bridges(see 1st picture). Able to scan with module in gelpak.
- Assuming defects =2*bridged+missing, rate is 1-2%.





Die	Broken		Good	
	Bridged	Missing	Bridged	Missing
0	7	1	15	0
1	0	1	20	0
2	0	1	3	0
3	10	0	6	0
4	26	0	8	1
5	2	0	52	0
6	2	0	23	0
7	2	0	3	0
8	46	0	27	0
9	5	0	3	0
10	24	1	16	0
11	44	0	31	0
12	106	0	3	0
13	35	0	10	0
14	43	0	3	0
15	------	------	42	2
Total	352	4	265	3
Defects	708		533	
% defects	1.6%		1.2%	

M. Gilchriese -February 1999

Conclusions

- Boeing indium flip chip assembly shows “slippage”. Possibly similar evidence for Alenia/Genoa but much more statistics needed.
- Solder flip-chip(at single assembly level) appears better but first look at modules shows defect rate 1-2%, a bit high.
- Demonstrated diagnostic tool for evaluation of flip chip assembly problems
- Simple mechanical modifications would allow higher resolution
- Can this be used to scan bare modules in production?
  - Yes
  - Can easily program automated step/stop/look sequence(but look only by eye)
  - Need real estimate, but guess would be 15-30 min per module with proper setup and experience.
  - The average module production rate is supposed to be about 30 per week => roughly two days per week of inspection to keep up.
- X-TEK is UK company. Capability also exists in Europe.
- There are other potential vendors to explore.