DCA15MA019

Attachment #3 to Group Chairman’s Electronic Devices and Flight Data Factual Report

Integrated Electronics Engineering Center (IEEC) Report

Author: Stephen R. Cain

Prepared for the National Transportation Safety Board

DCA15MA019

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Prepared for the Nation Transportation Safety Board

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Section 1

Overview and Summary of Results

Personnel and Methods

- All analyses were performed by Stephen Cain, IEEC, 607-777-5467
- Instruments
  - ✓ Optical microscopy
    - ➢ Wild M420 zoom stereoscope
  - ✓ X-ray
    - ➢ Fein Focus FXS 100.23
    - ➢ Tube set to 65 – 80 kV
    - ➢ 255 integrations
  - ✓ Sonic imaging – SamTec Evolution II
    - ➢ Done only when X-rays were good
    - ➢ 50 MHz transducer
    - ➢ Pulse echo mode
- Samples received (IEEC added label to the bags)
  - ✓ 1 Card
    - ➢ 1 processor
    - ➢ 16 memory modules
    - ➢ Back to back configuration
  - ✓ 2 flash memory units
    - ➢ 1 processor
    - ➢ 2 memory modules
    - ➢ Back to back configuration
- Handling to avoid ESD
  - ✓ Grounded wrist strap
  - ✓ Metal tweezers

Results for Contents of Bag 1

Front	Optical	X-Ray	C-SAM	Likely Data Retrieval
U19	Cracked	Good	Cracked die	Poor
U20	Cracked	Good	Cracked die	Poor
U21	Good	Good	Good	Good
U22	Good	Good	Good	Good
U27	Cracked	Good	Cracked die	Poor
U28	Cracked	Good	Cracked die	Poor
U29	Broken	Broken wires	Not done	Poor
U30	Cracked	Broken wires	Not done	Poor

U21 and U22 are the only memory modules on the card for which data recovery is recommended

Back	Optical	X-Ray	C-SAM	Likely Data Retrieval
U23	Thin crack	Good	Cracked die	Poor
U24	Broken	Suspect wires	Not done	Poor
U25	Good	Good	Cracked die	Poor
U26	Cracked	Good	Cracked die	Poor
U31	Cracked	Broken wires	Not done	Poor
U32	Badly cracked	Broken wires	Not done	Poor
U33	Badly cracked	Broken wires	Not done	Poor
U34	Badly cracked	Broken wires	Not done	Poor
U15	Good	Good	Good	NA

U15 is a Sand Force 2281 processor (probably no useful data)

Results for Contents of Bag 2 and Bag 3

Bag 2	Optical	X-Ray	C-SAM	Likely Data Retrieval
U1	Good	Good	Likely OK	Fair
U3	Fine crack	Good	Good	Good
U5	Good	Good	Good	NA

U5 is a Silicon Systems processor

Bag 3	Optical	X-Ray	C-SAM	Likely Data Retrieval
U1	Cracked	Good	Cracked die	Poor
U3	Cracked	Broken wires	Not done	Poor
U5	Cracked	Broken wires	Not done	NA

U5 is a Silicon Systems processor

Bag 2

- U3 is recommended as a candidate for data recovery
- U1 may also work, but successful data recovery is questionable

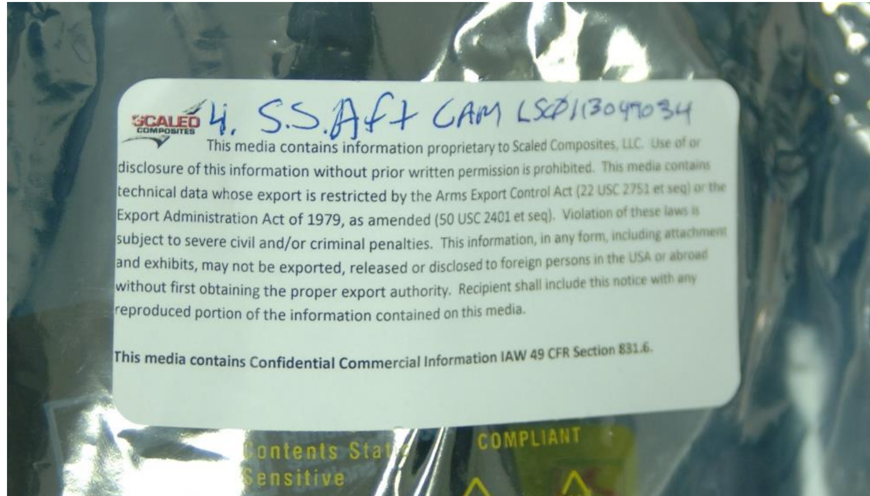
Bag 3

- Data recovery from this memory device is unlikely

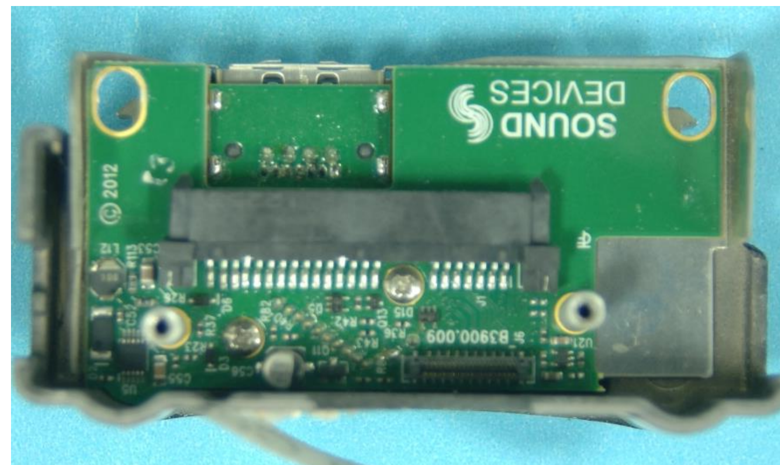
Section 2

Catalog of Contents

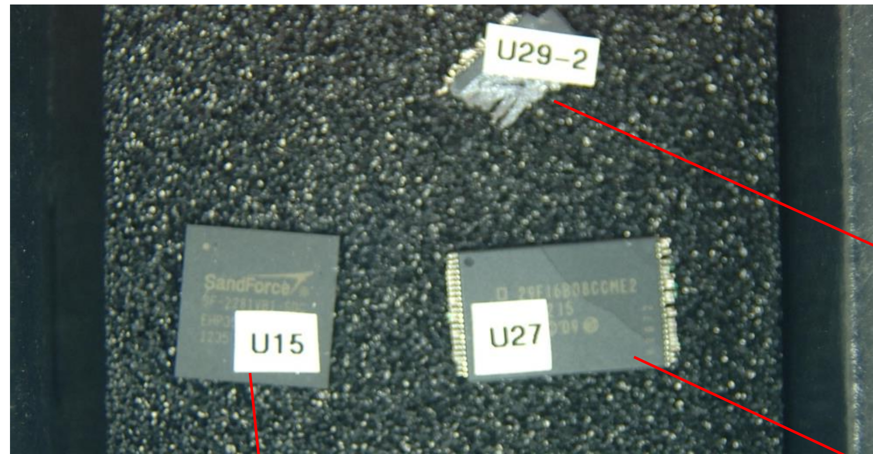
Bag 1: Casing and Connector

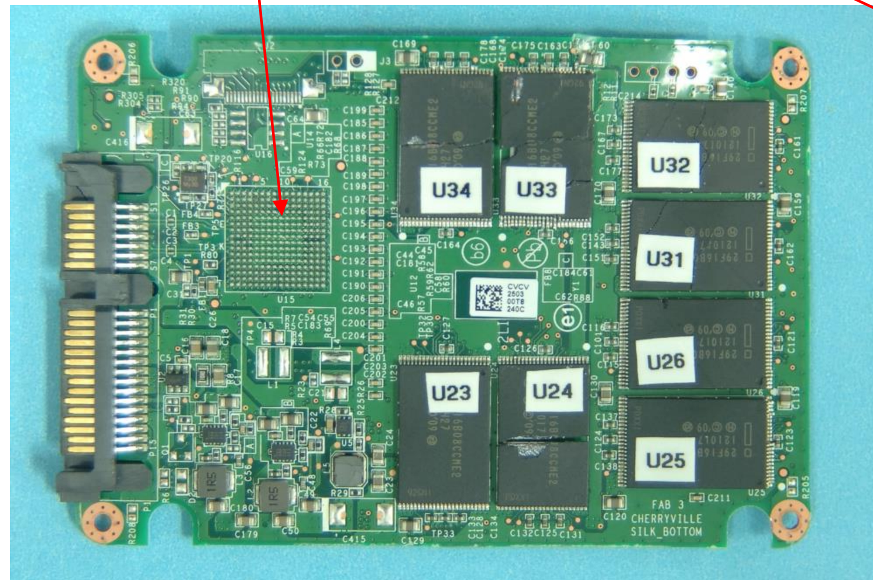


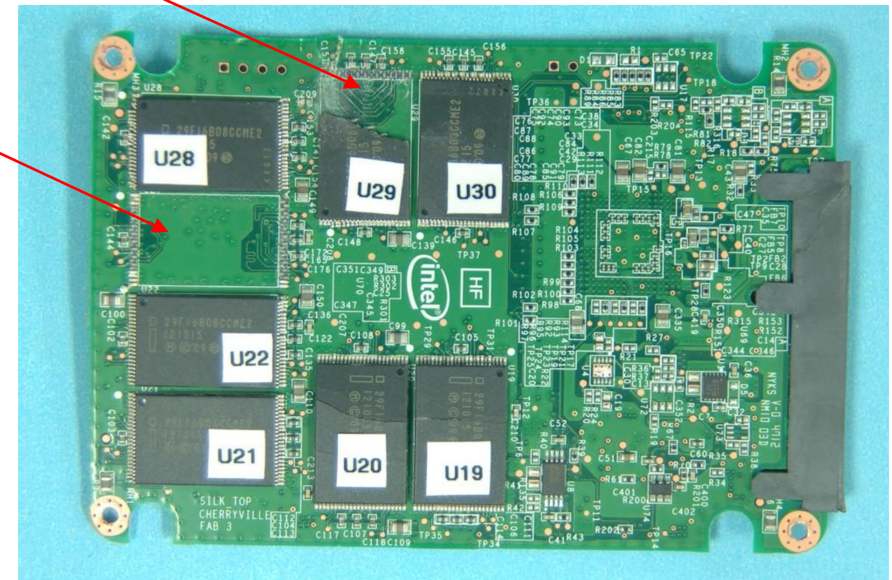
Casing badly bent, components inside badly fractured



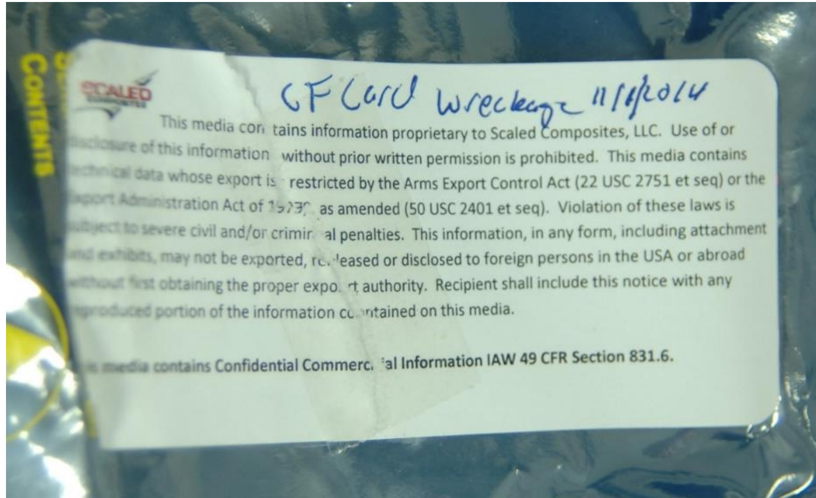
Bag 1: Card and Components

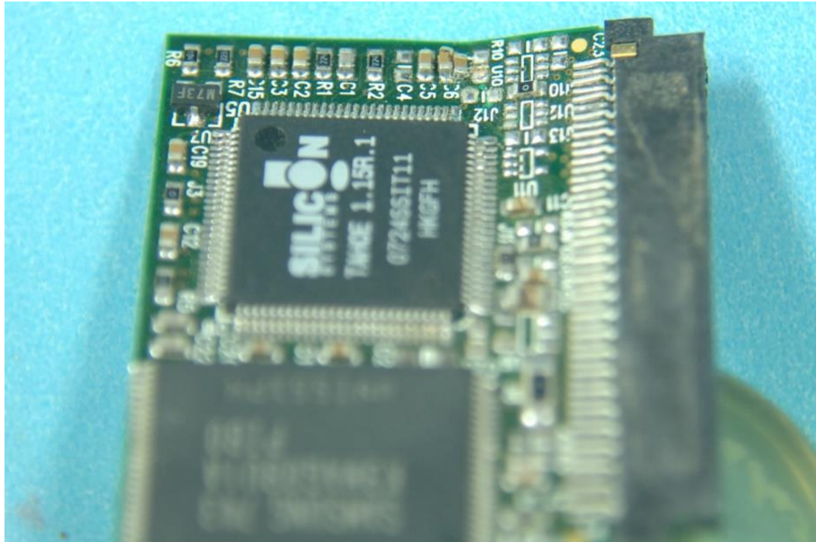


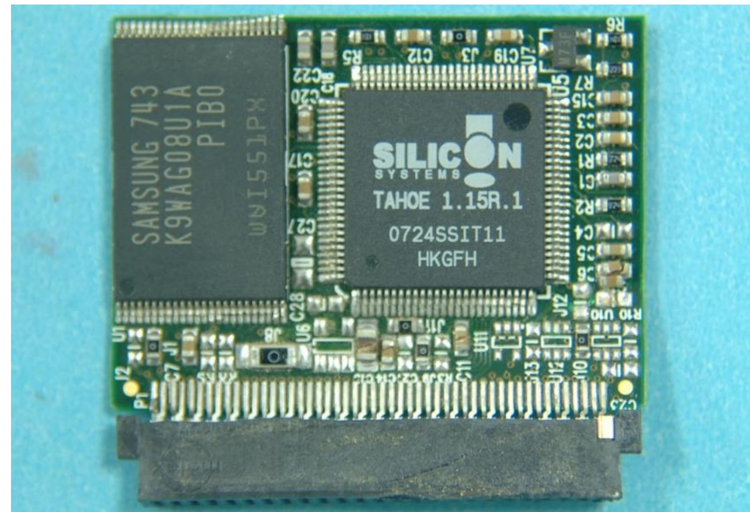




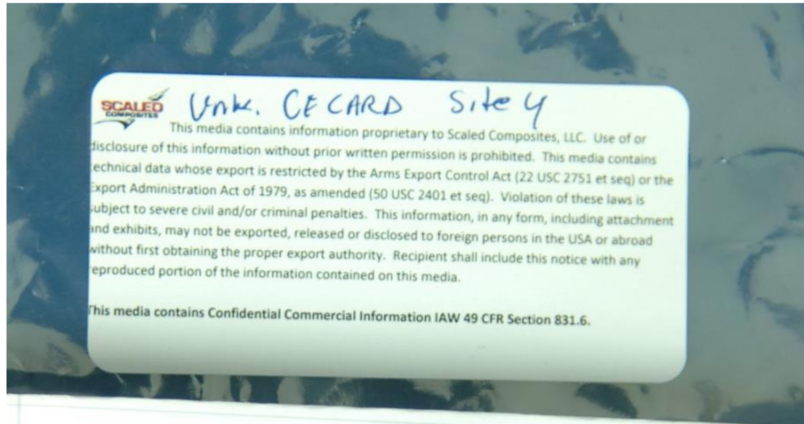
Bag 2: Casing and Card

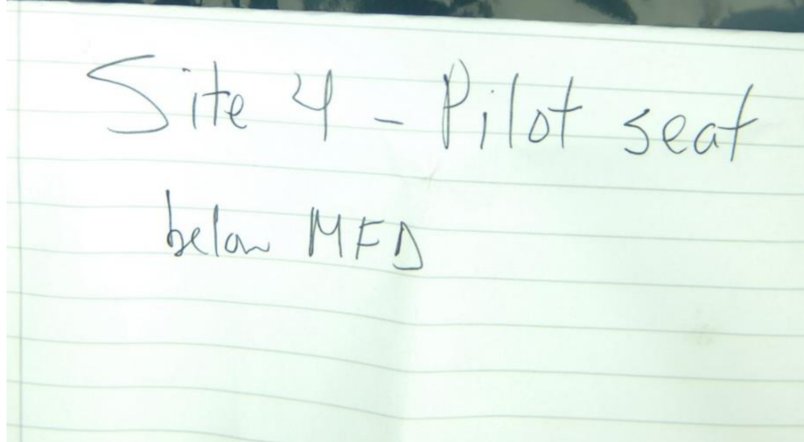


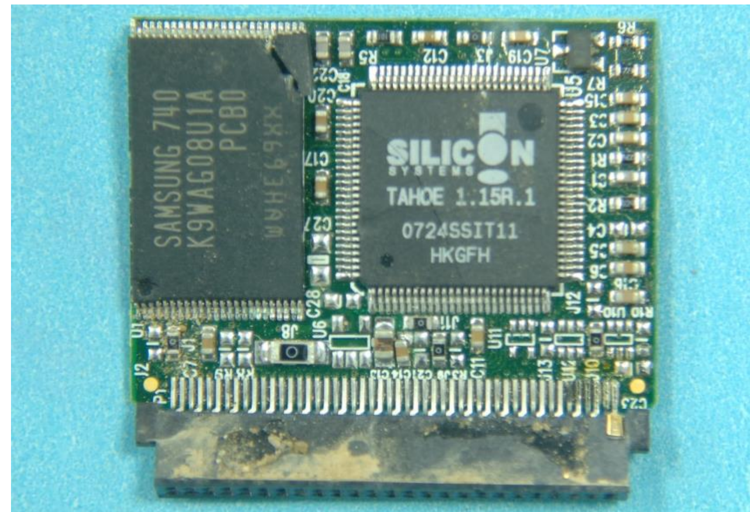




Bag 3: Casing and Card



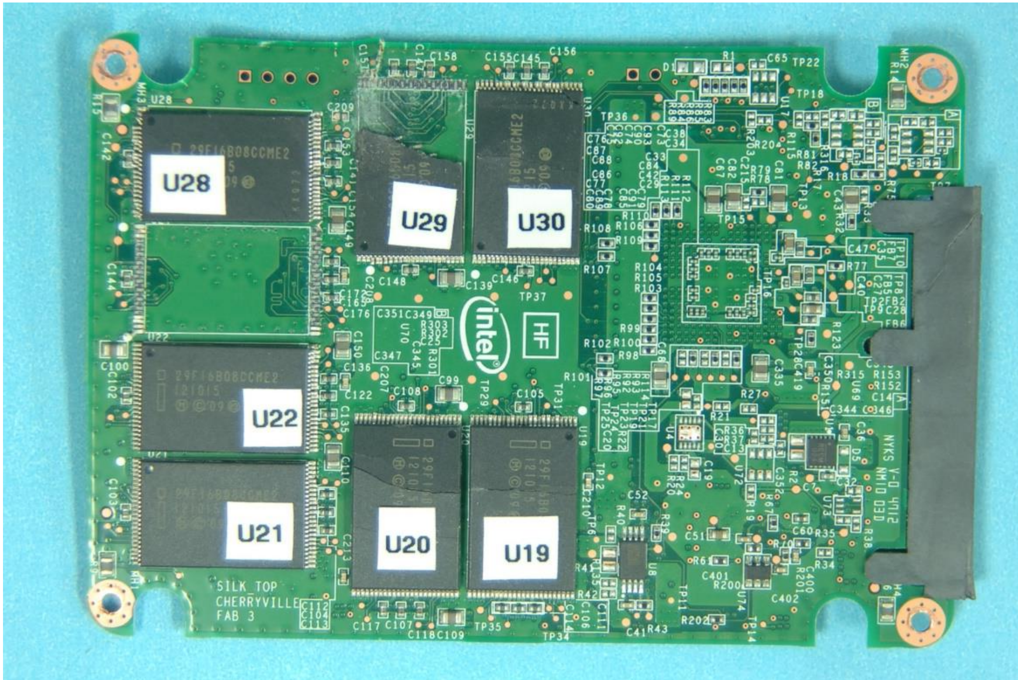


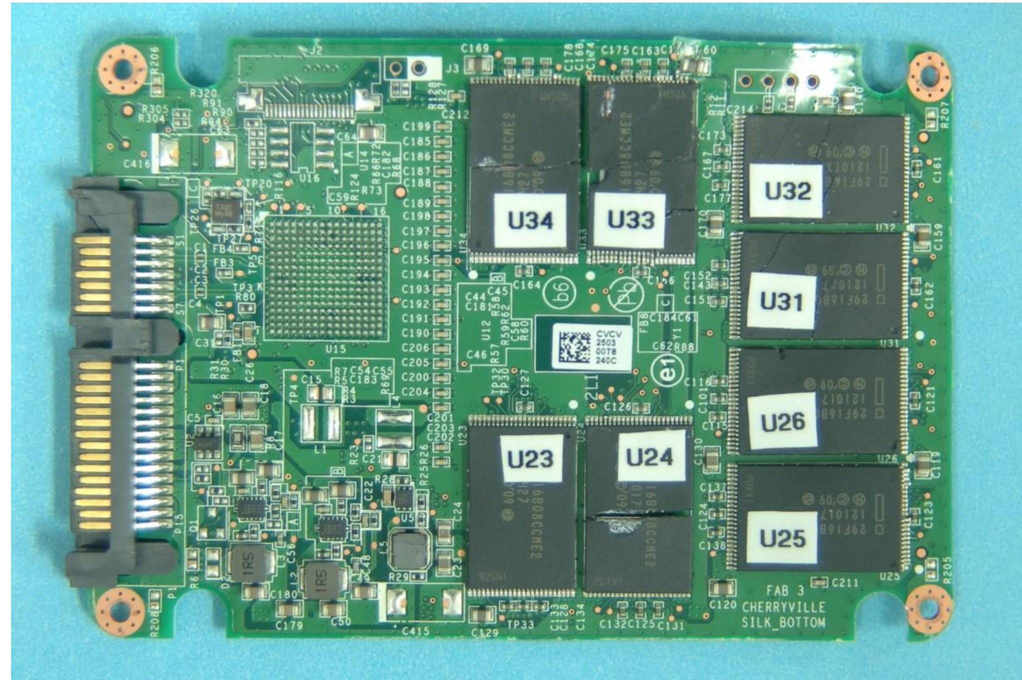


Section 3

Modules in Bag 1

Layout of the Card

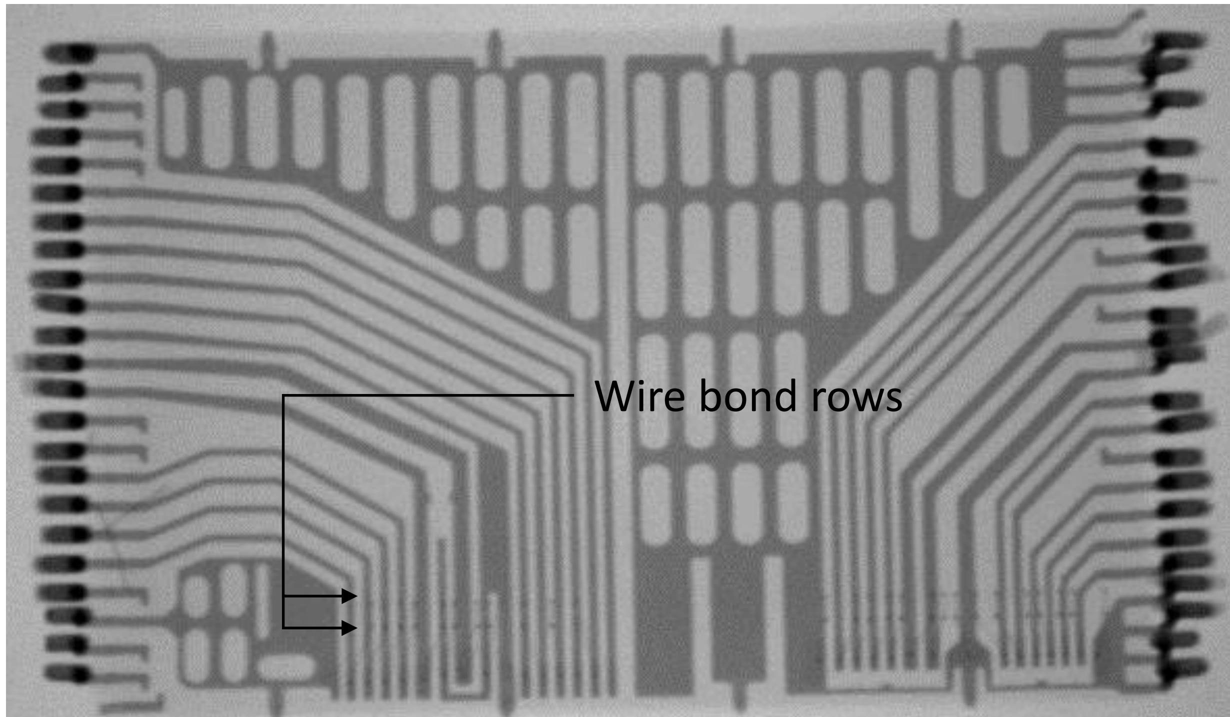




Front	Back
U19	U23
U20	U24
U21	U25
U22	U26
U27	U31
U28	U32
U29	U33
U30	U34

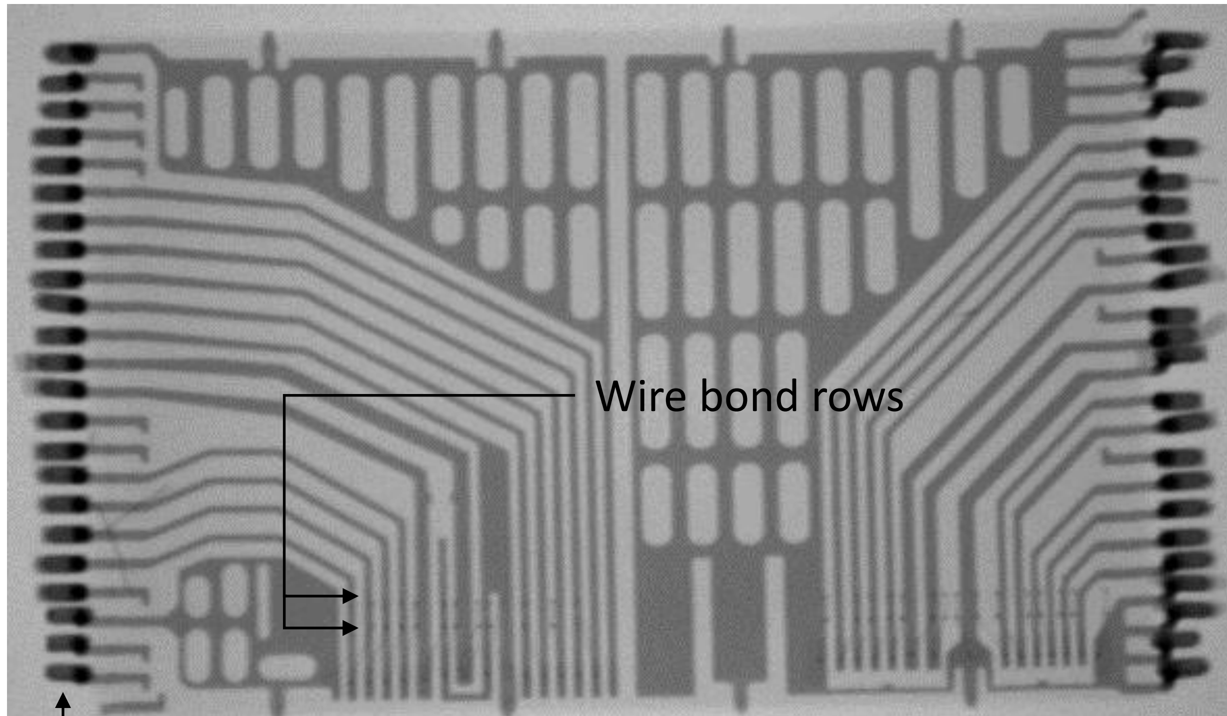
- U15 was separated completely from the card
- U27 was separated completely from the card
- U29 was broken and partly separated from the card
- The degree of damage to the card precludes using it as is for data recovery
- A module by module assessment was performed to determine if data could be recovered from certain modules

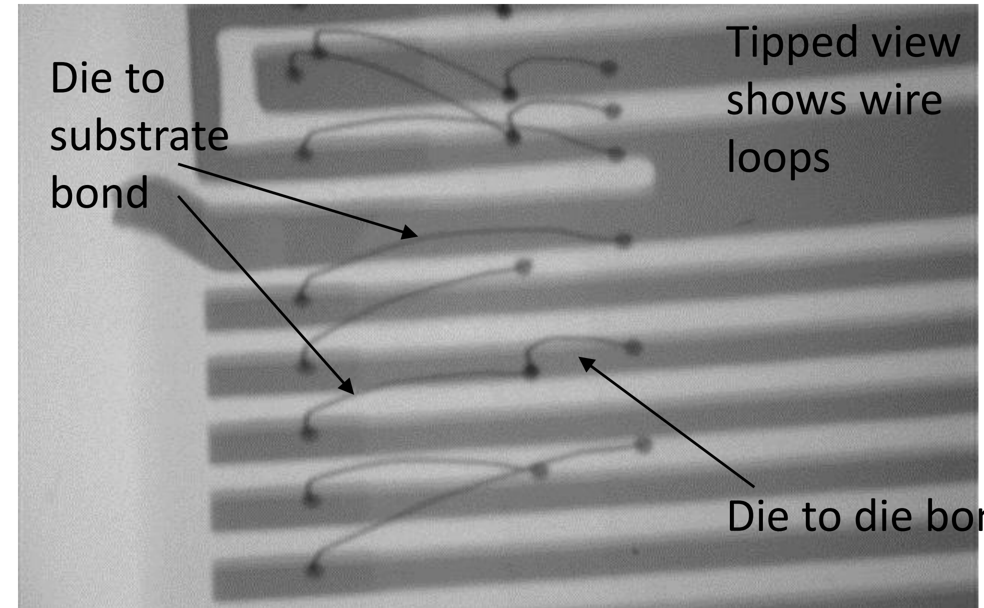
Basic Construction from Module U27 X-ray and Micrograph



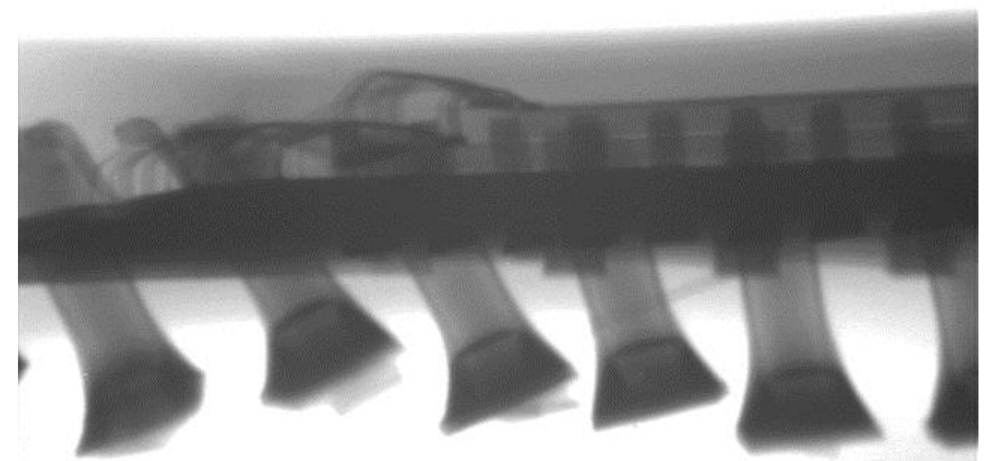
When stamped manufacturer's information is upright, the wire bonds are on the bottom side of the module only. This allows a determination of which module in the back to back configuration has the broken wires

Basic Construction from Module U27 X-rays

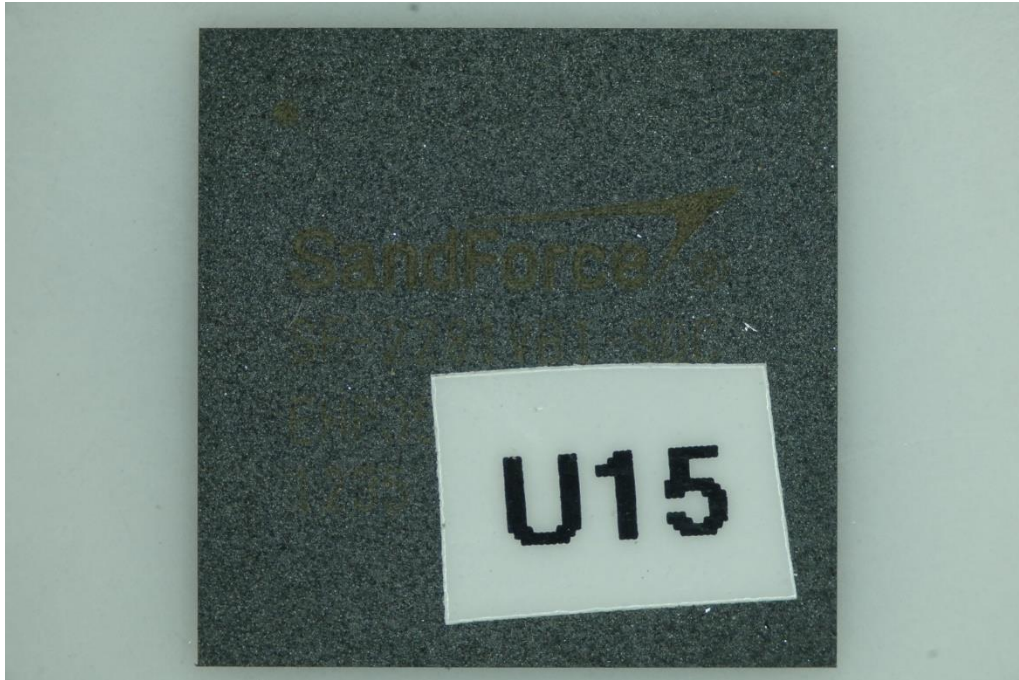


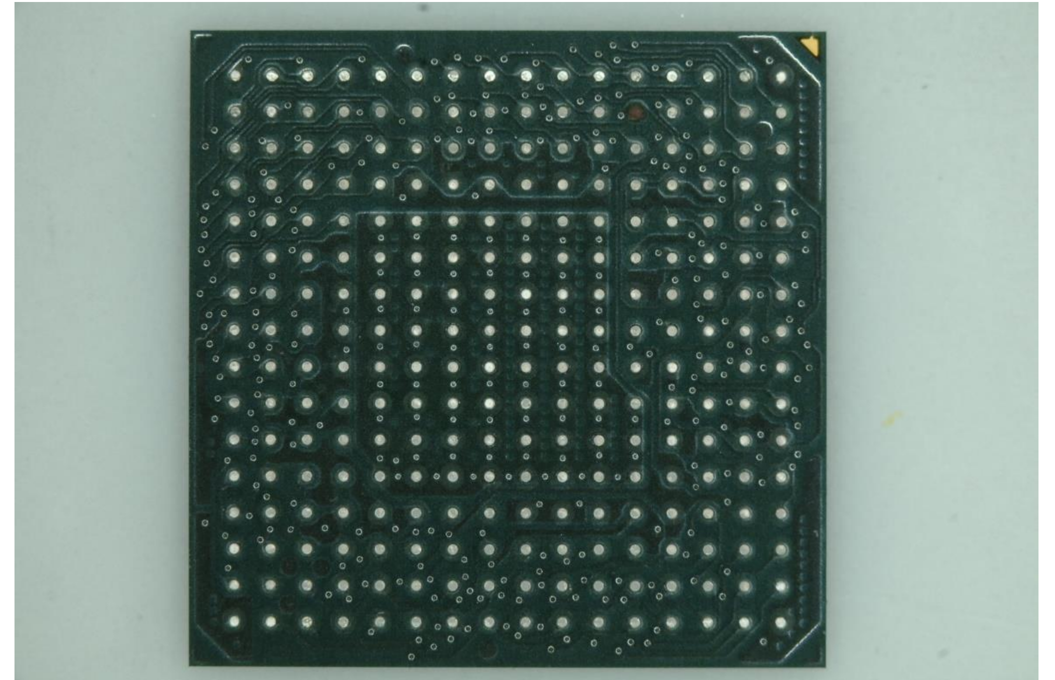


Edge view shows stacked die and rows of wire bonds



Module U15 Photos

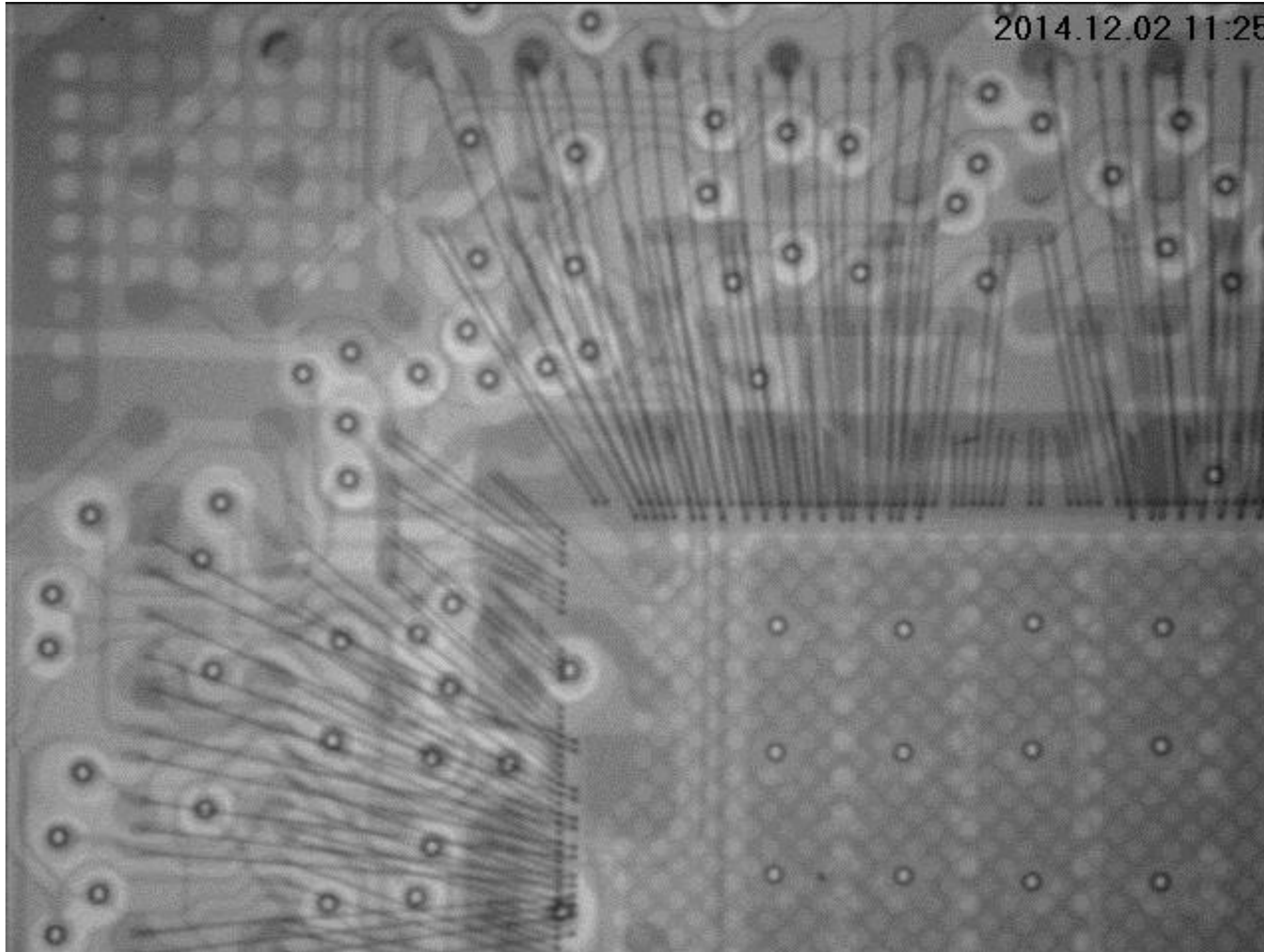


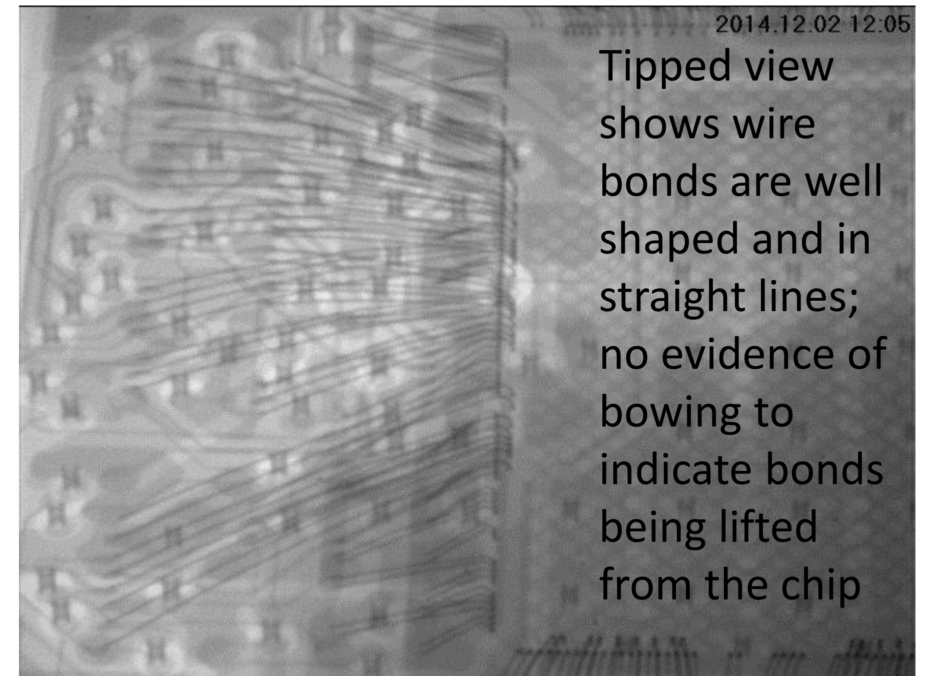


Other than separation from the card, there is no visual evidence of damage to the module

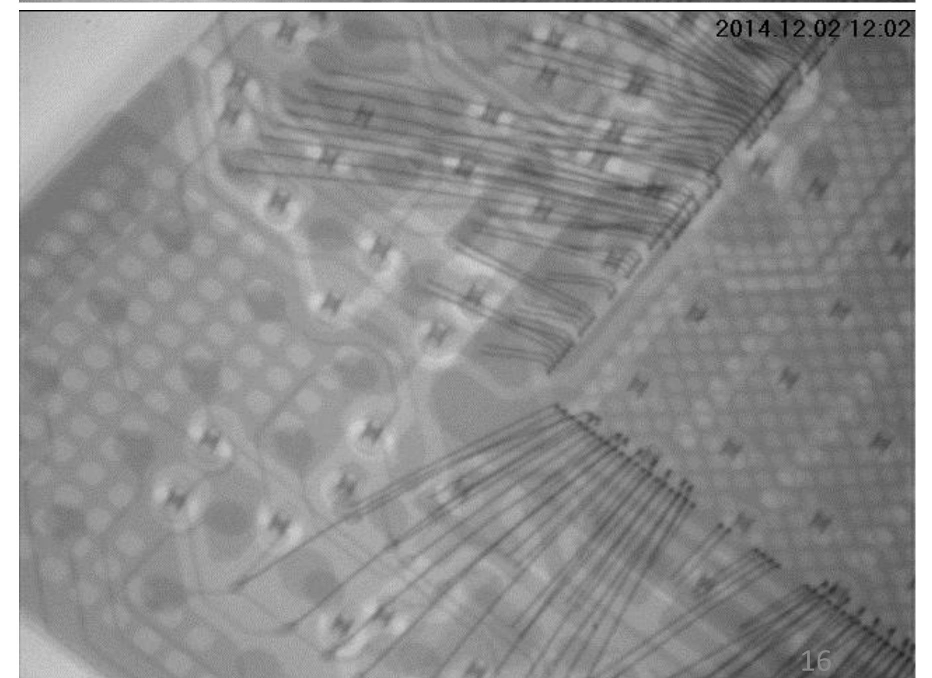
Module U15 X-rays

Typical x-ray showing good wire integrity



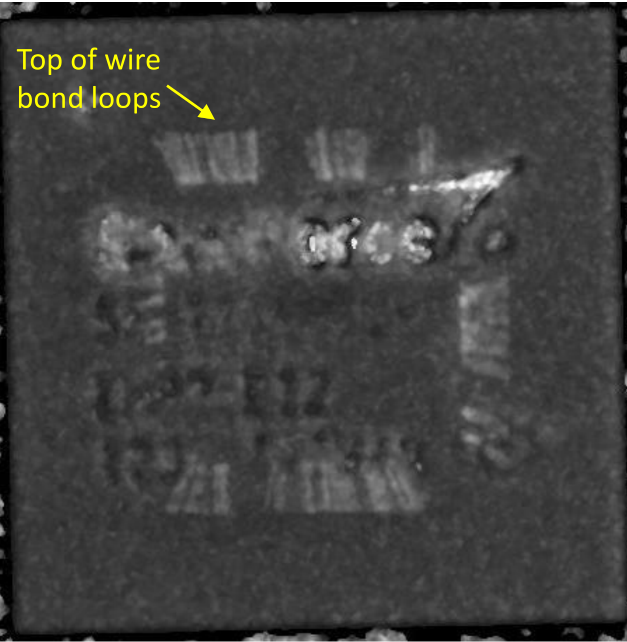


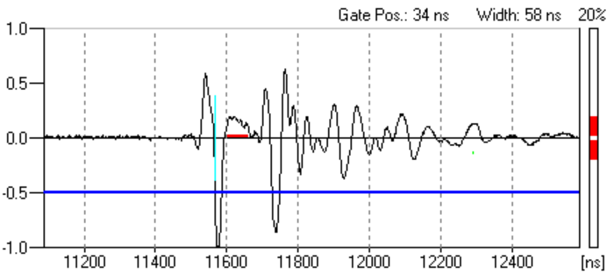
Tipped view shows wire bonds are well shaped and in straight lines; no evidence of bowing to indicate bonds being lifted from the chip



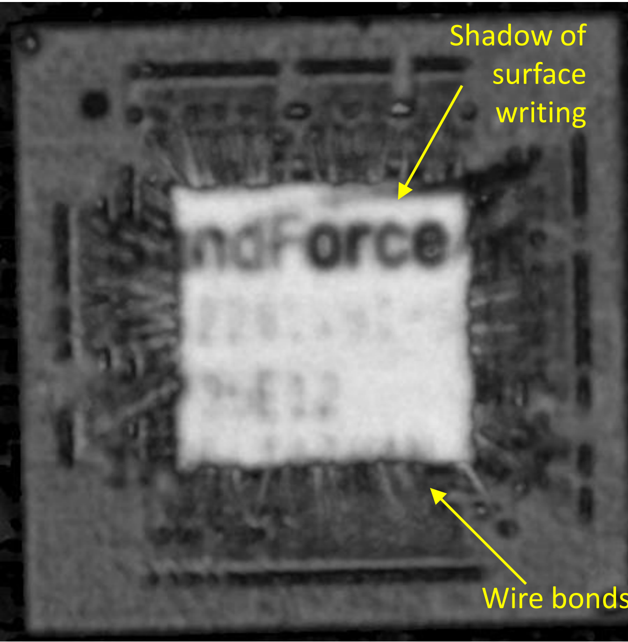
Module 15 C-SAMs

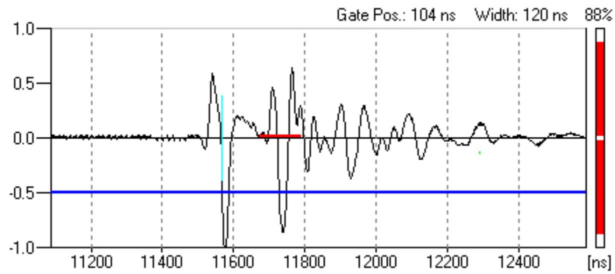
In the overmold



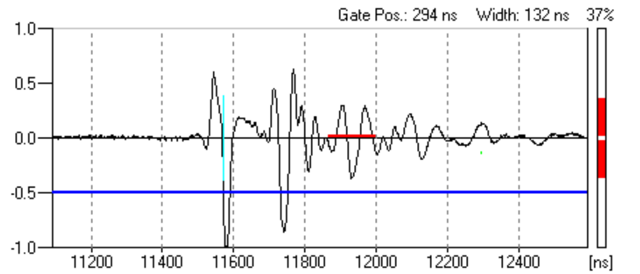


Top of the chip



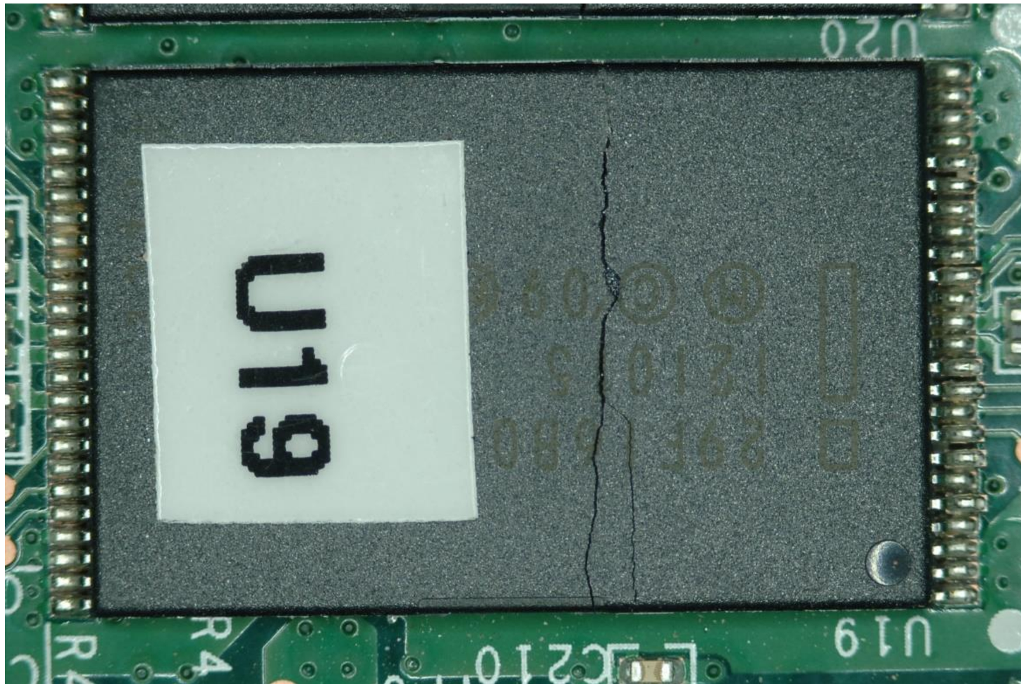


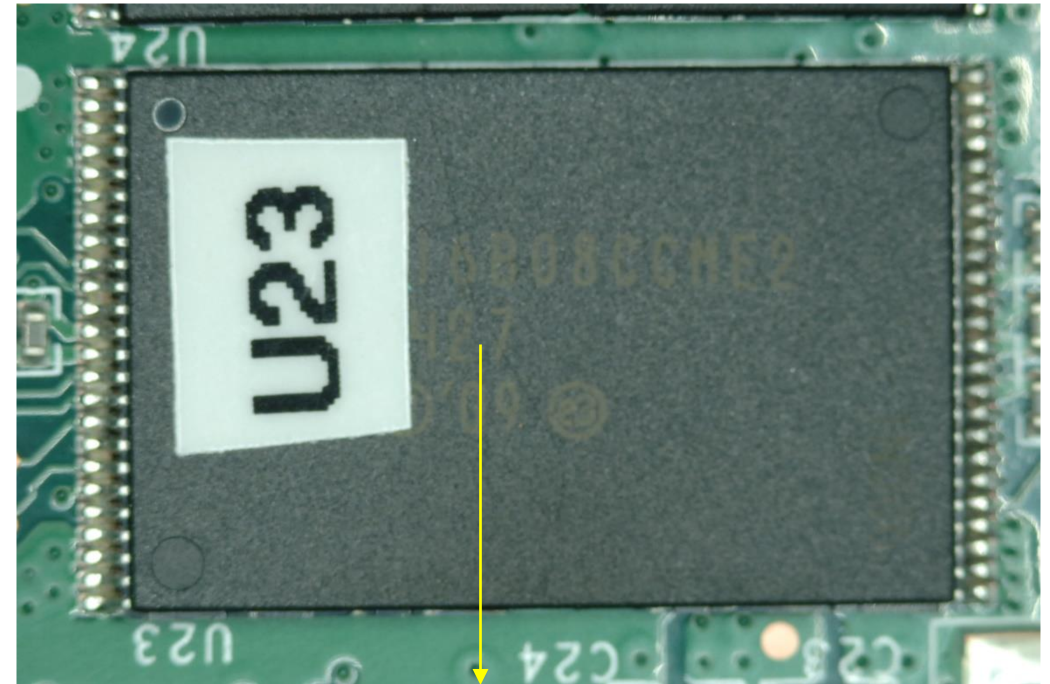
Top of the laminate



No evidence of cracking or delamination

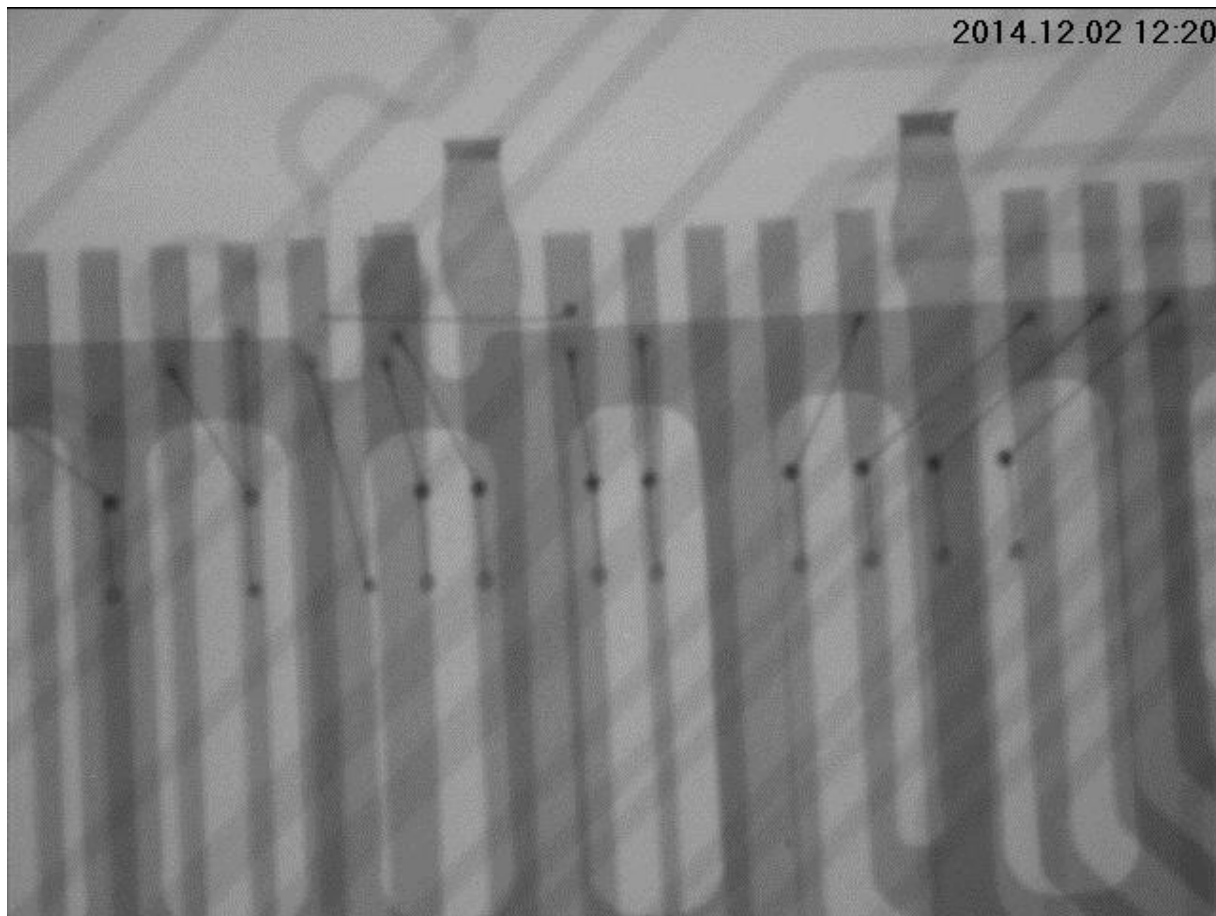
Module U19 / U23 Pair - Photos

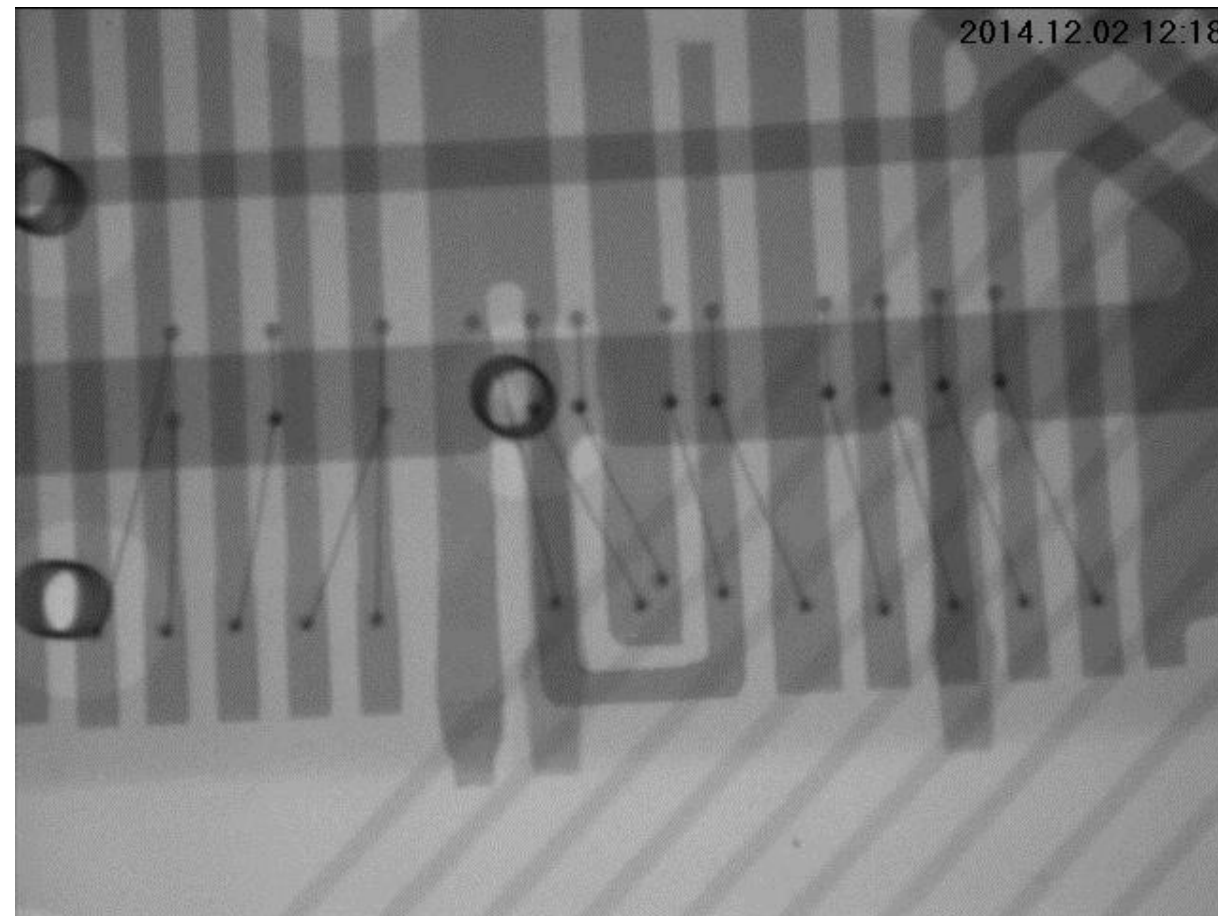




Obvious crack in U19
Subtle crack in U23

Module U19 / U23 Pair – X-rays



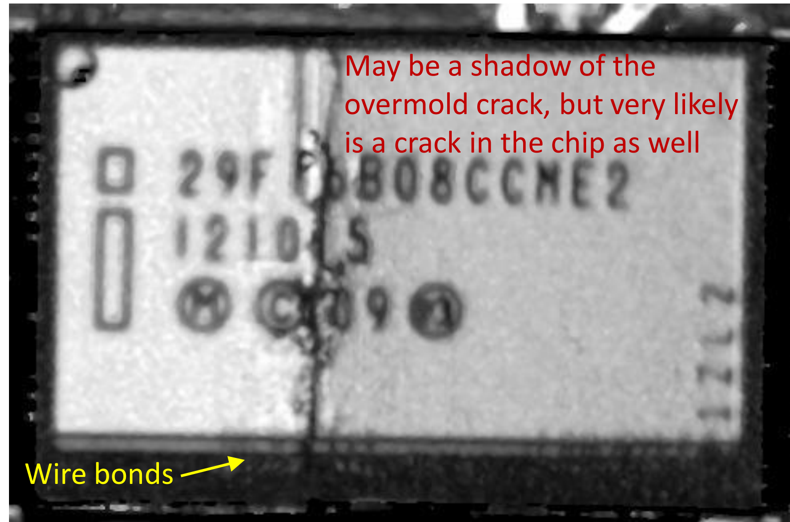


X-rays (typical ones are given above) show good integrity of wire bonds on both modules (wire bonds are on one side of the module, hence appear on opposite edges in the X-rays in the back to back configuration on the card)

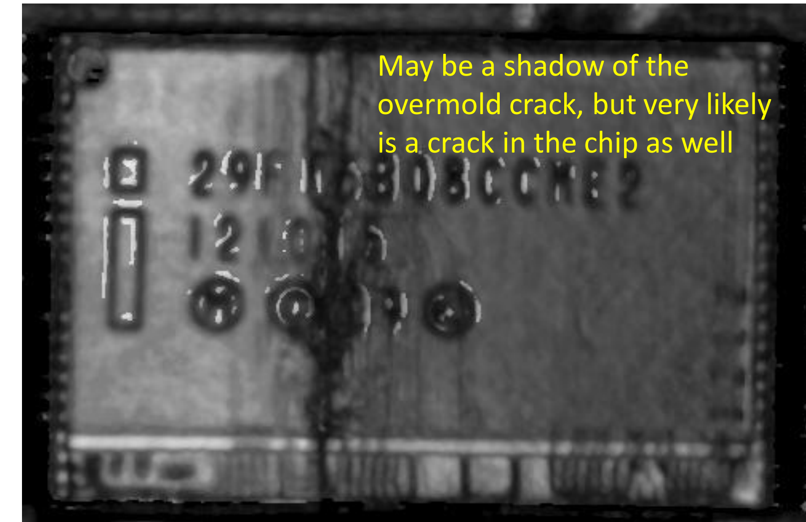
Module U19 C-SAMs

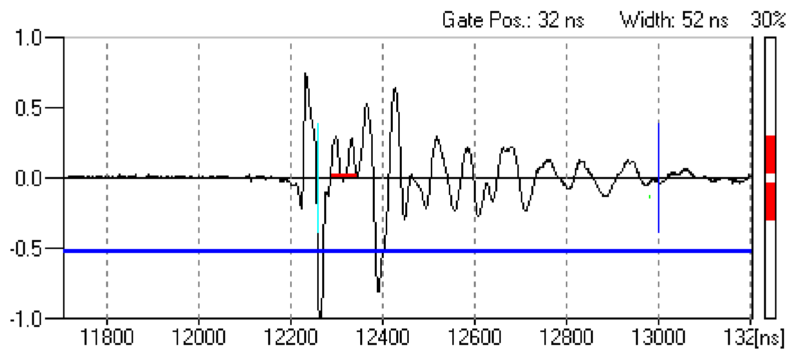
In overmold

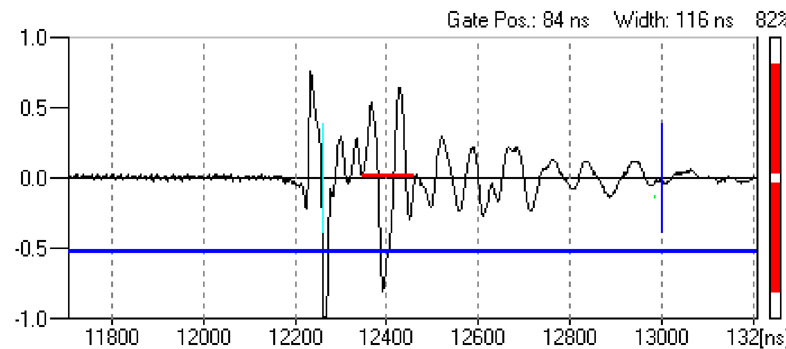
Top chip

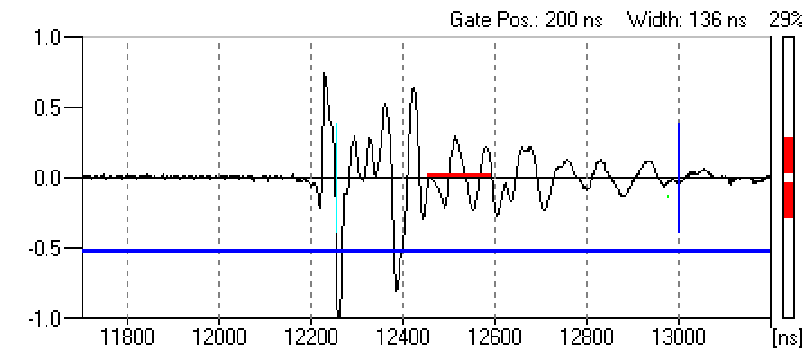


Bottom chip





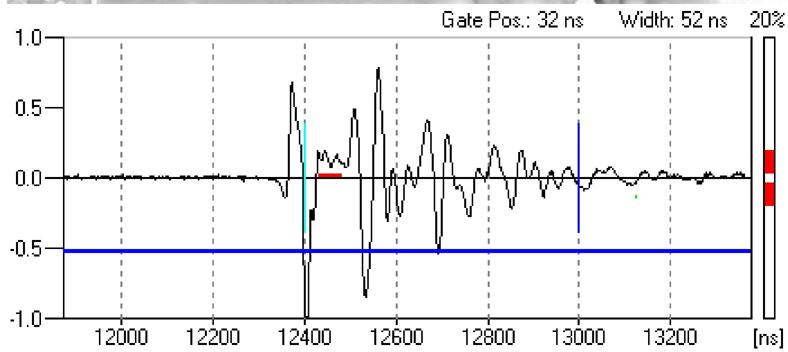




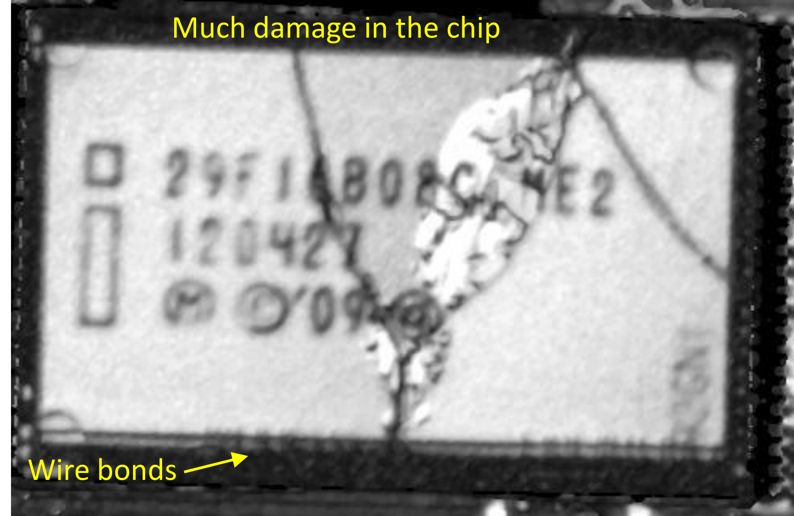
Given the flex of the module, the C-SAM anomaly is probably from a crack in the chip, not just a shadow of the crack in the overmold

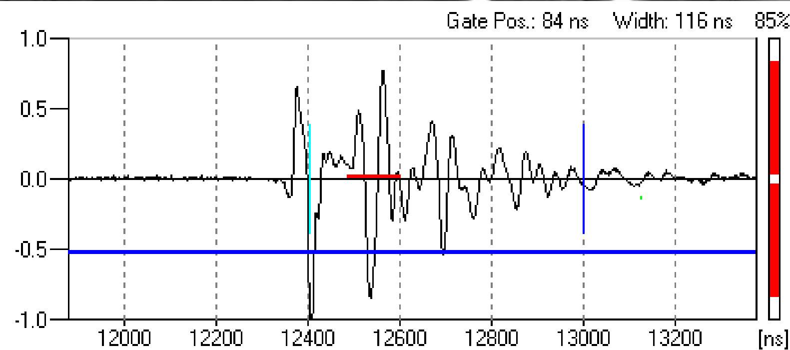
Module U23 C-SAMs

In overmold

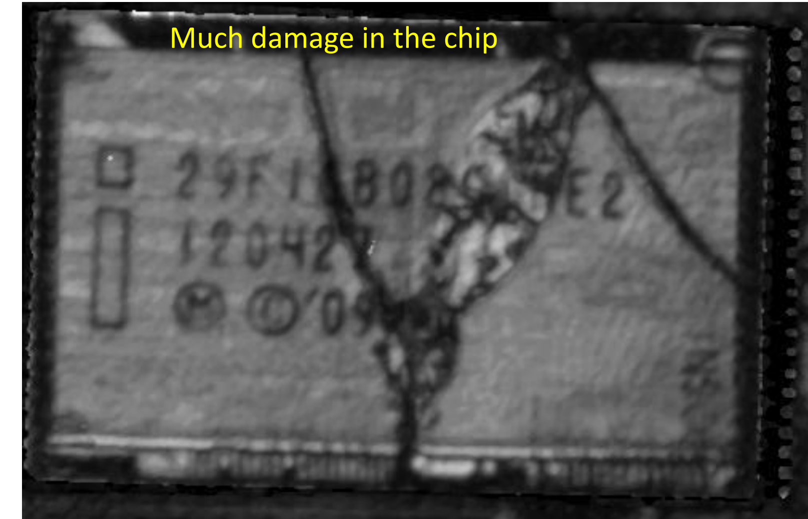


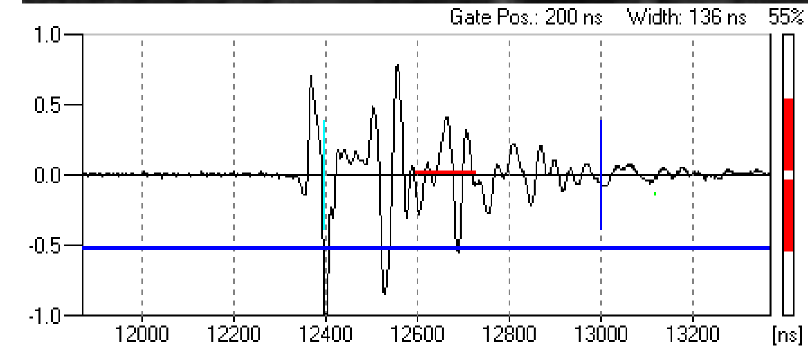
Top chip





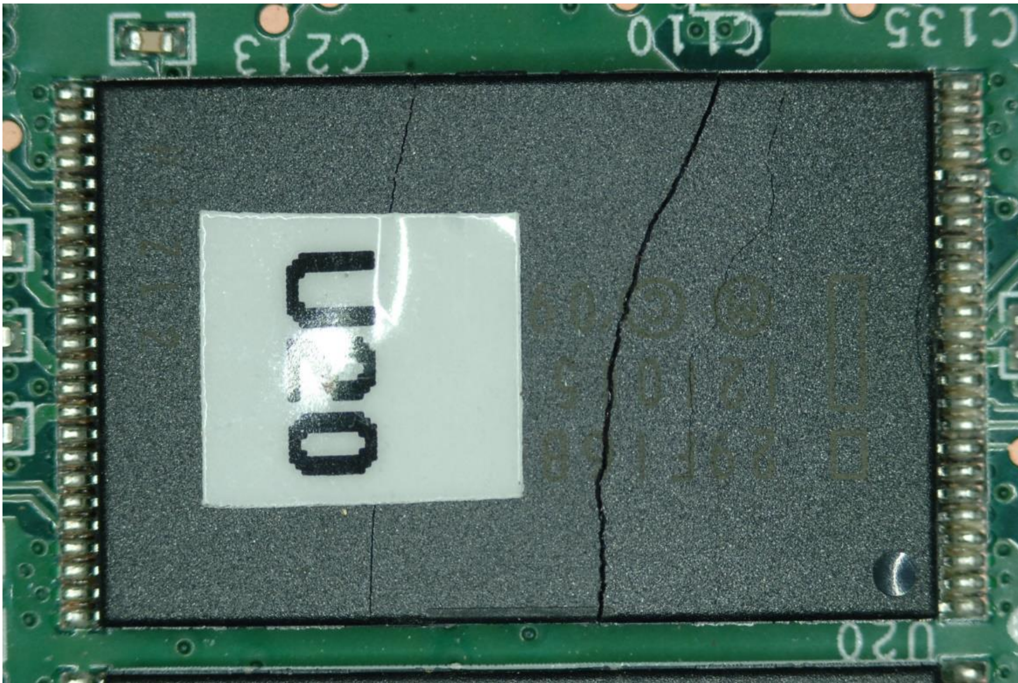
Bottom chip

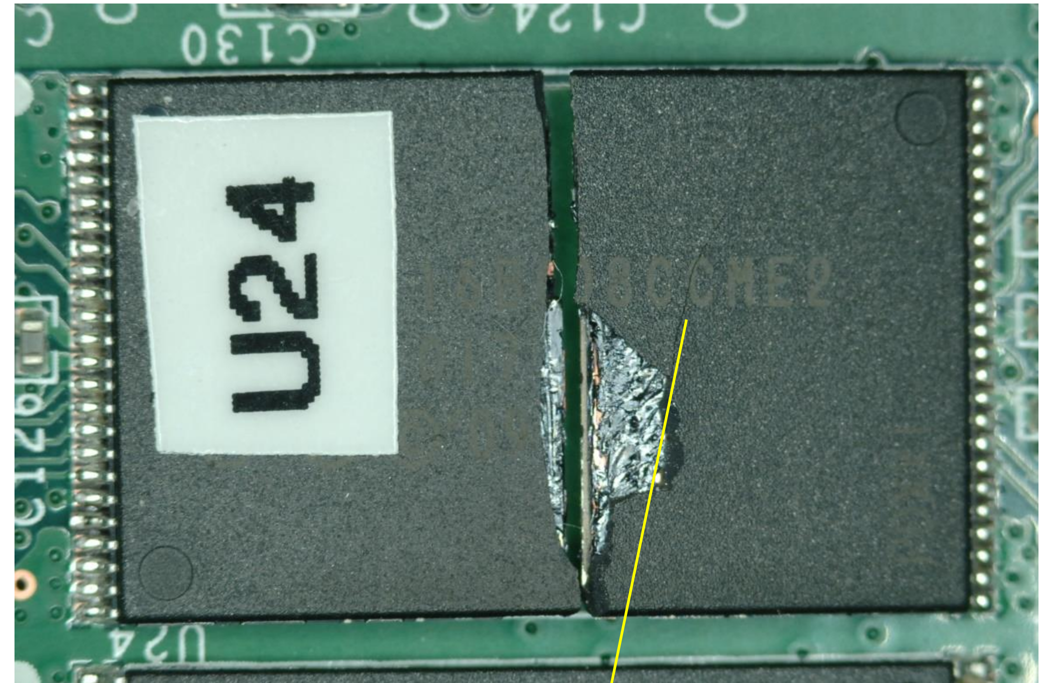


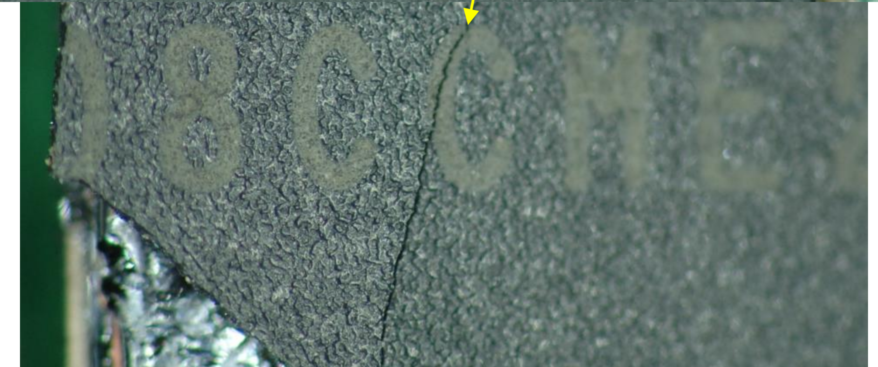


Chip is badly damaged from the flexing

Module U20 / U24 Pair - Photos

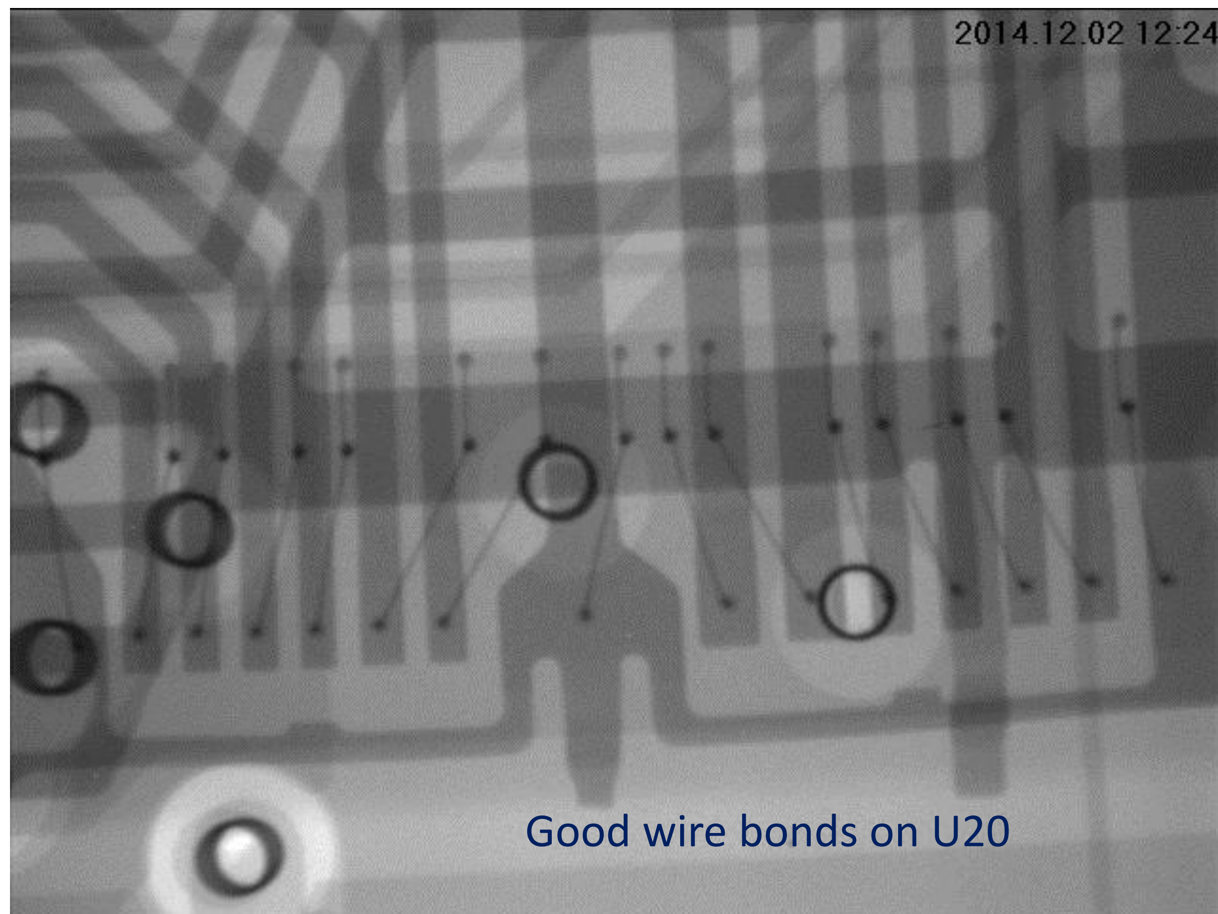


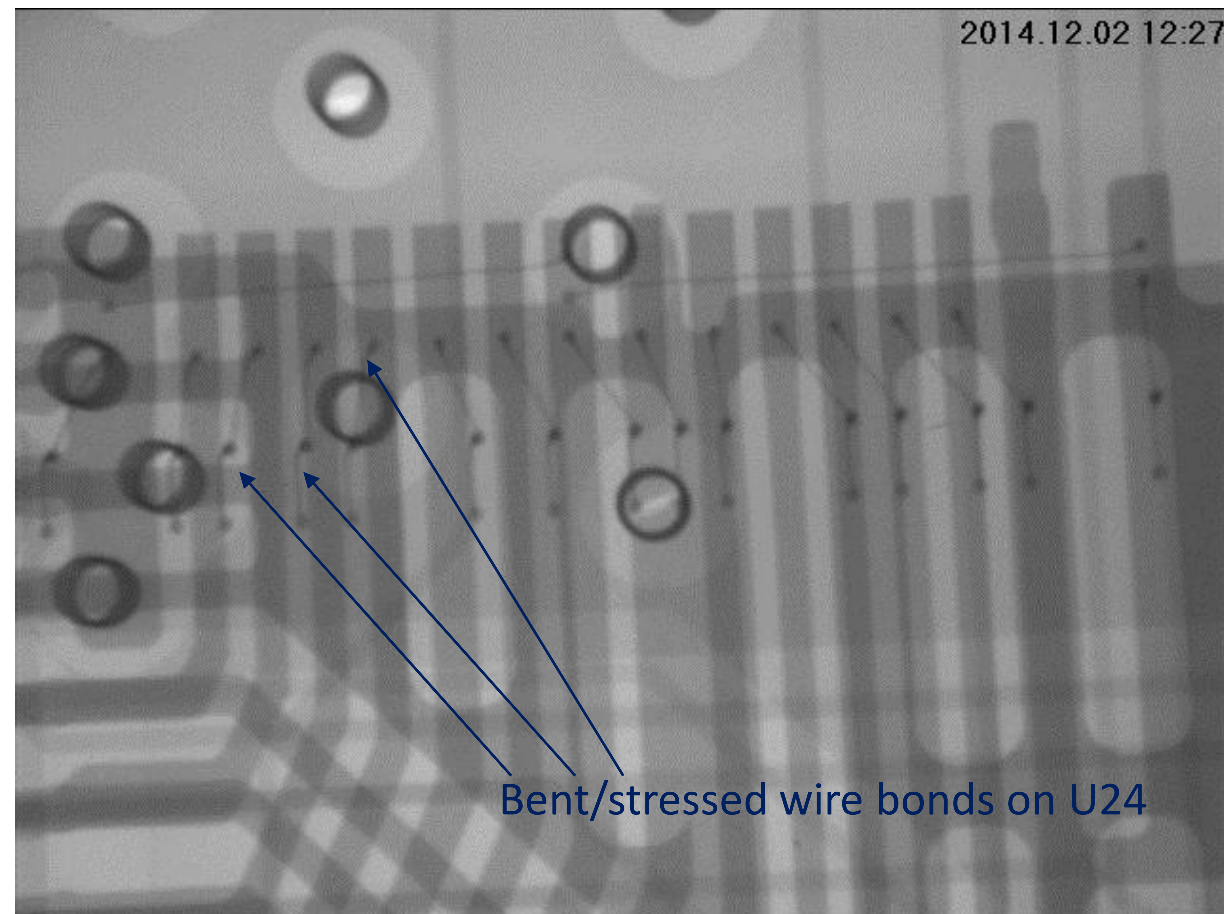




Obvious cracks in U20
U24 broke apart

Module U20 / U24 Pair – X-rays



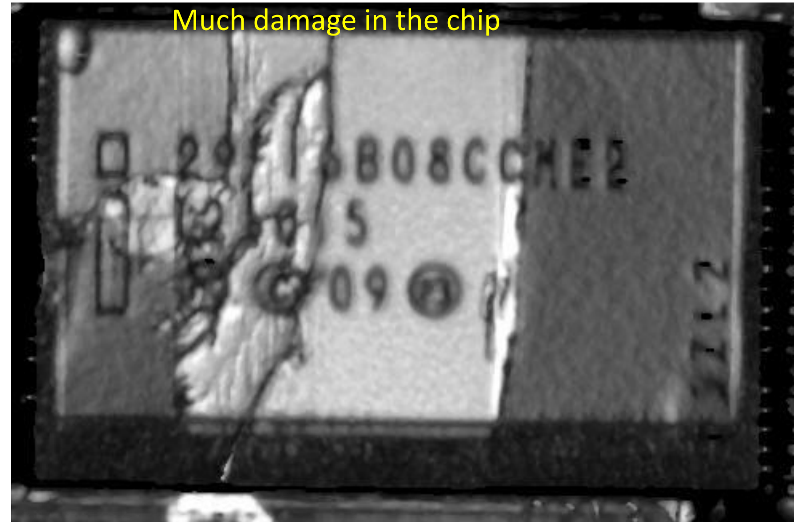


X-rays show good integrity of wire bonds on one side (U20), but evidence of stress and displacement on the other side (U24). The complete fracture of U24 missed the wire bonds in that module. Wire bonds on U20 are all good

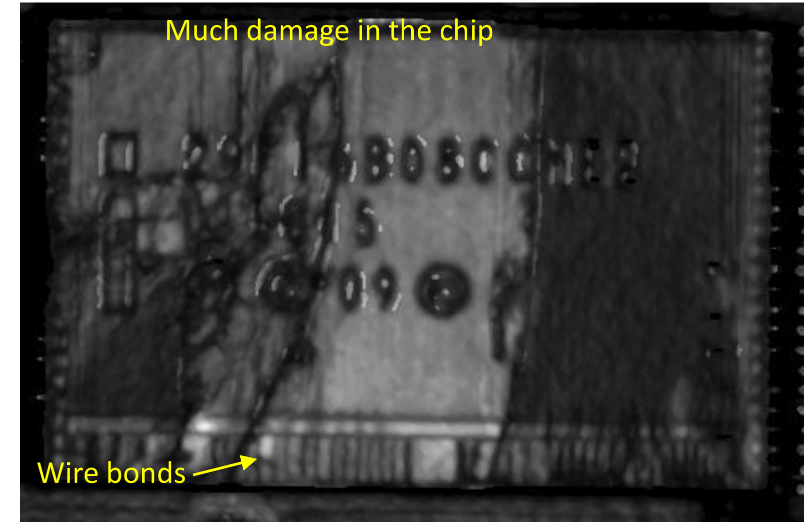
Module U20 C-SAMs

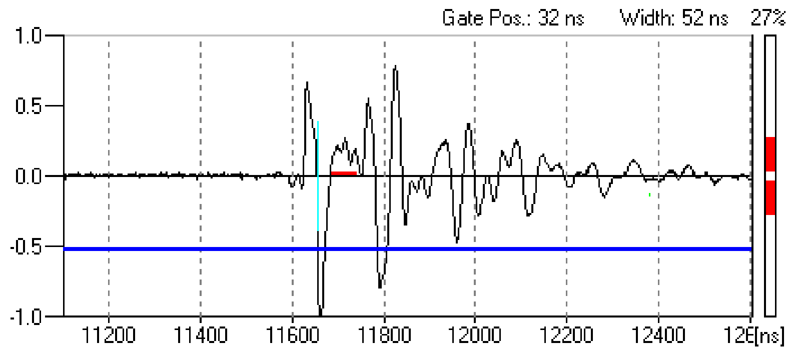
In overmold

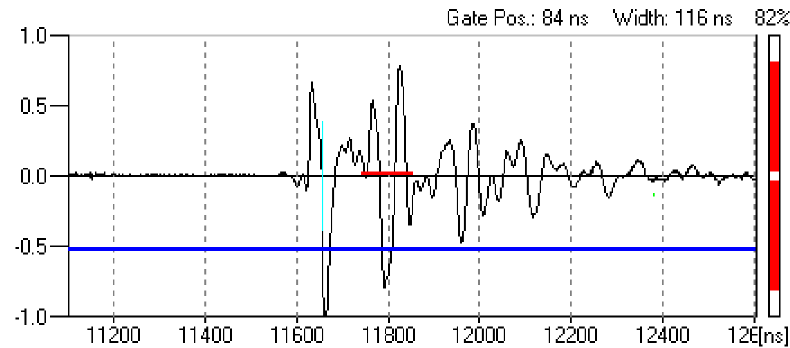
Top chip

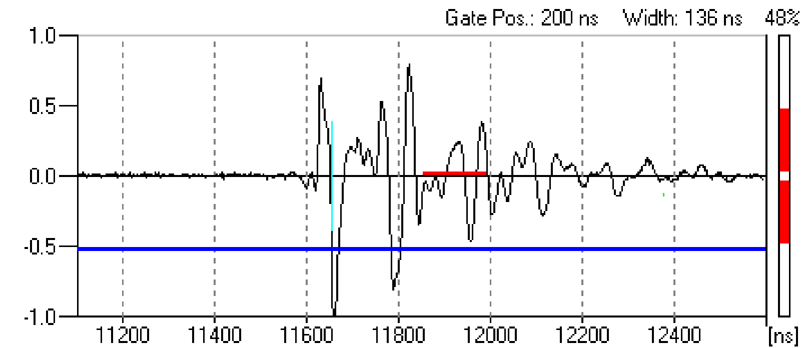


Bottom chip



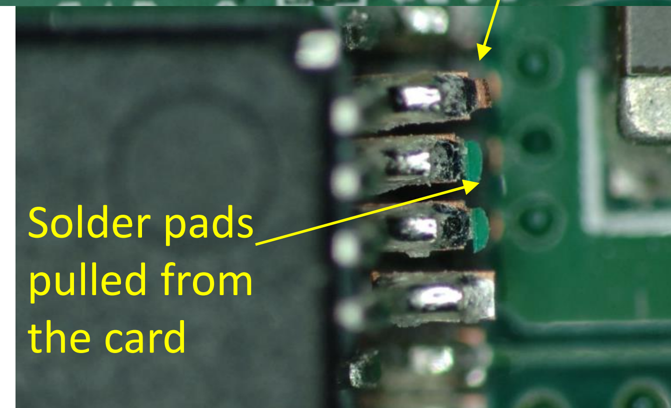






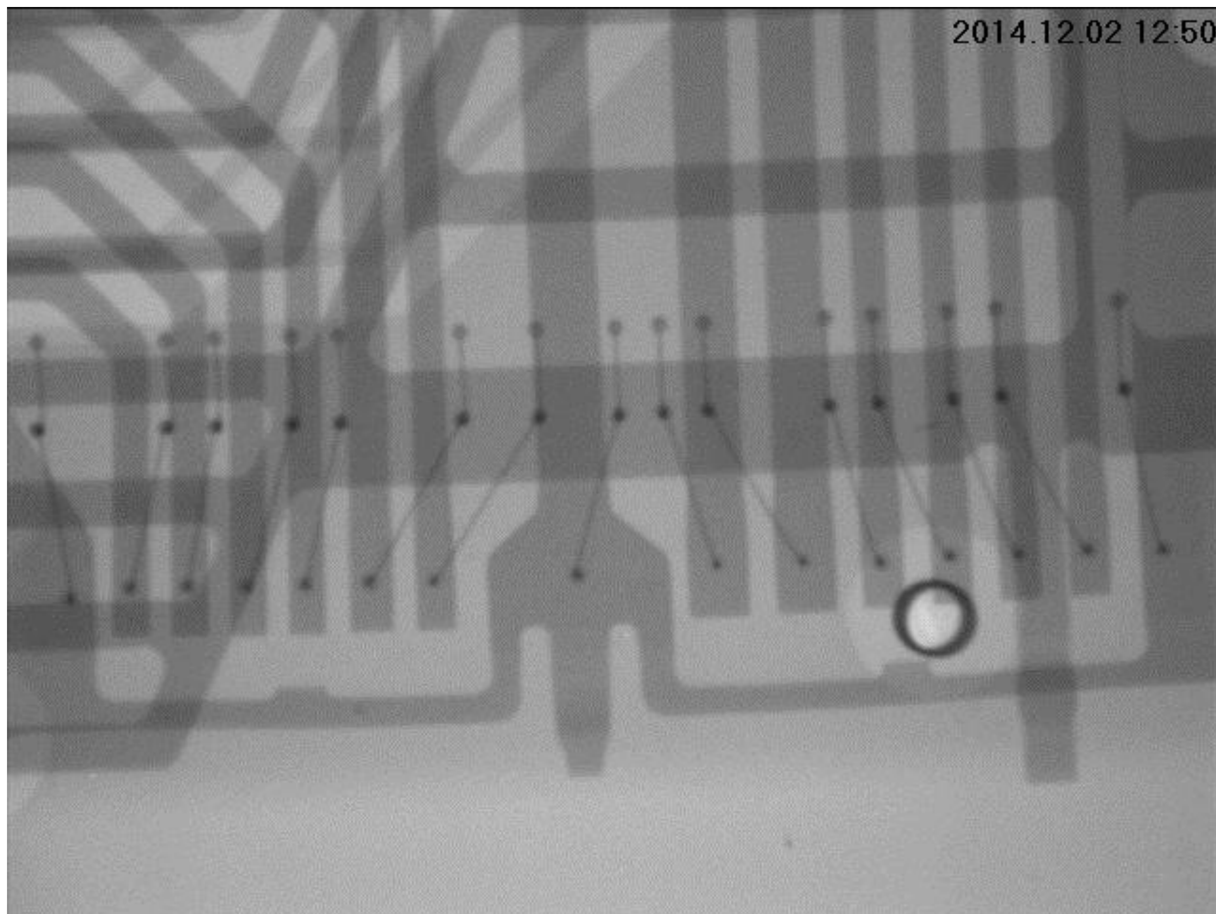
Chip is badly damaged from flexing

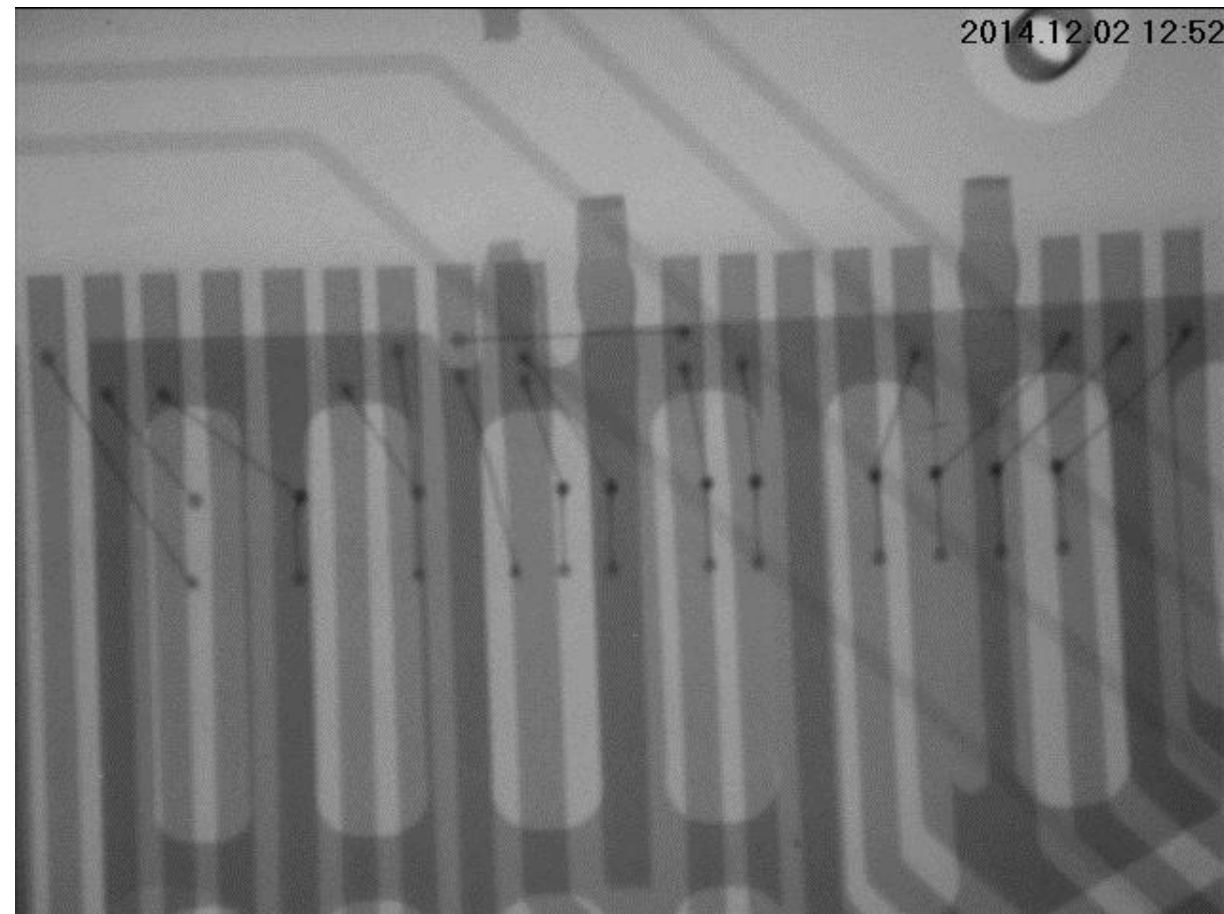
Module U21 / U25 Pair - Photos



Cracks were not found in either module
U25 pulled pads from the card

Module U21 / U25 Pair – X-rays

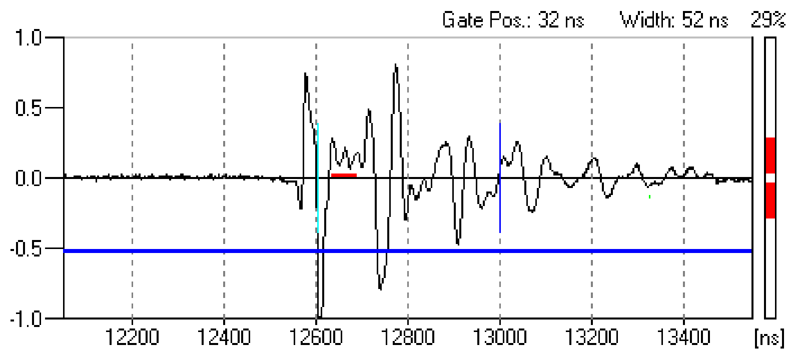




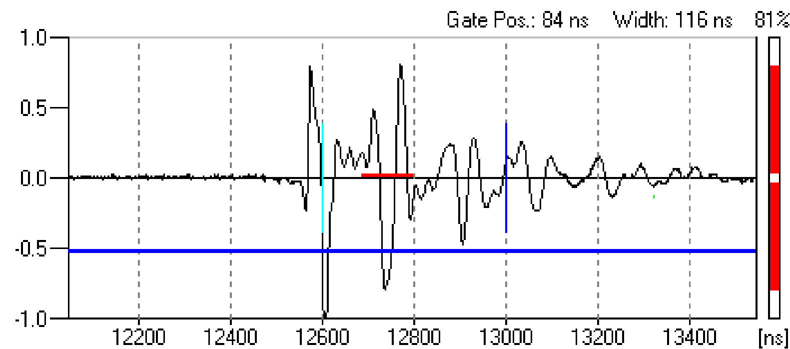
X-rays (typical ones are given above) show good integrity of wire bonds on both modules (wire bonds are on one side of the module, hence appear on opposite edges in the back to back configuration on the card)

Module U21 C-SAMs

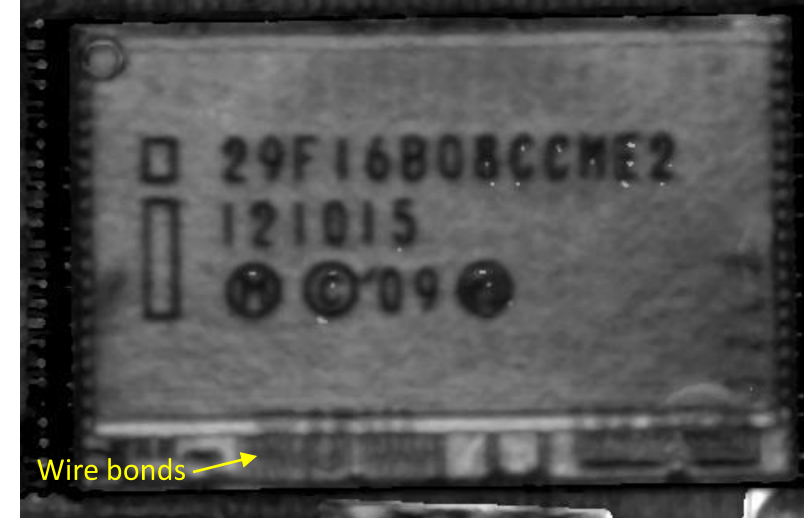
In overmold

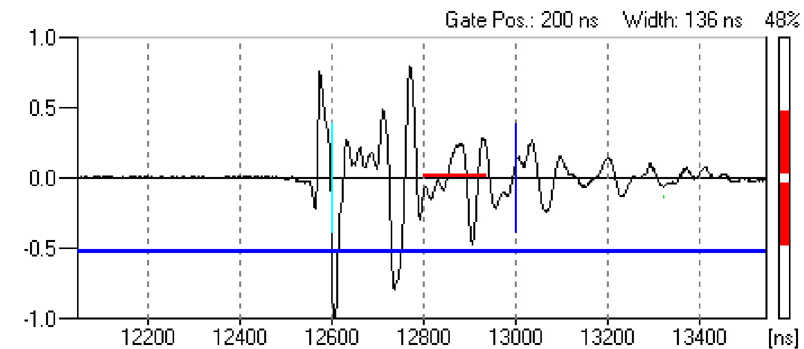


Top chip



Bottom chip

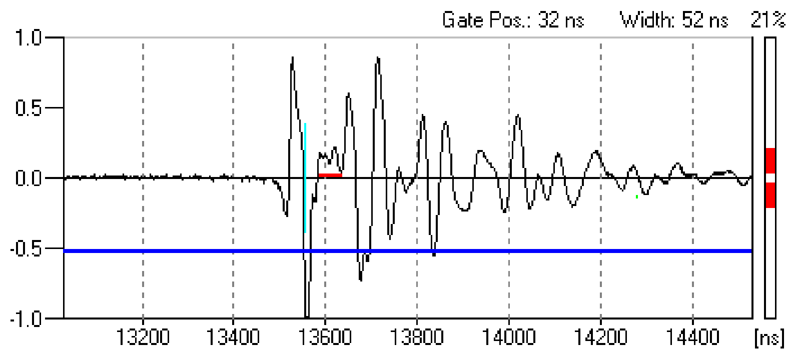




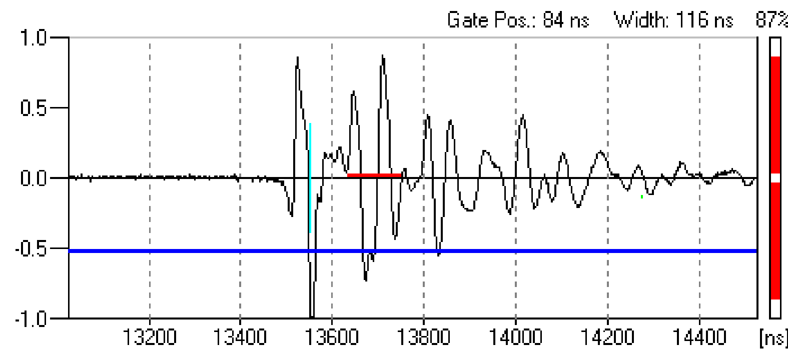
Chip appears to be in tact – no evidence of cracking or catastrophic delamination

Module U25 C-SAMs

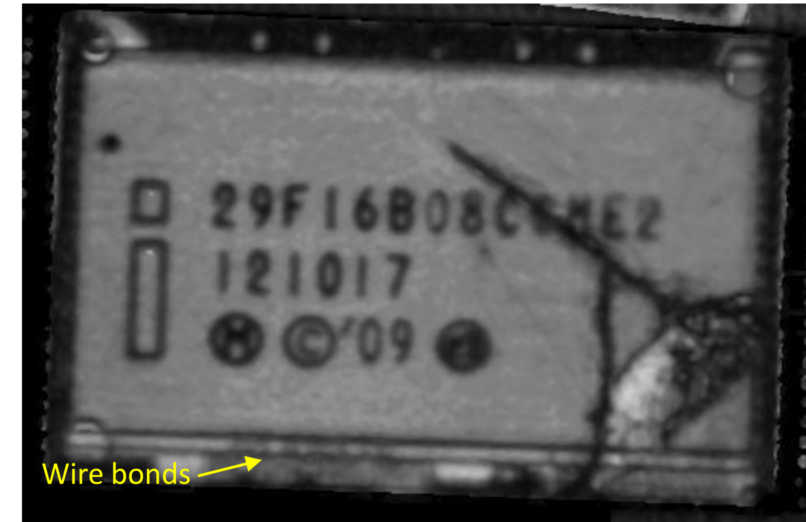
In overmold

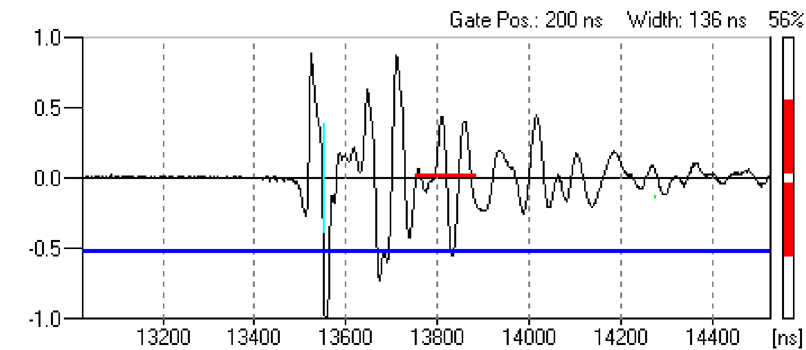


Top chip



Bottom chip



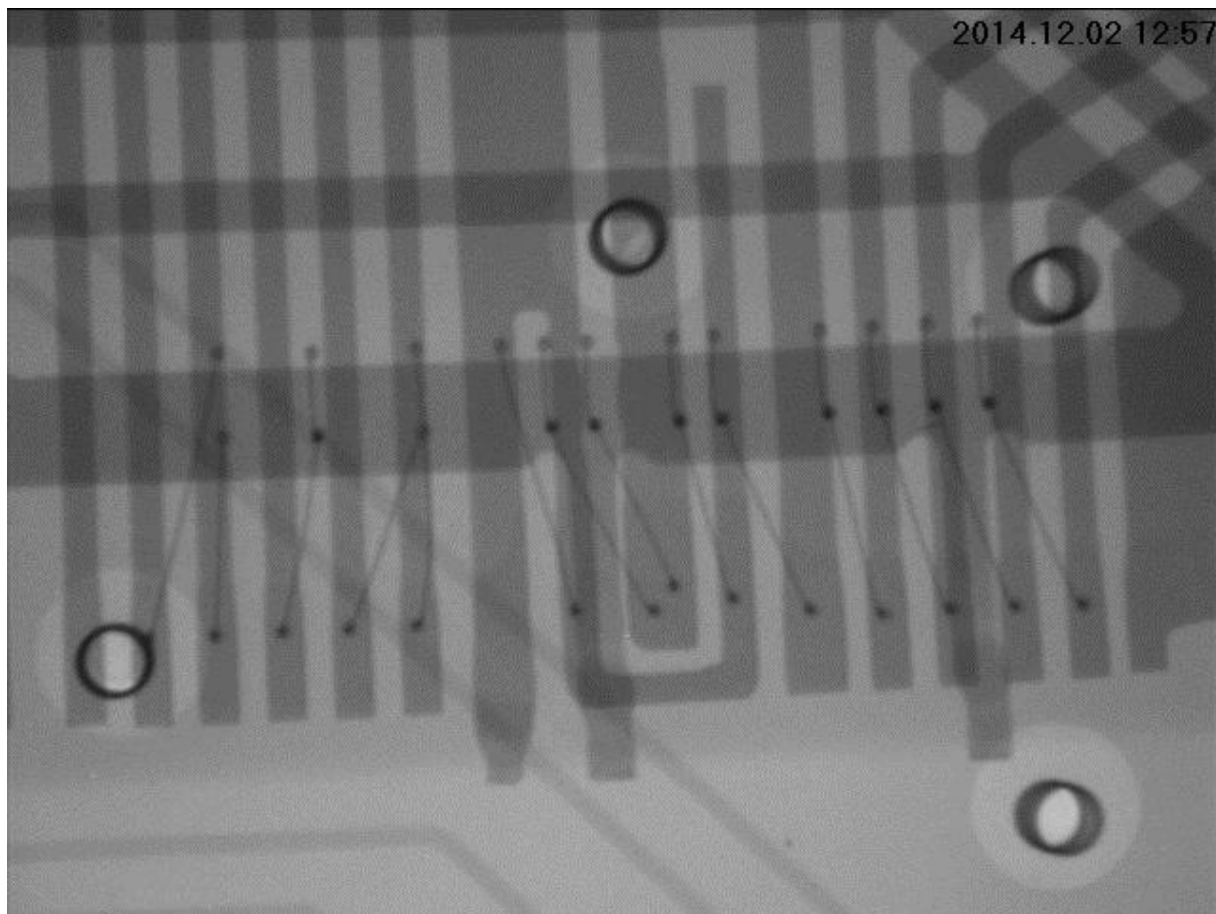


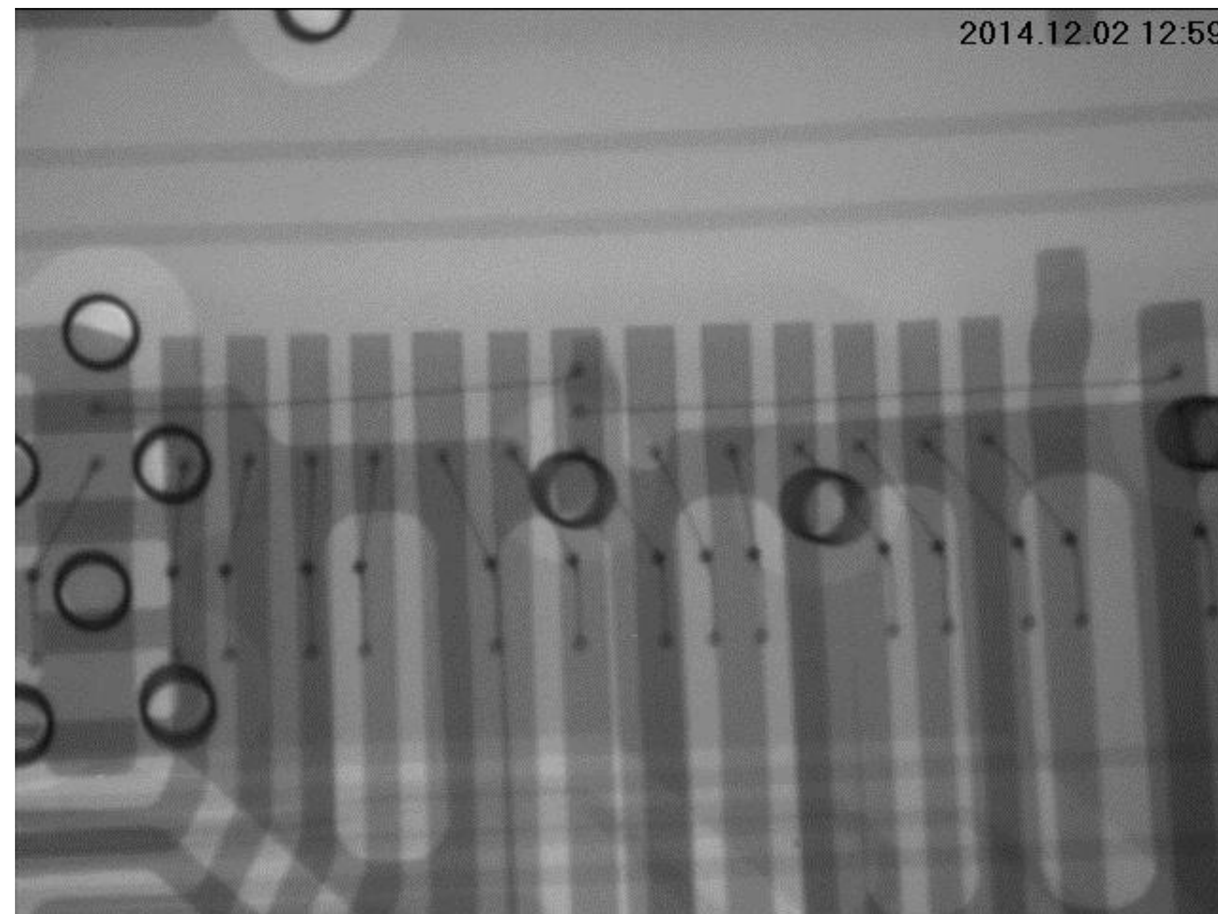
Corner of the chip is crushed from flexing

Module U22 / U26 Pair - Photos

No cracks in U22
Obvious cracks in U26

Module U22 / U26 Pair – X-rays





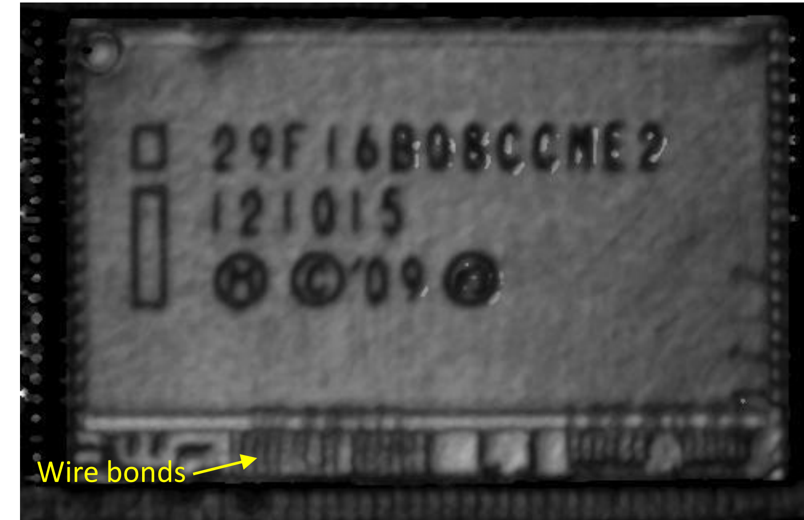
X-rays (typical ones are given above) show good integrity of wire bonds on both modules (wire bonds are on one side of the module, hence appear on opposite edges in the back to back configuration on the card)

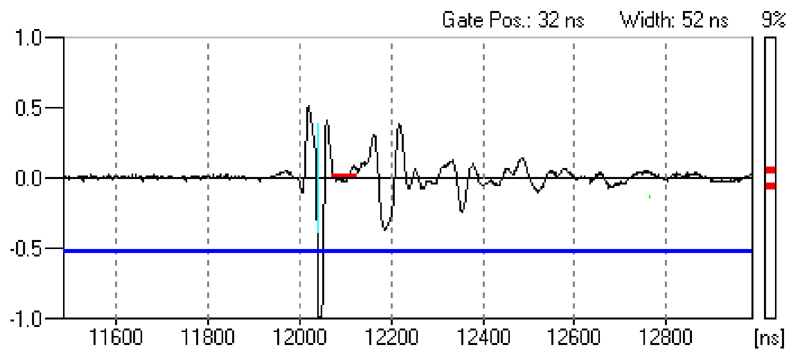
Module U22 C-SAMs

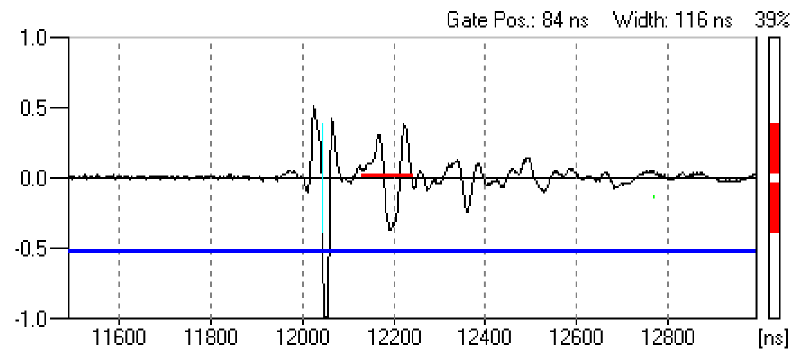
In overmold

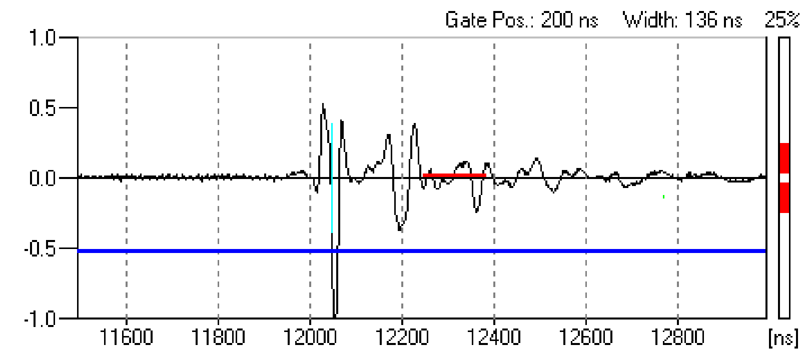
Top chip

Bottom chip





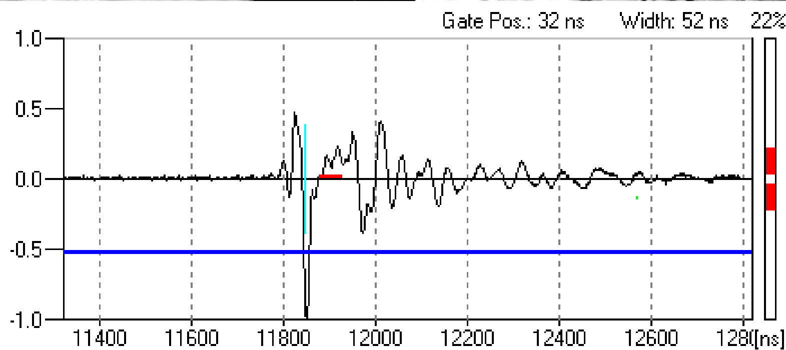




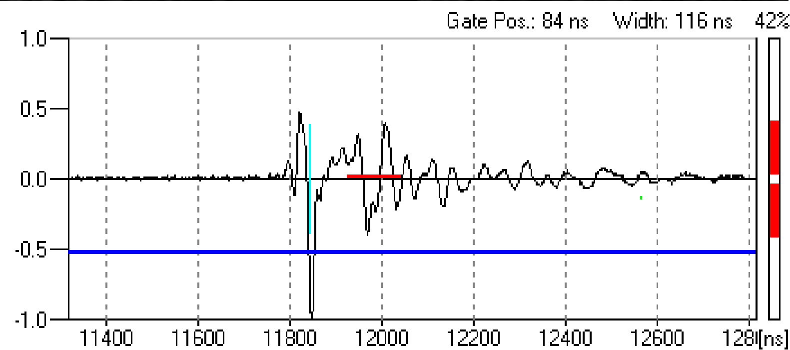
Chip appears to be in tact – no evidence of cracking or catastrophic delamination

Module U26 C-SAMs

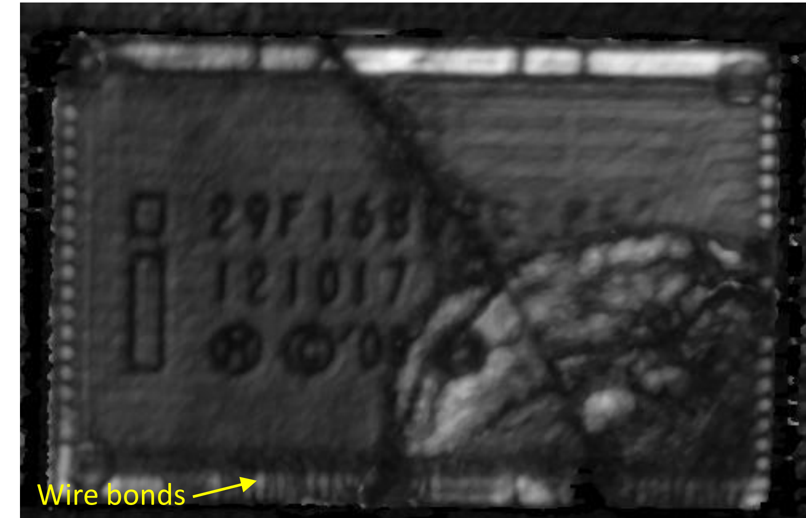
In overmold

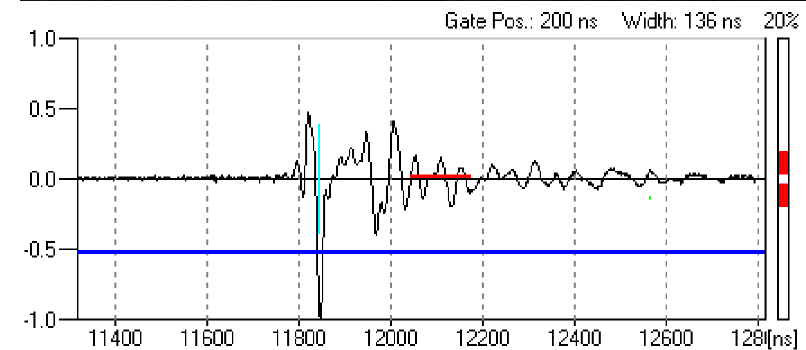


Top chip



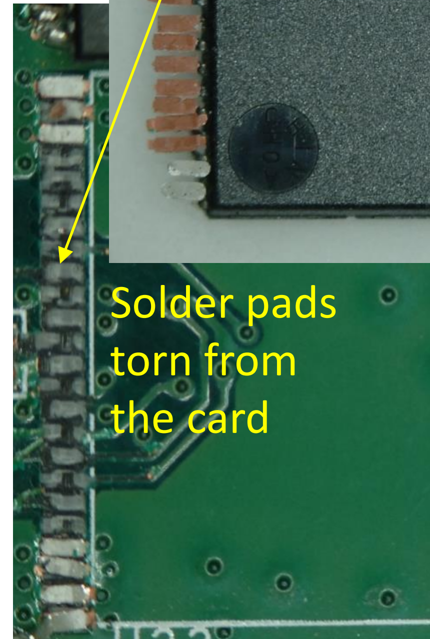
Bottom chip





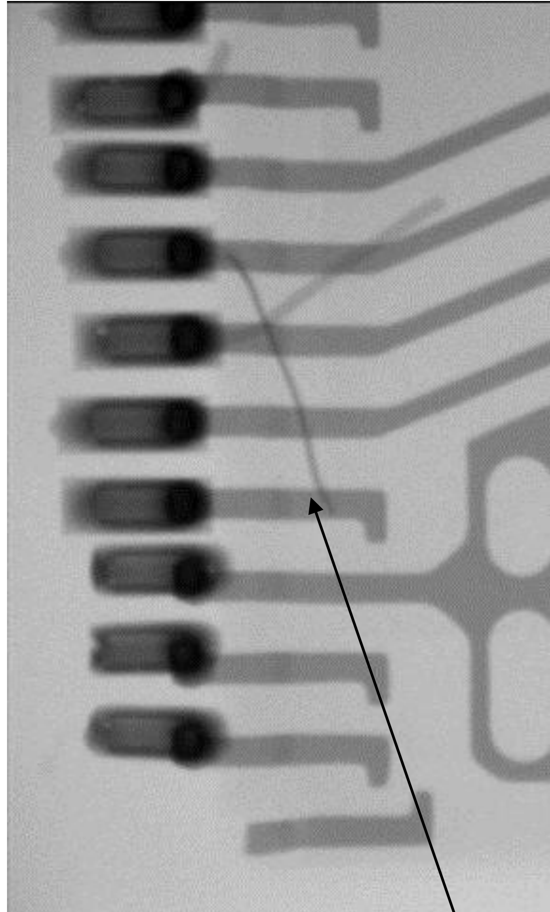
Chip is cracked, and the corner of the chip is crushed from flexing

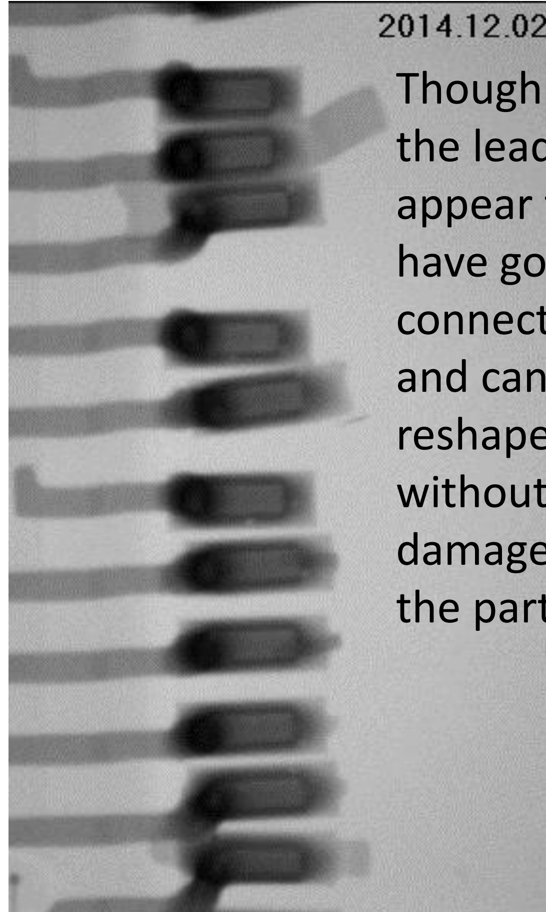
Module U27 - Photos



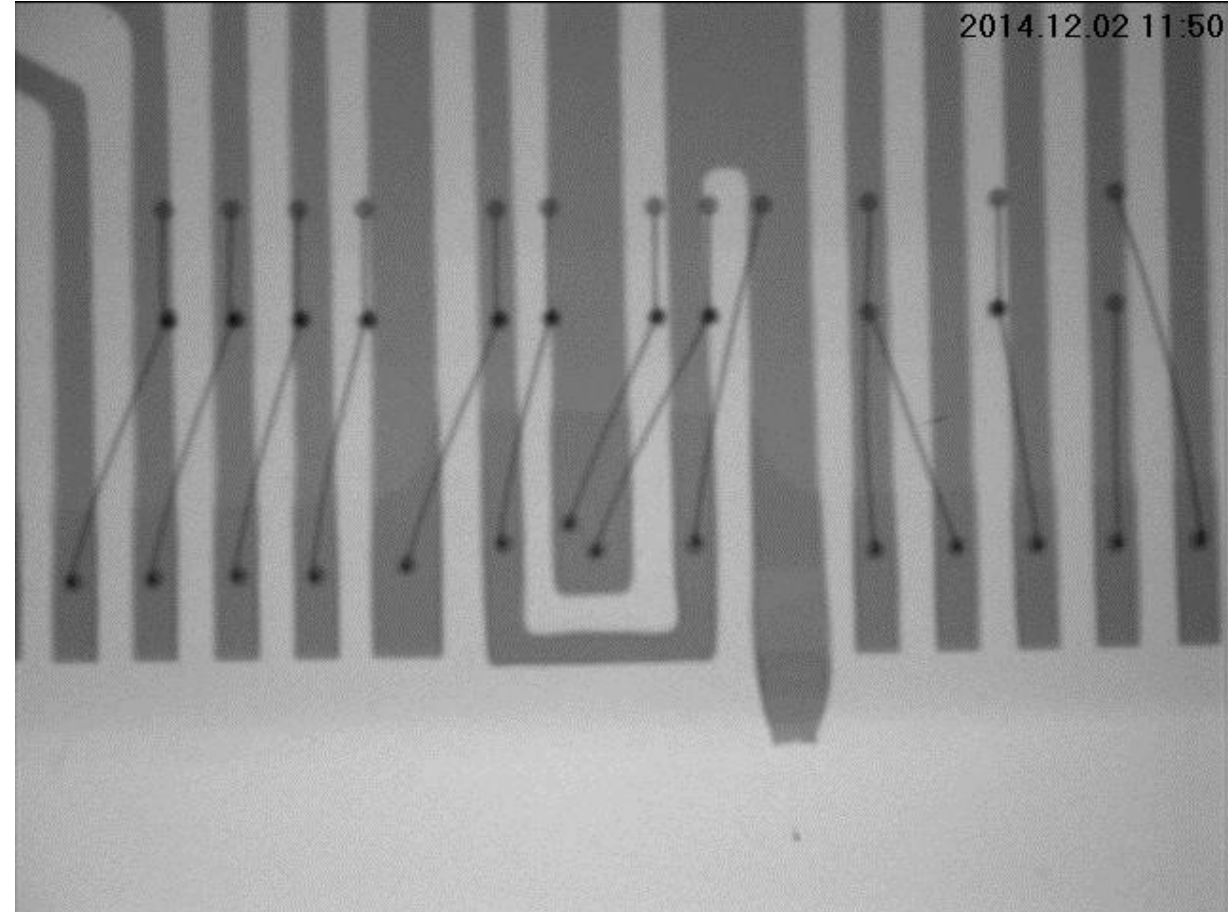
Cracks in the top side
No cracks on the bottom side

Module U27 – X-rays





Though bent, the leads appear to have good connectivity, and can be reshaped without damage to the part



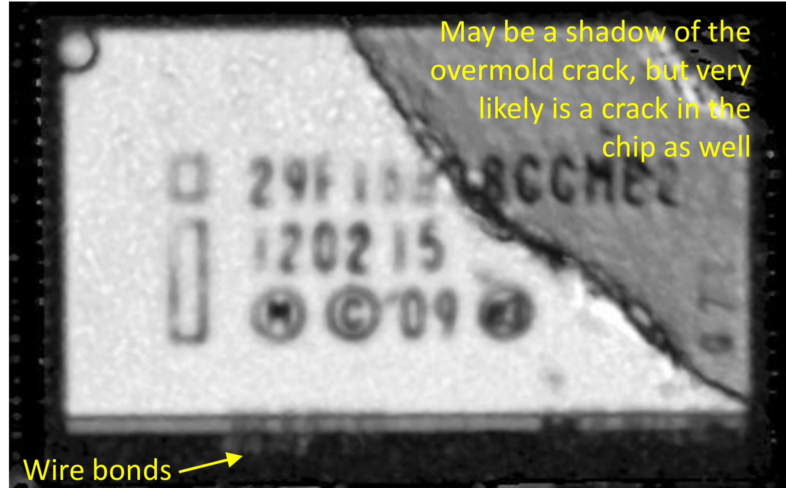
Wires pulled from the card; can be removed if necessary

Typical X-rays show good integrity of wire bonds

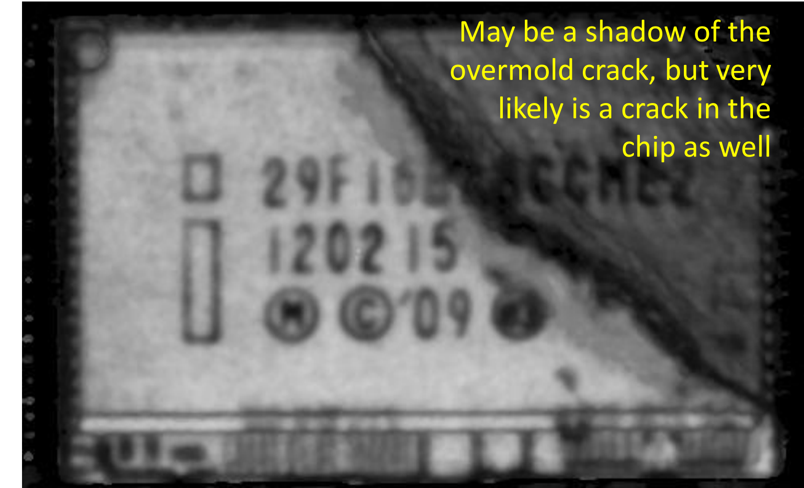
Module U27 C-SAMs

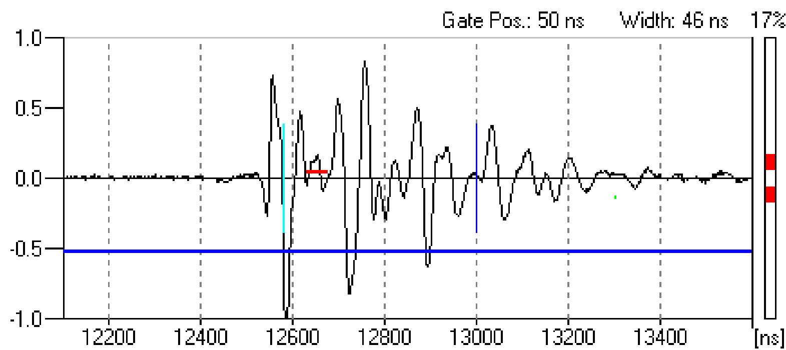
In overmold

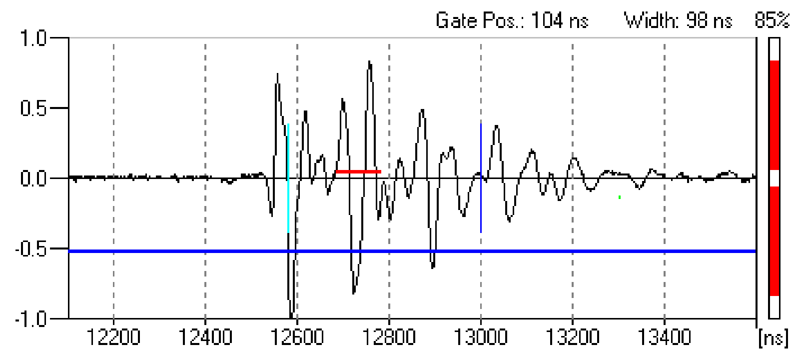
Top chip

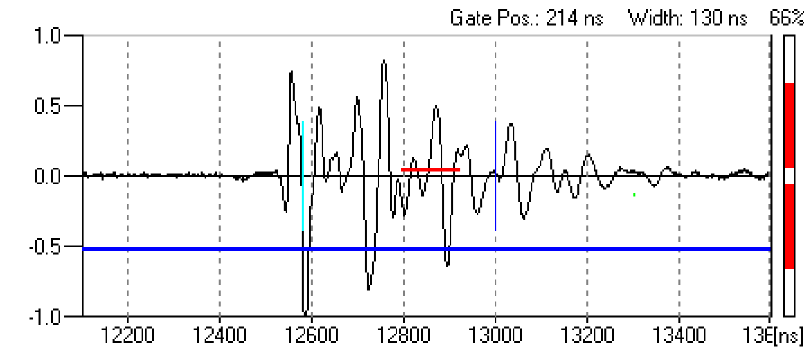


Bottom chip





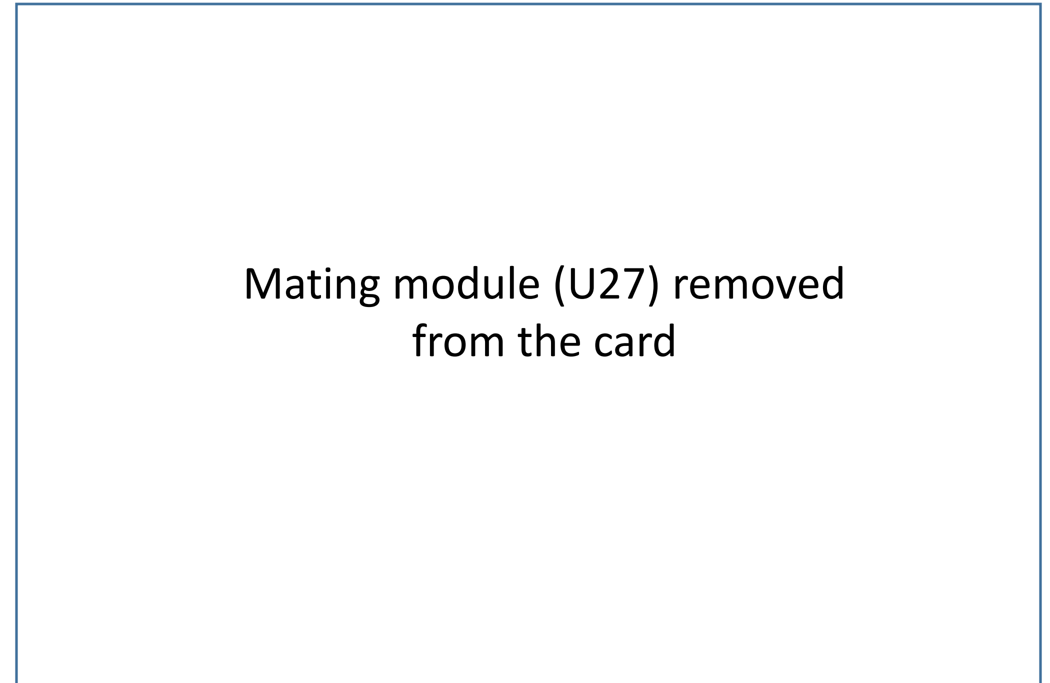




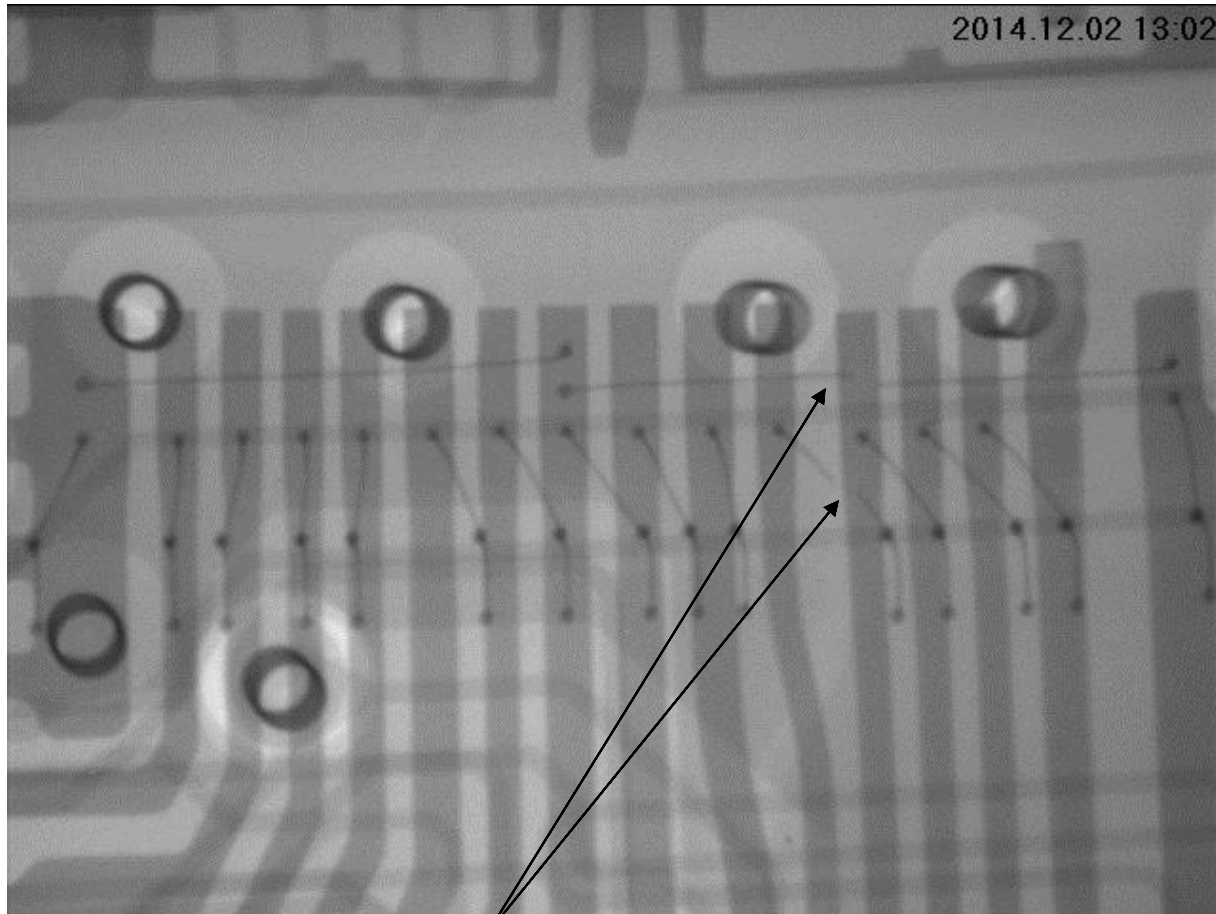
Given the flex of the module, the C-SAM anomalies are probably from cracks in the chip, not just a shadow of the cracks in the overmold

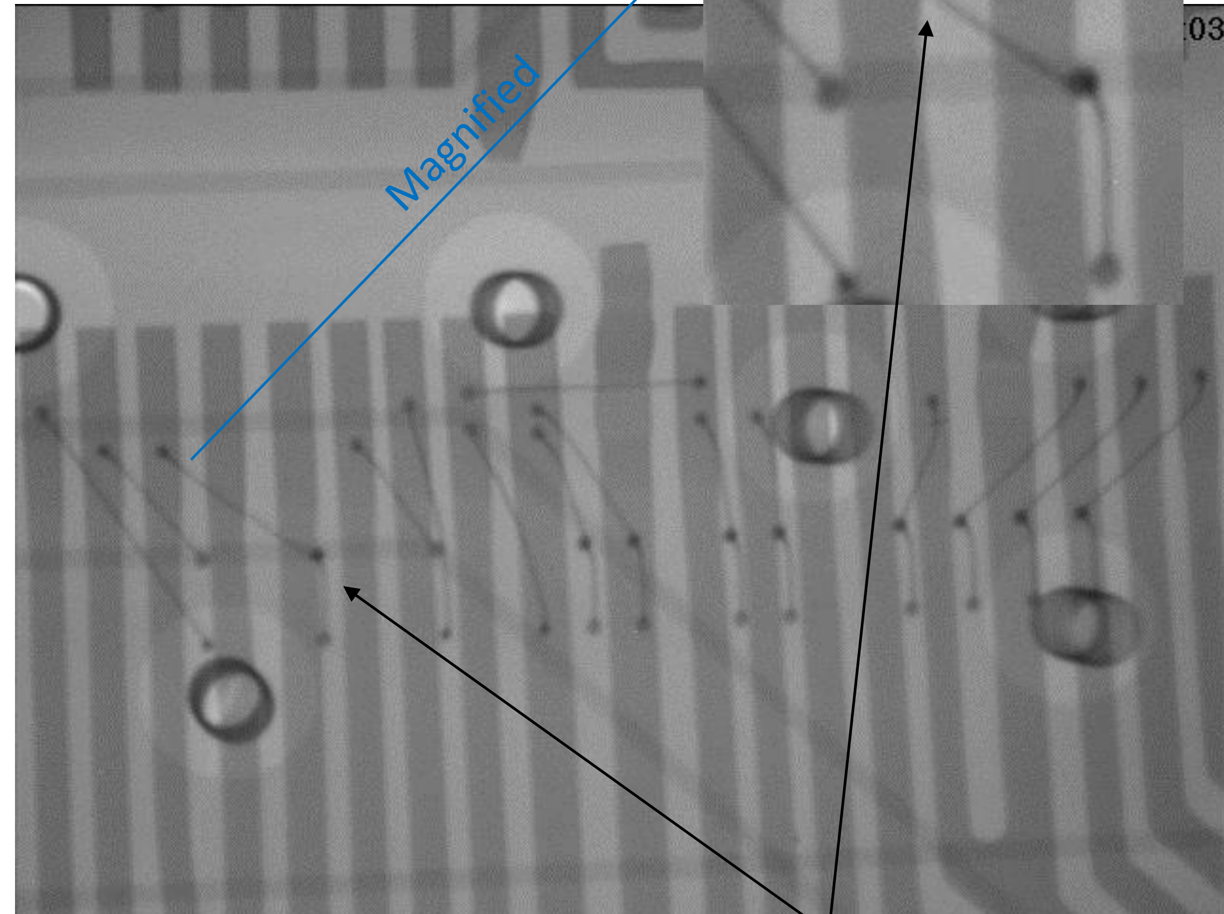
Module U31 - Photos

Obvious cracks in U31



Module U31 – X-rays

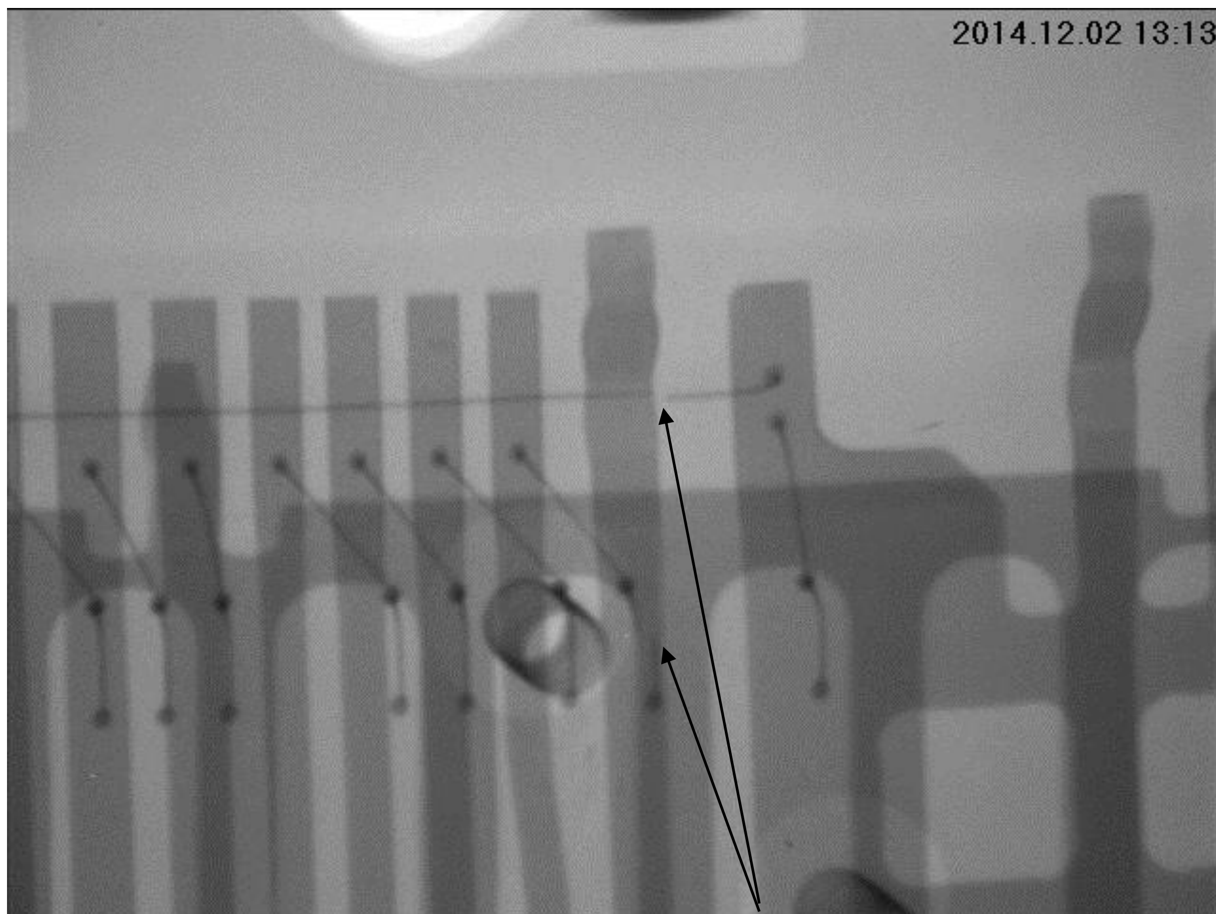




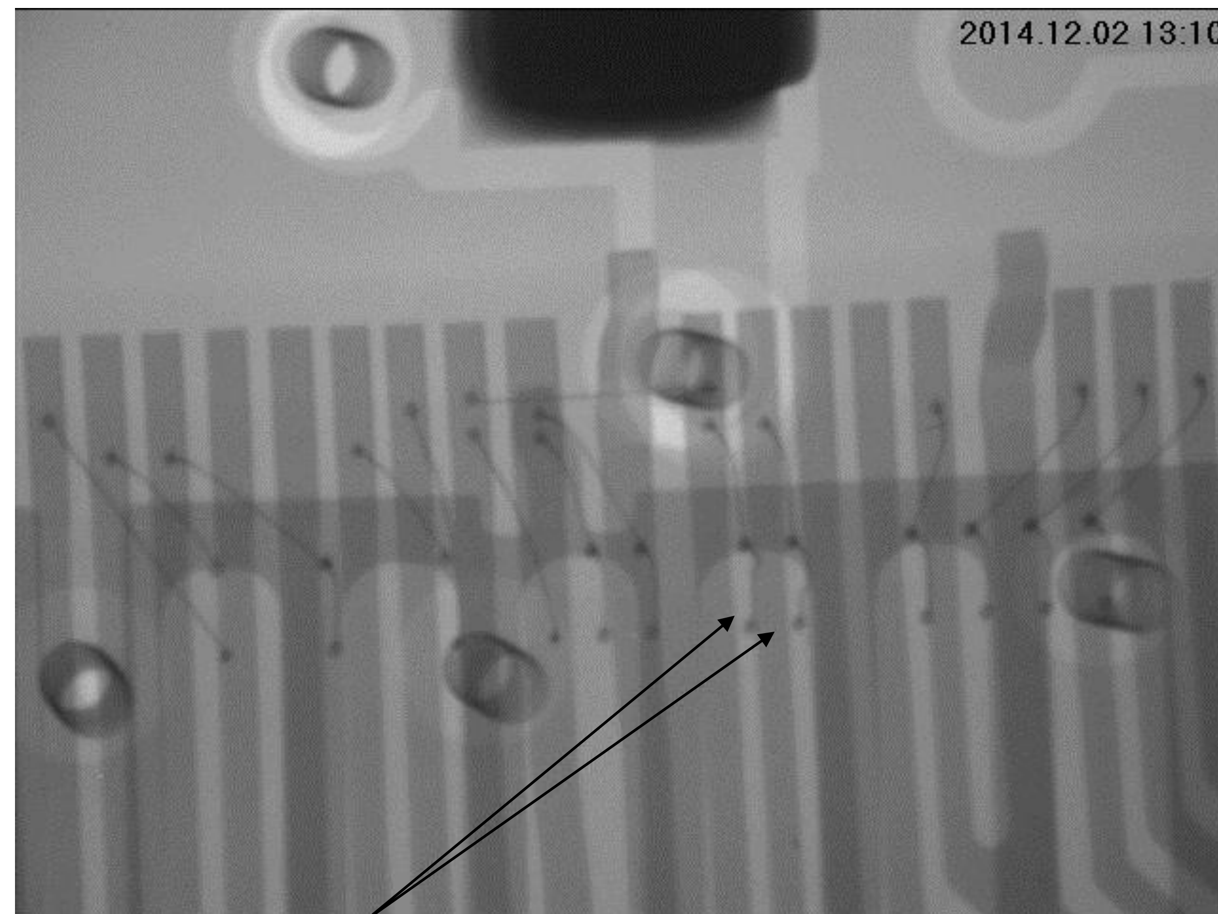
Module U28 / U32 Pair - Photos

Obvious cracks in U28
Cracks in U32 expose internal features

Module U28 / U32 Pair – X-rays



Broken wires (U32)



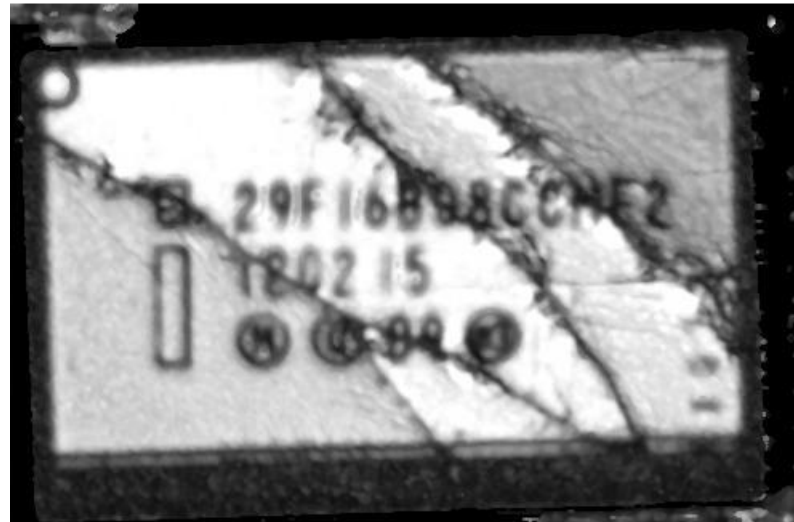
Kinked and likely broken wires (U32)

Wire bonds on the other side (U28 – X-rays not shown here) are good

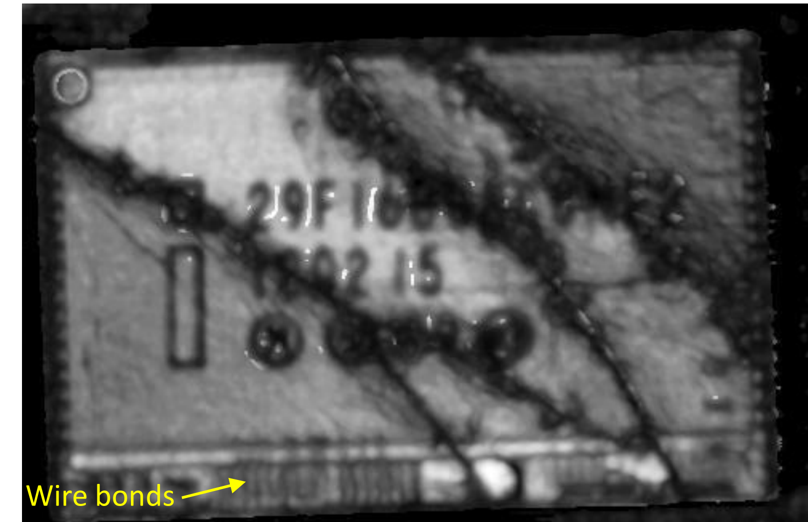
Module U28 C-SAMs

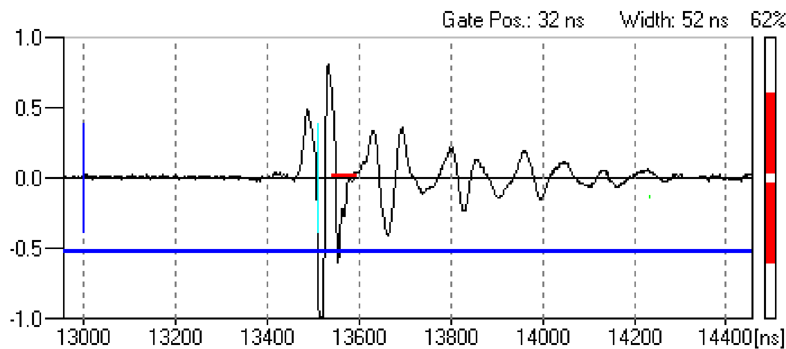
In overmold

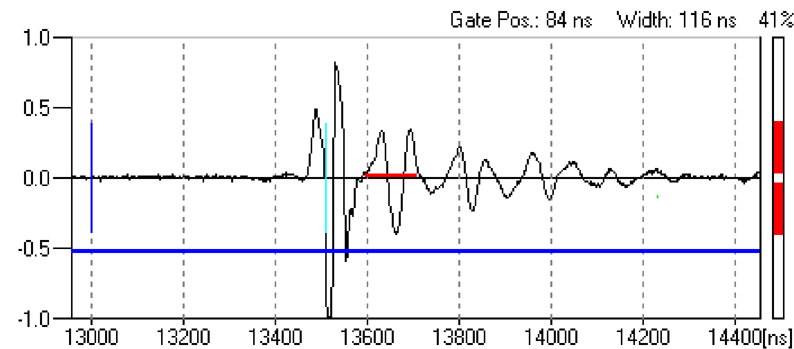
Top chip

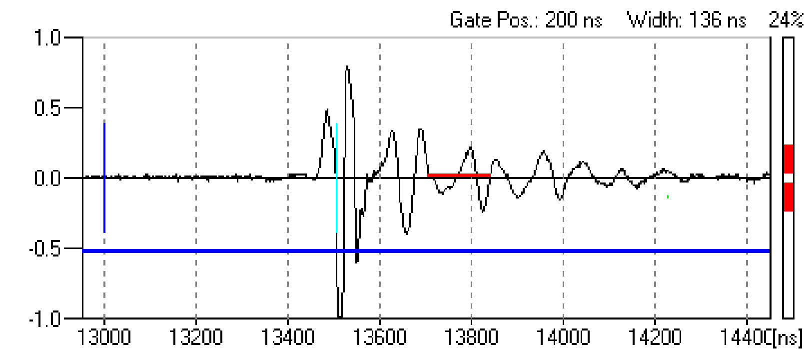


Bottom chip



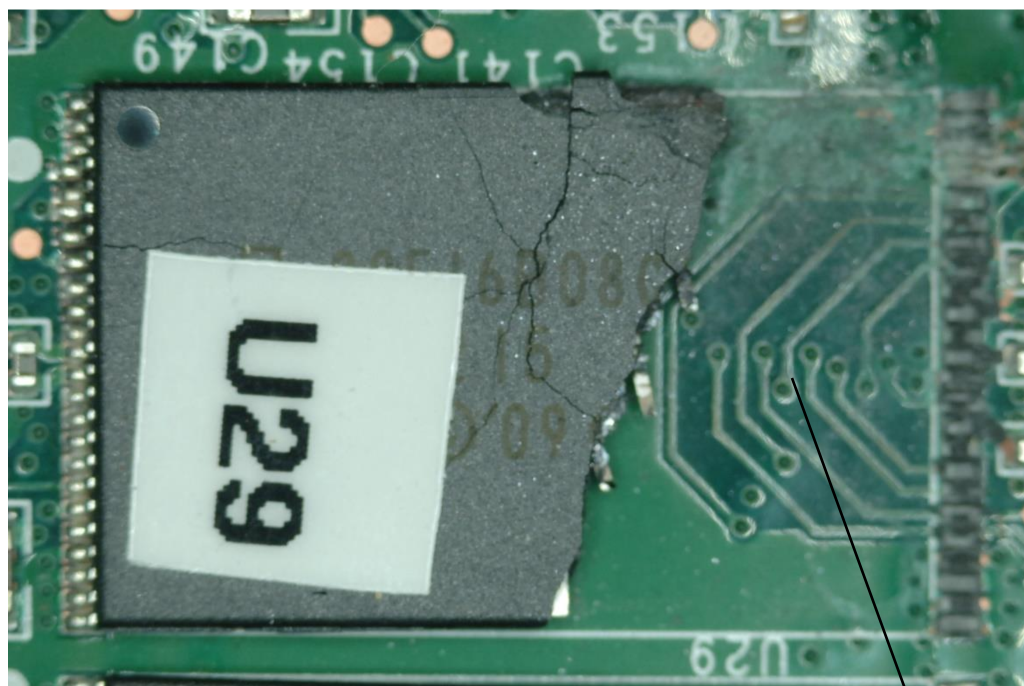






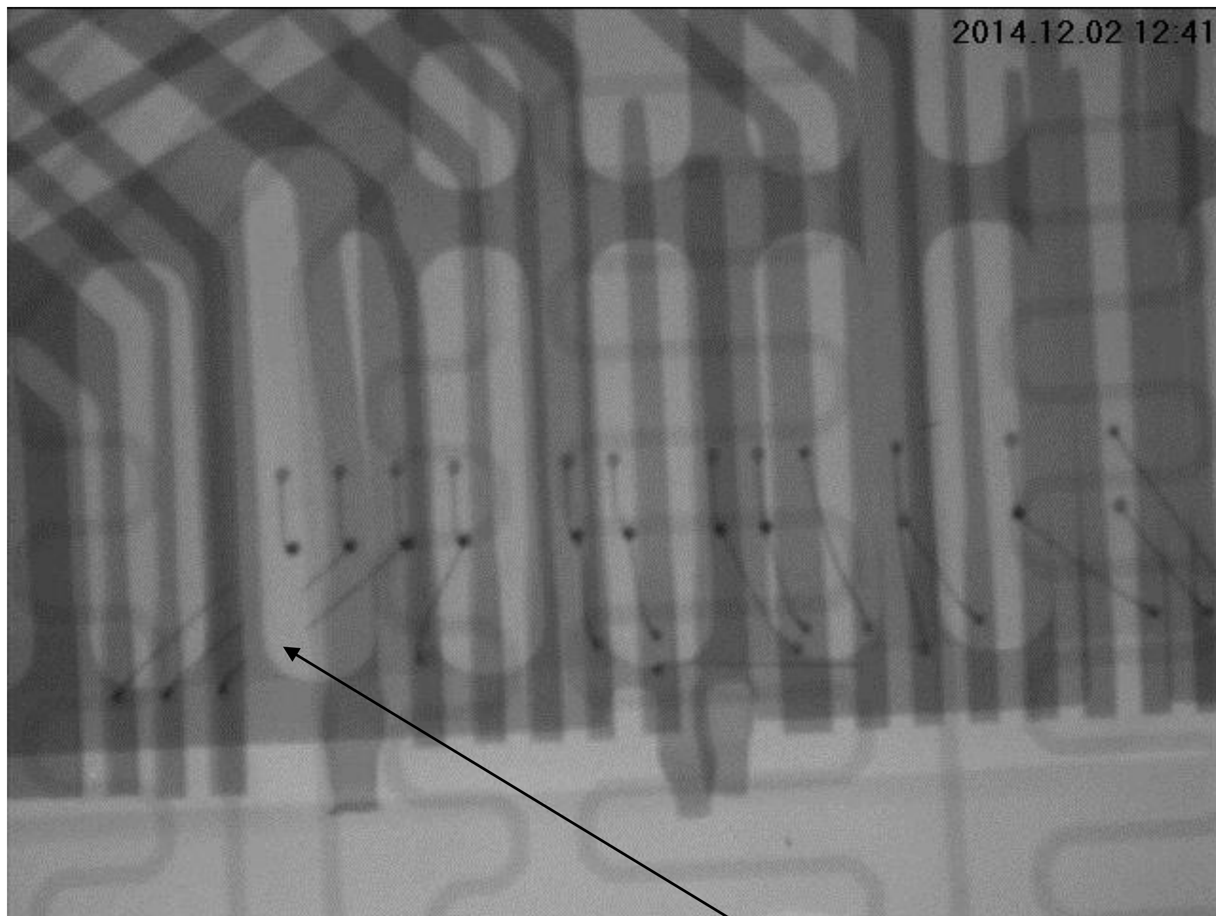
Given the flex of the module, the C-SAM anomaly is probably from a crack in the chip, not just shadows of the cracks in the overmold

Module U29 / U33 Pair - Photos

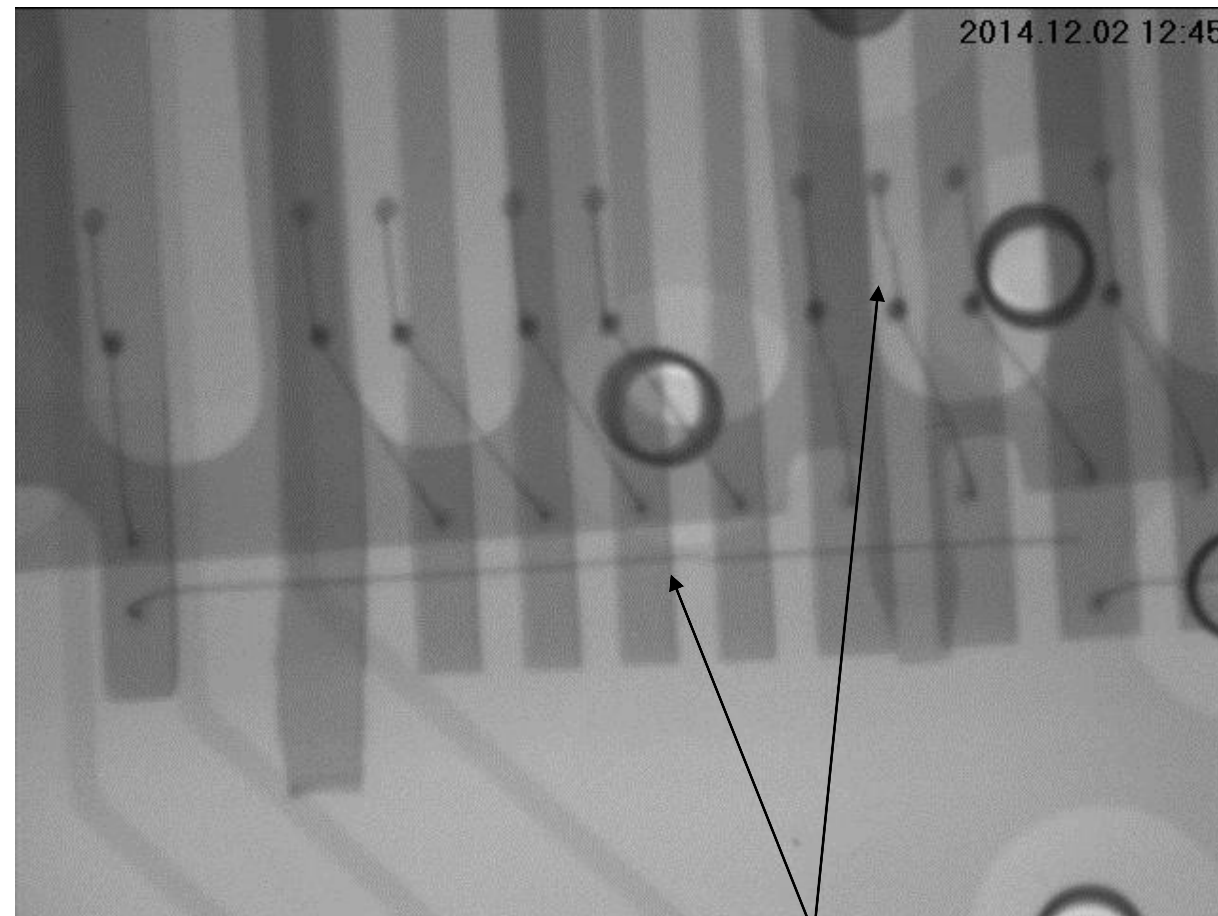


U29 is broken into 2 parts
U33 is badly cracked, exposing internal features

Module U29 / U33 Pair – X-rays

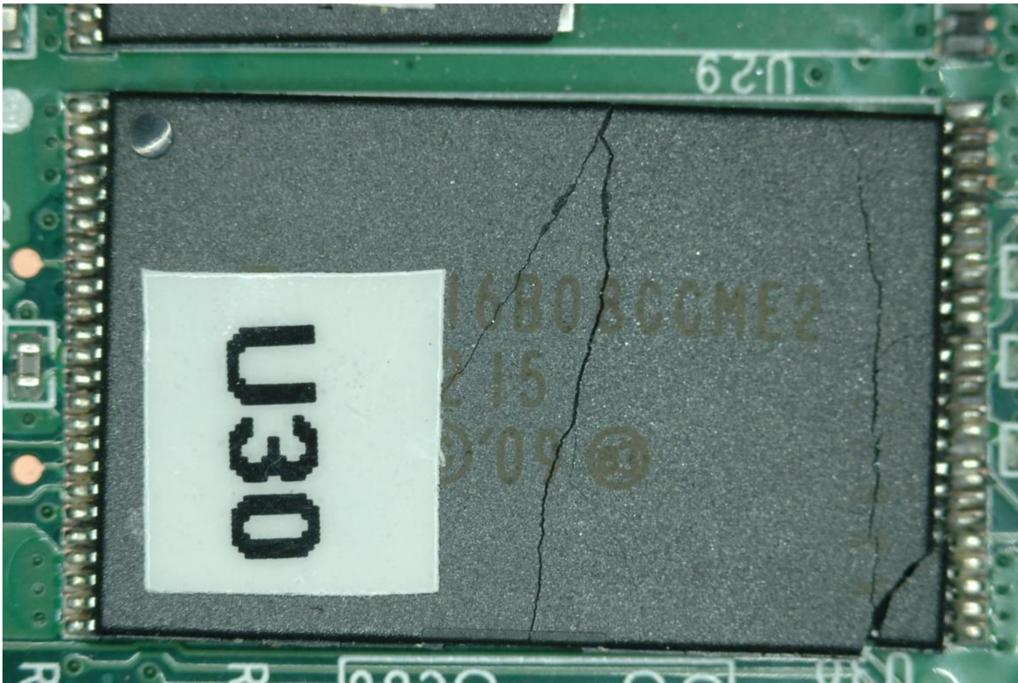


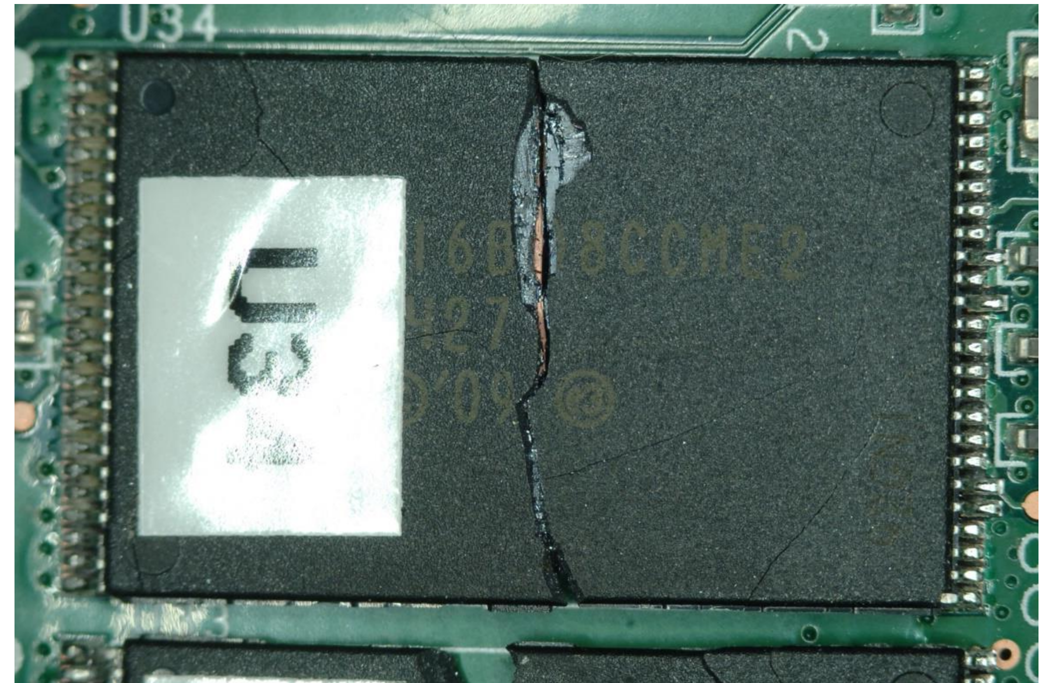
Broken wires in U33



Broken wires in U33

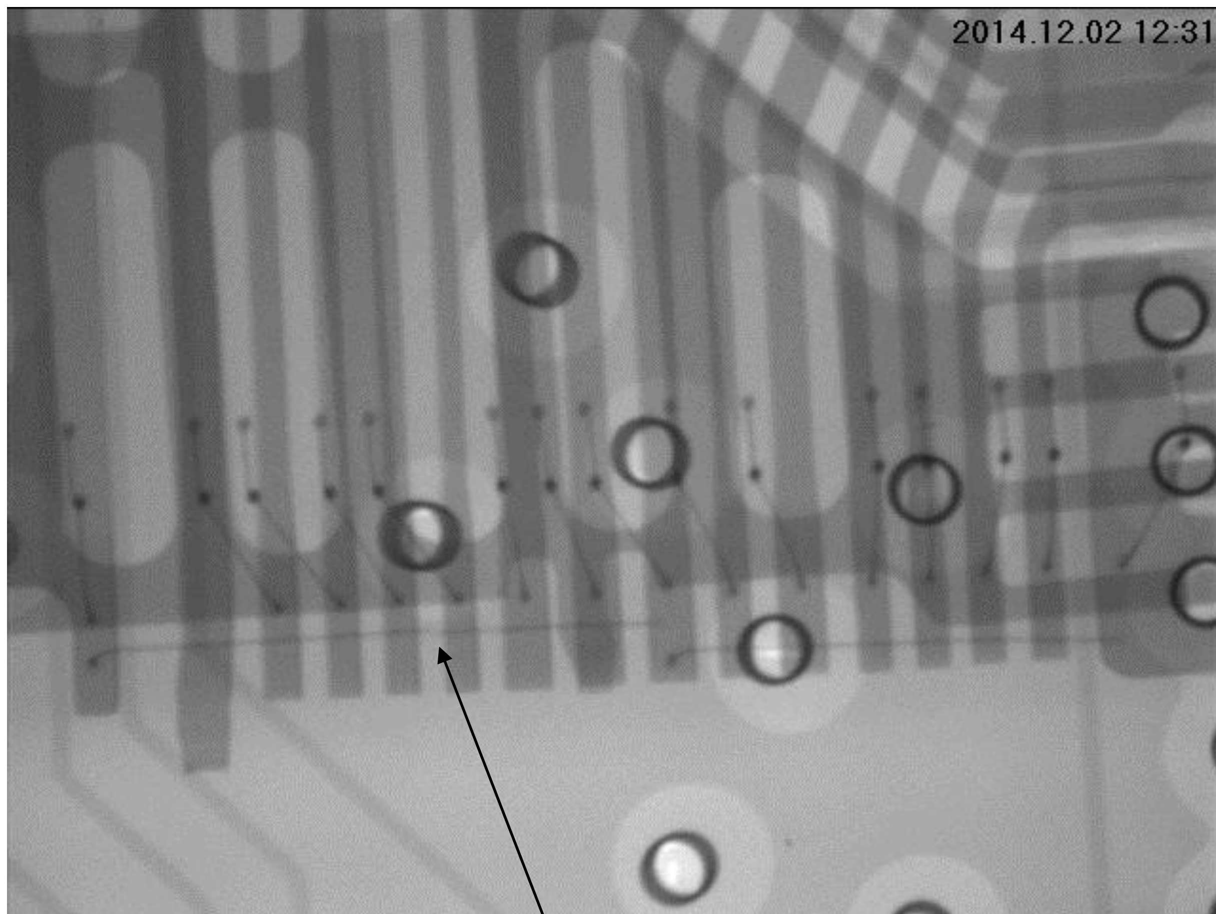
Module U30 / U34 Pair - Photos



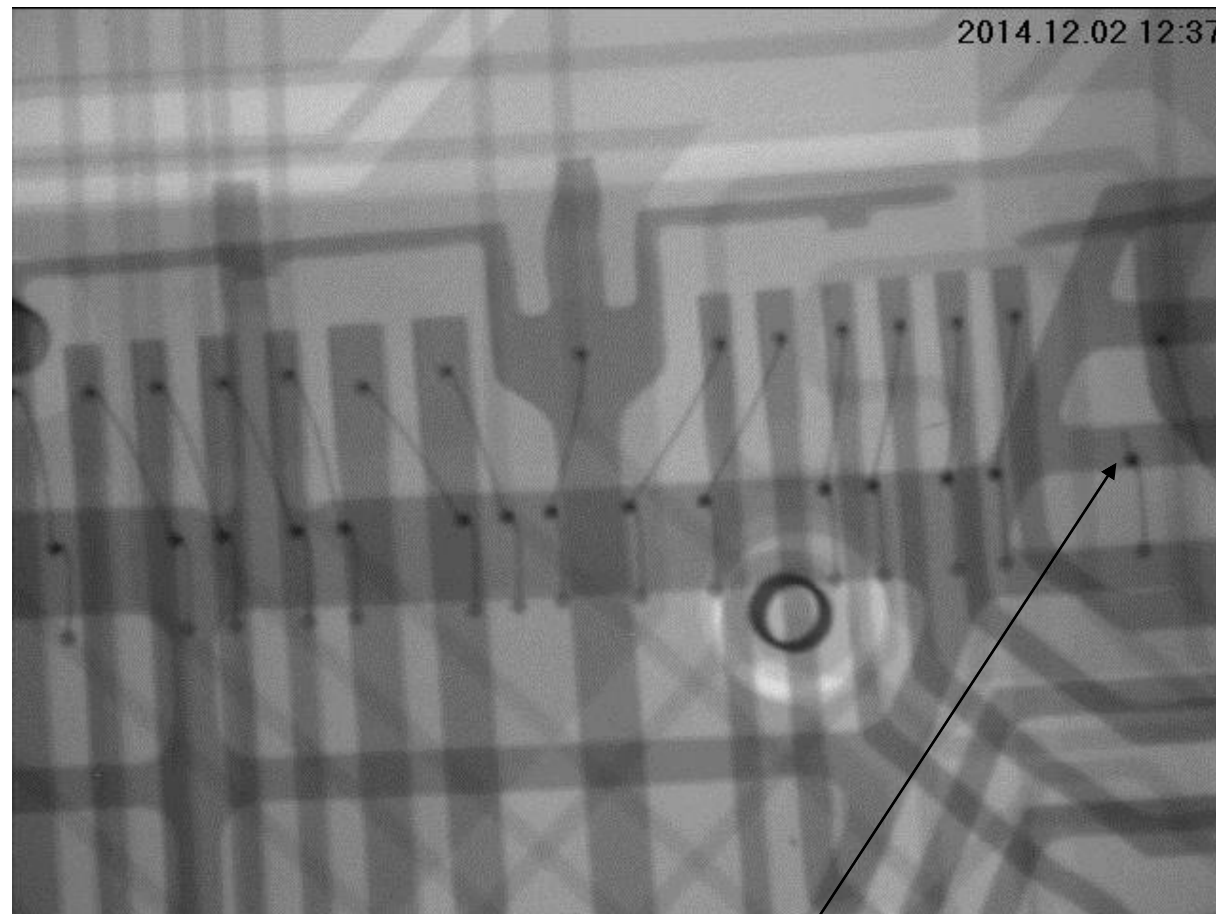


Obvious cracks in U30
U34 is badly cracked, exposing internal features

Module U30 / U34 Pair – X-rays



Broken wire in U34

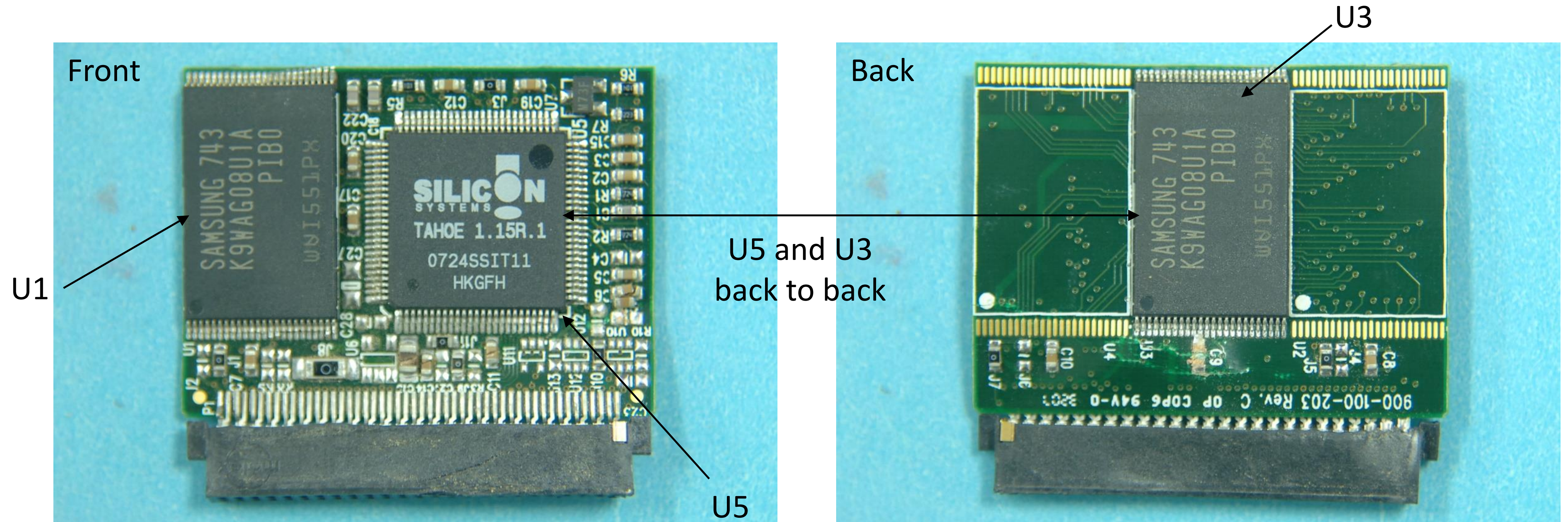


Broken wire in U30

Section 4

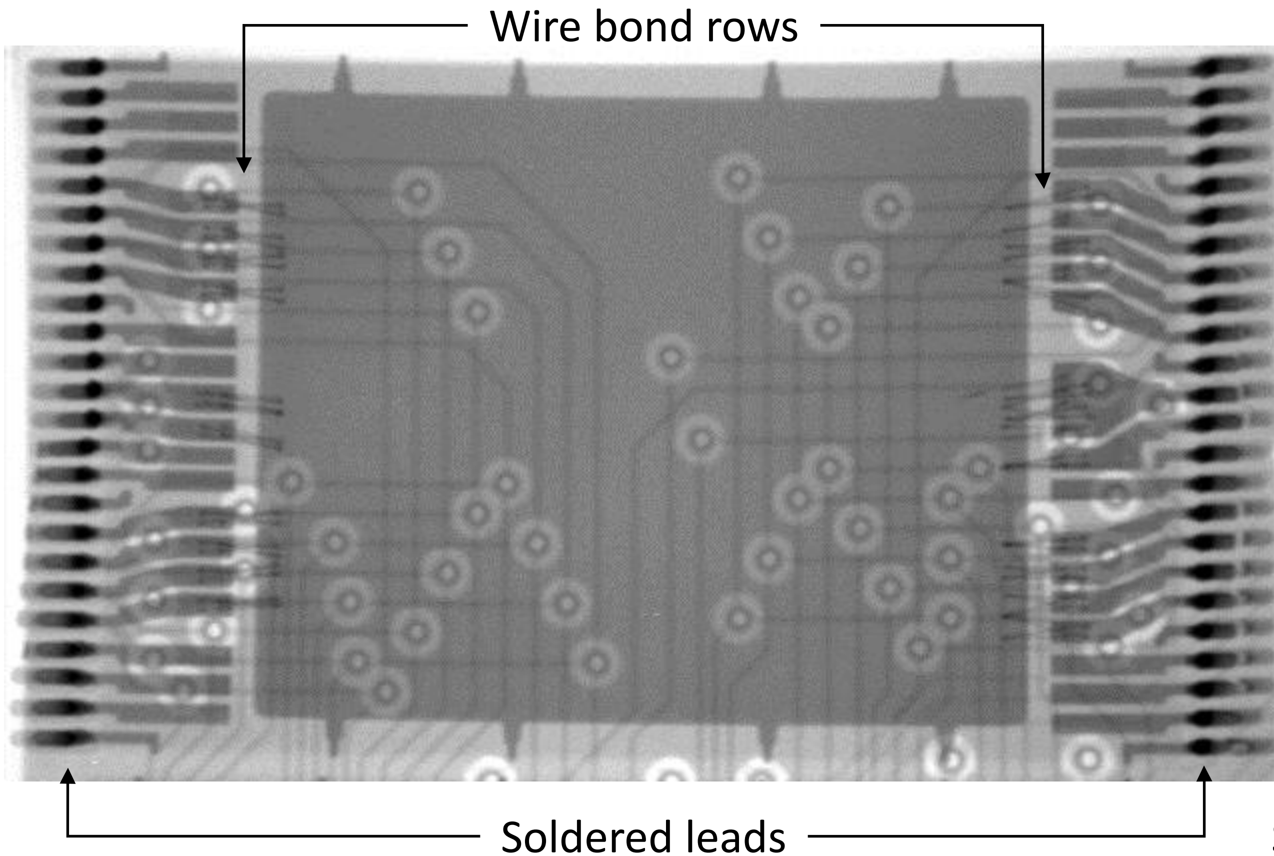
Modules in Bag 2

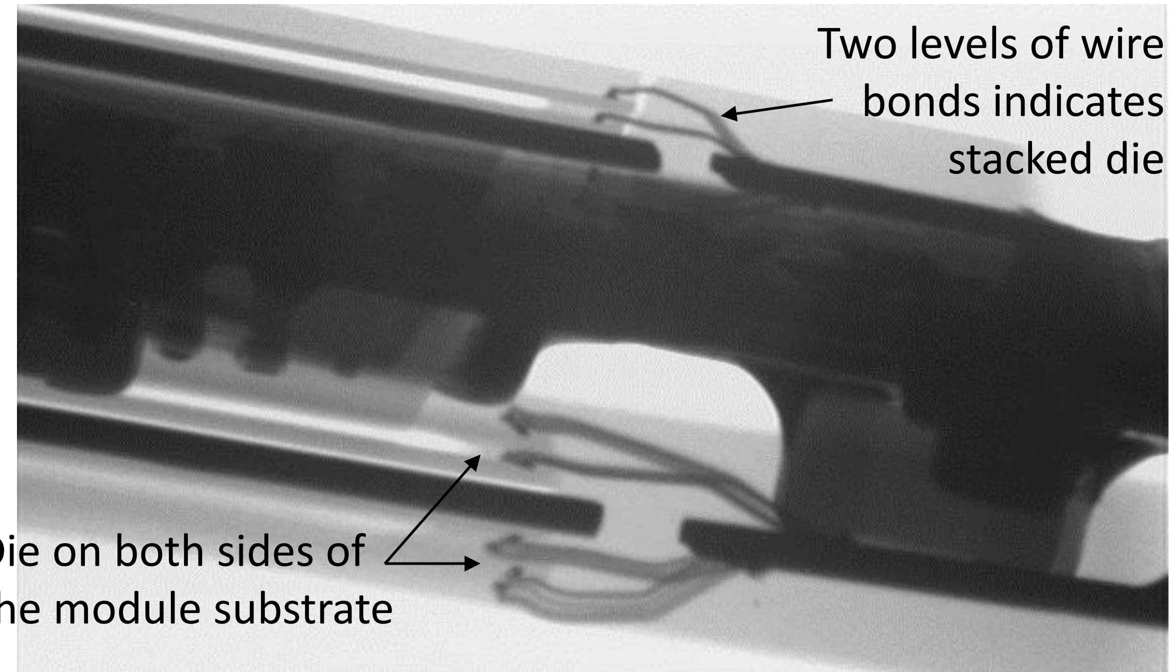
Layout of the Card

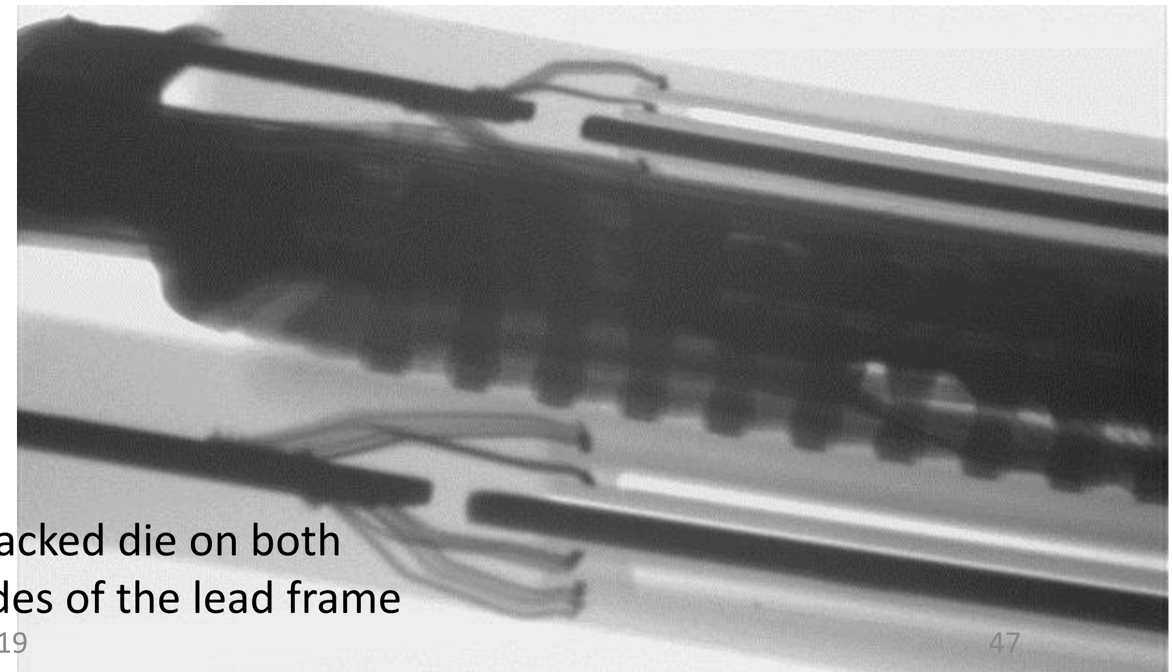


U1 and U3: Samsung Memory Modules
U5: Silicon Systems Processor

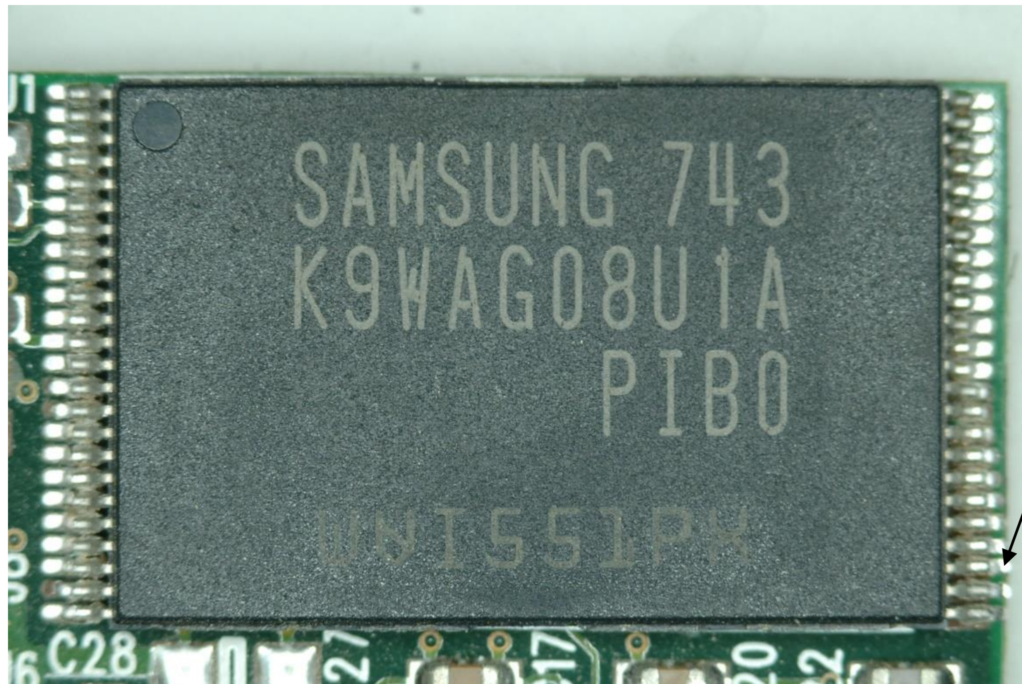
Basic Construction from U1 (and U3) X-rays



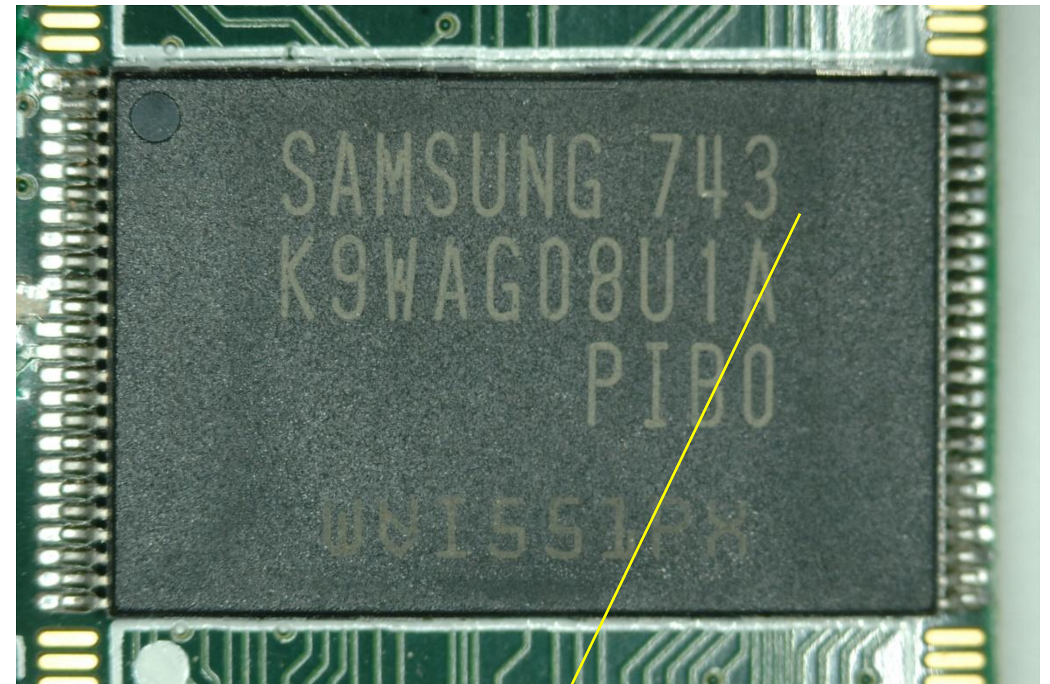




Micrographs of U1 and U3



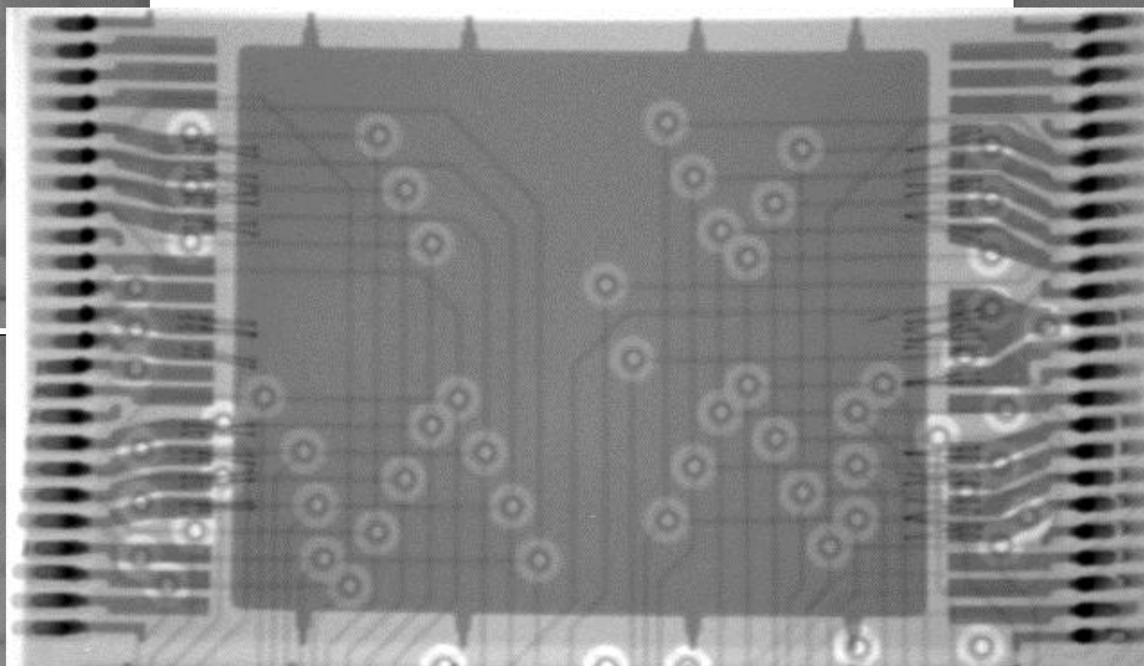
Solder pads pulled from card



Subtle crack

No cracks in U1, solder pads pulled from card
Very fine crack in overmold of U3

X-rays of U1



All wire bonds show good integrity
(high mag X-rays are given in the corners)

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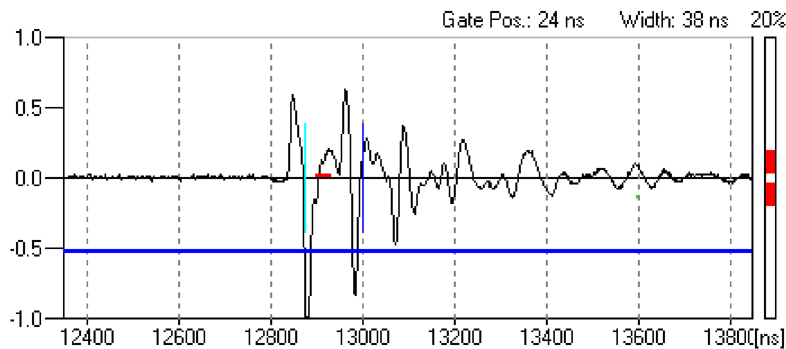
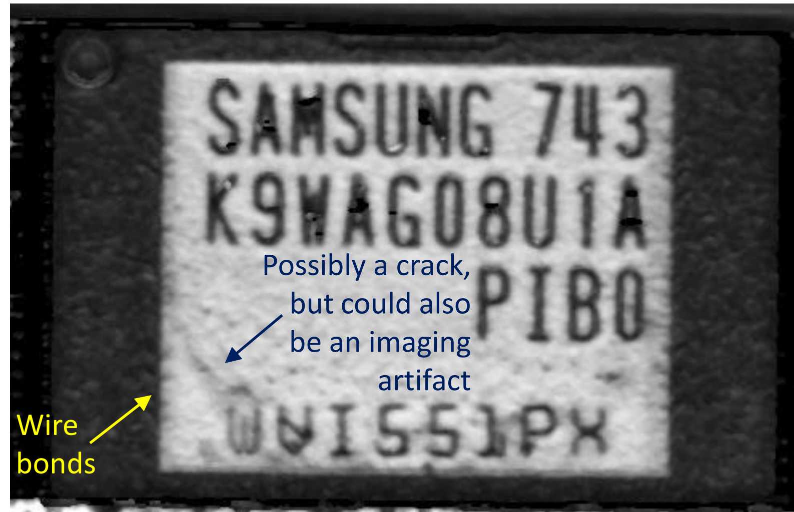
Broken solder joints

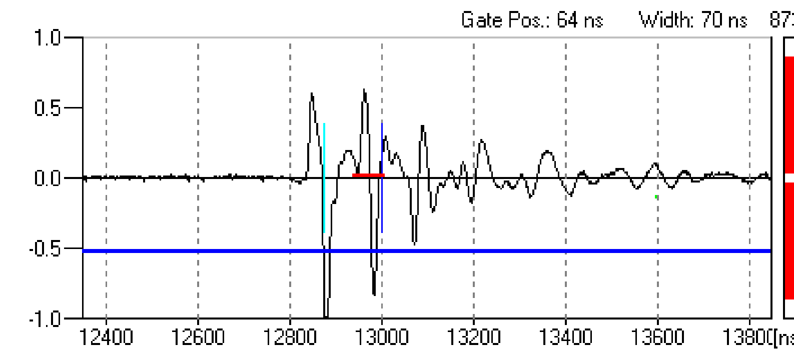
Module U1 C-SAMs

In overmold

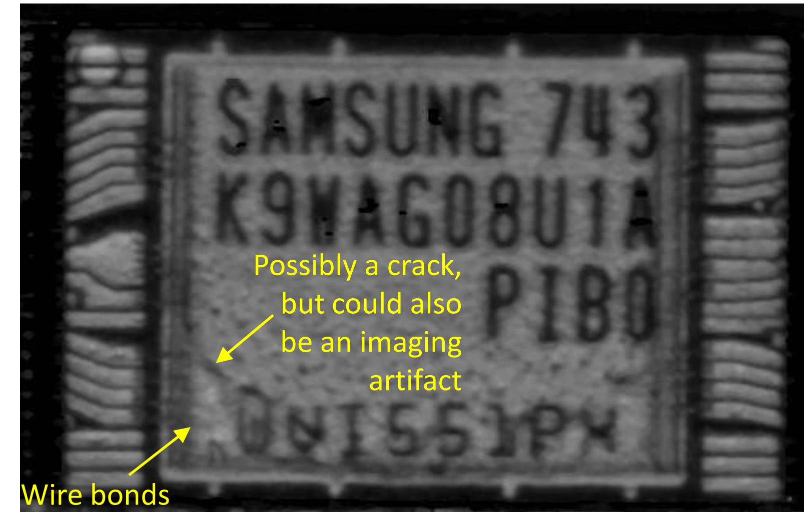


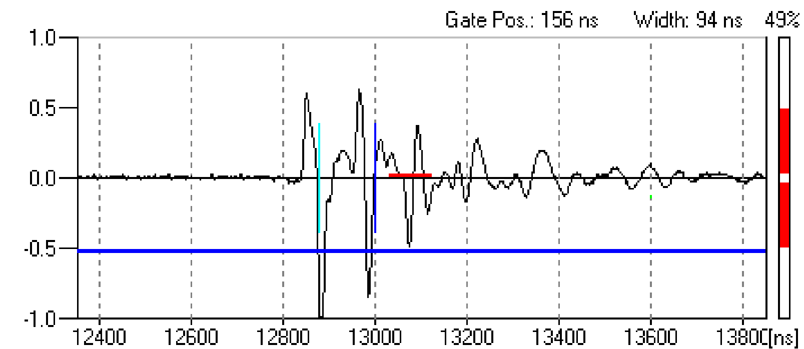
Top chip





Lower chip and leads

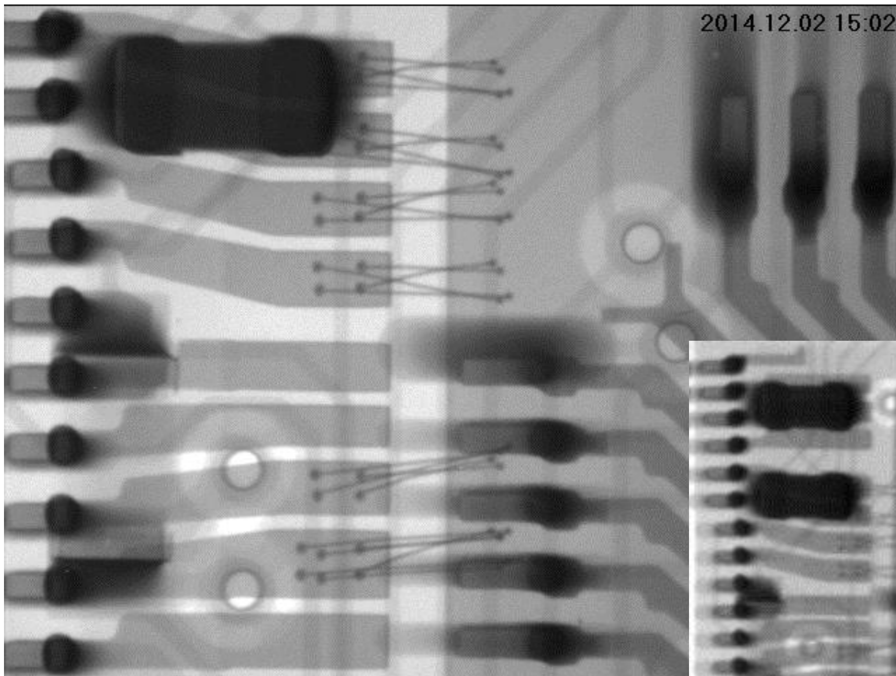


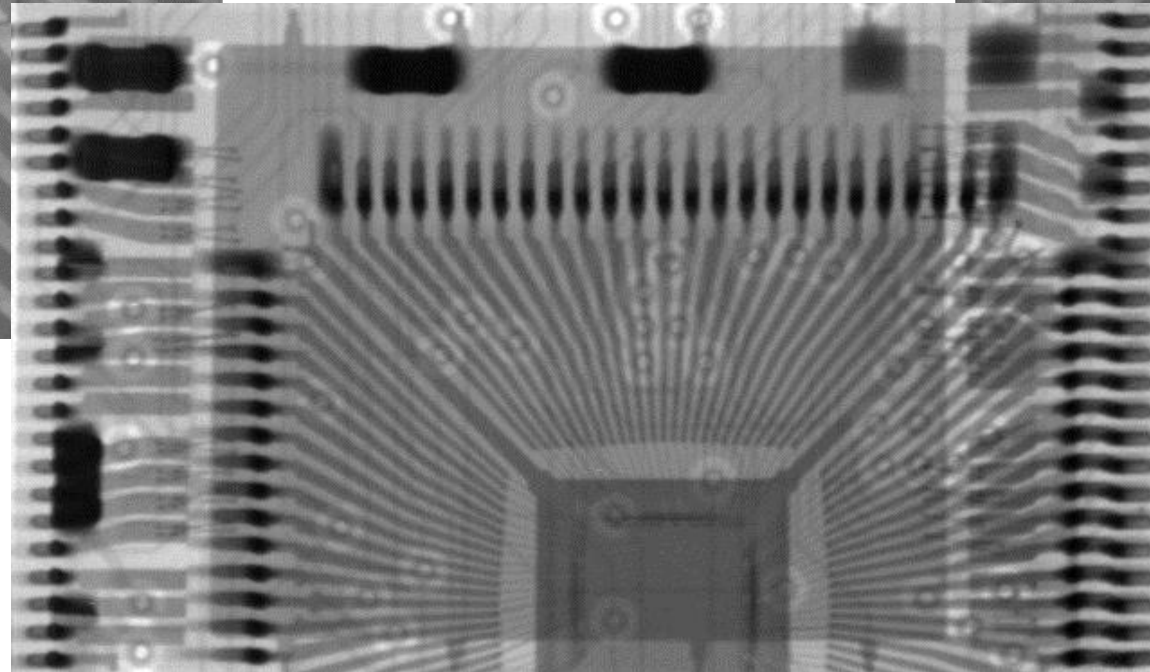


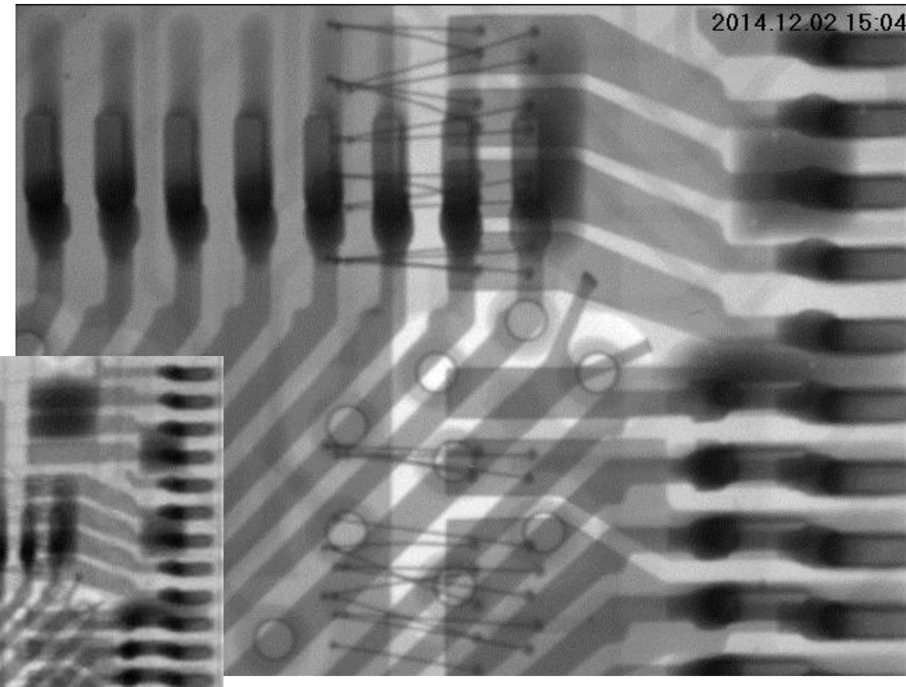
C-SAMs of deeper levels were taken, but gave no additional information

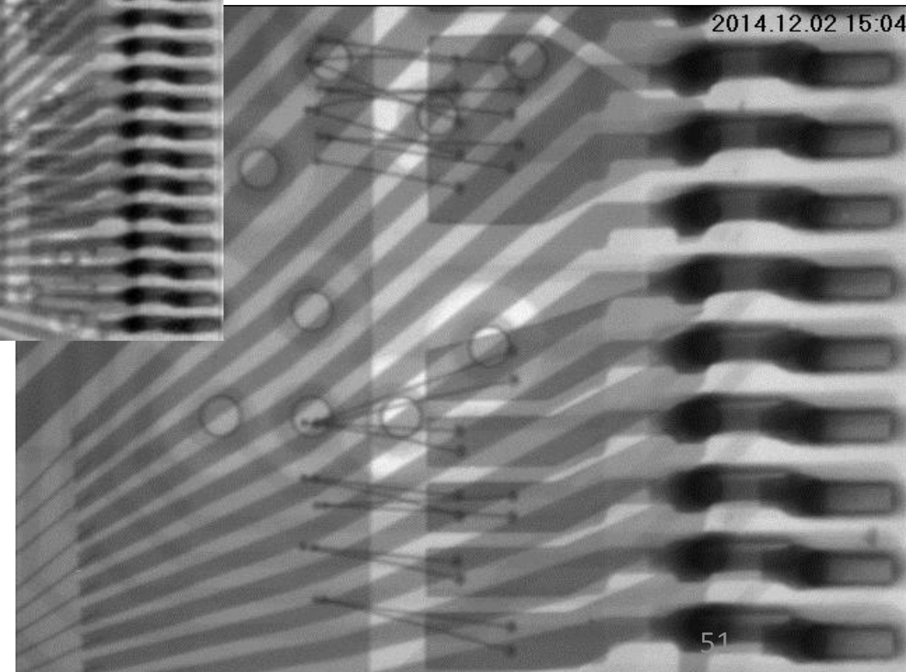
The anomaly may be a crack in the die, or an imaging artifact – overall, the top two chips appear to be intact (and very likely, the underlying ones as well)

X-rays of U3







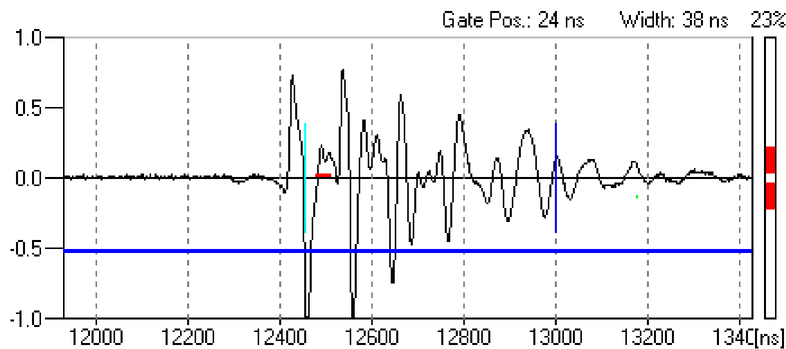


Circuitry is obscured by module U5, but the wire bonds are not

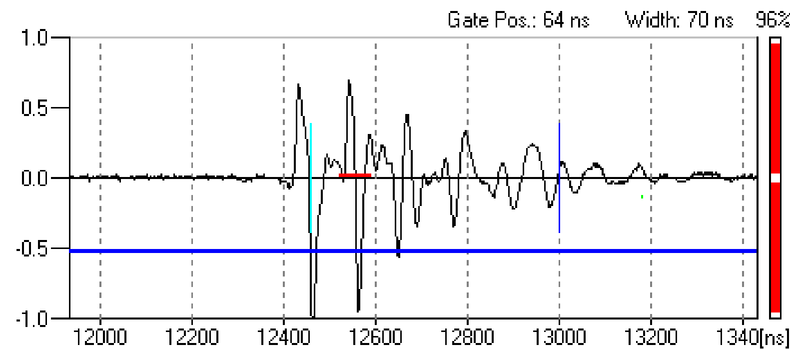
All wire bonds show good integrity (typical high mag x-rays are given)

Module U3 C-SAMs

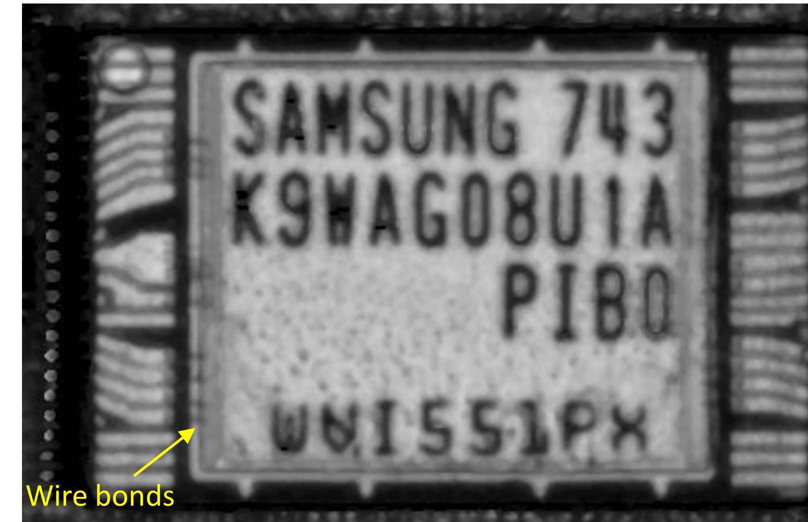
In overmold

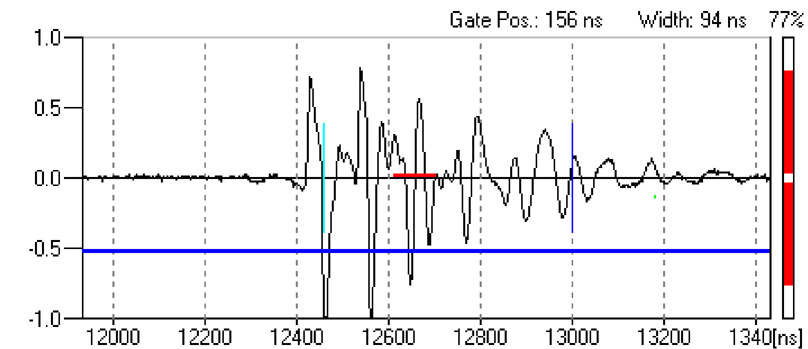


Top chip (taken with lower gain to avoid saturation)



Lower chip and leads



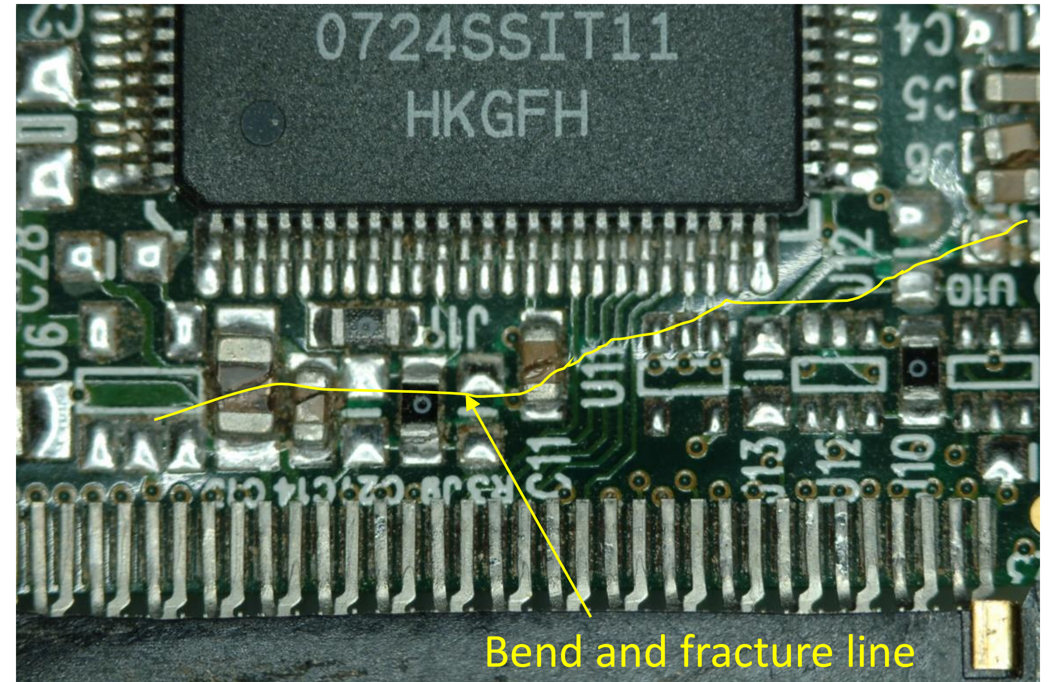


C-SAMs of deeper levels were taken, but gave no additional information

Overall, the top two chips appear to be intact (and very likely, the underlying ones as well)

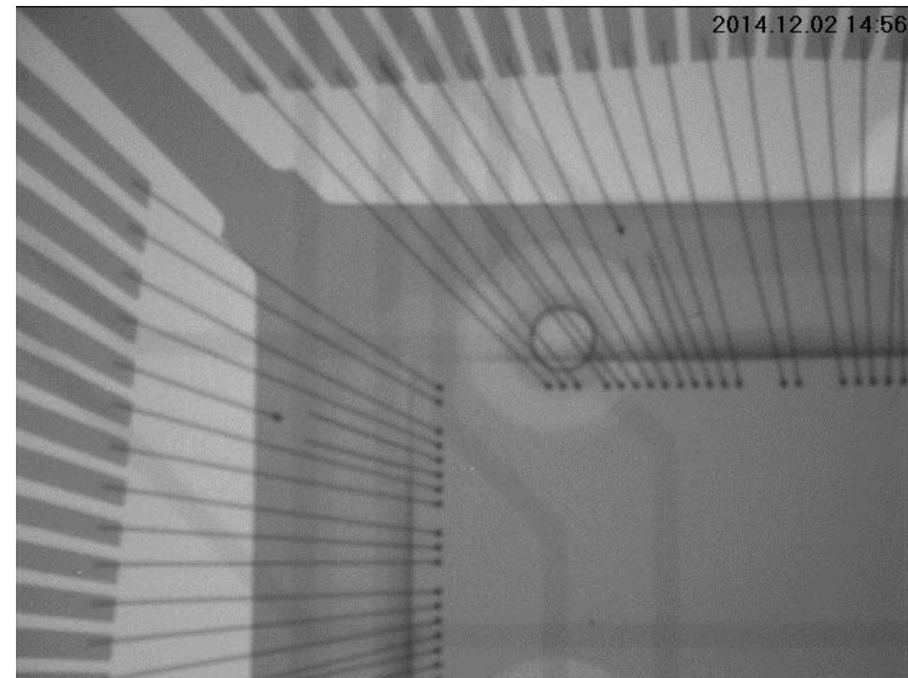
Micrographs of U5

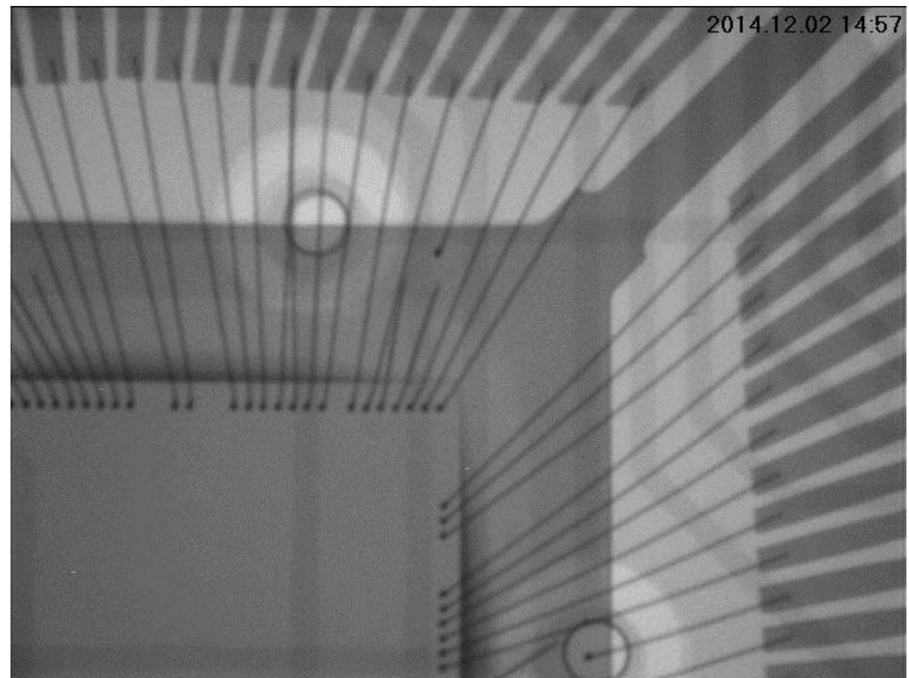
No cracks in U5

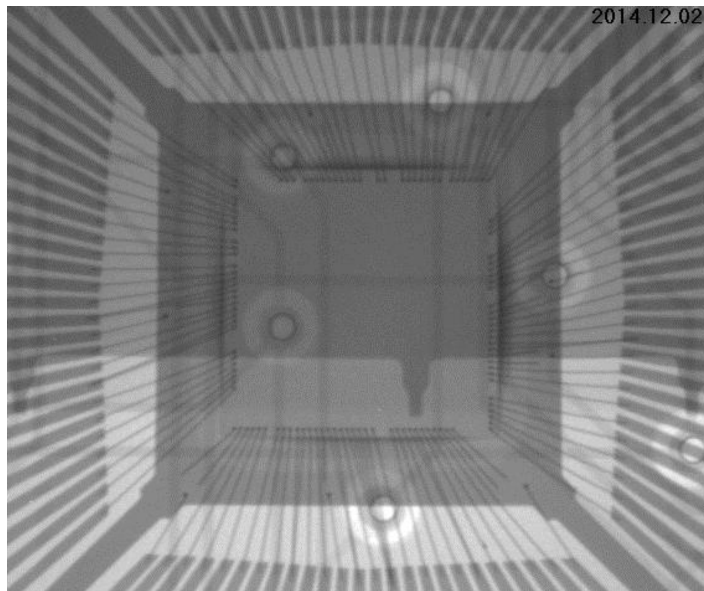


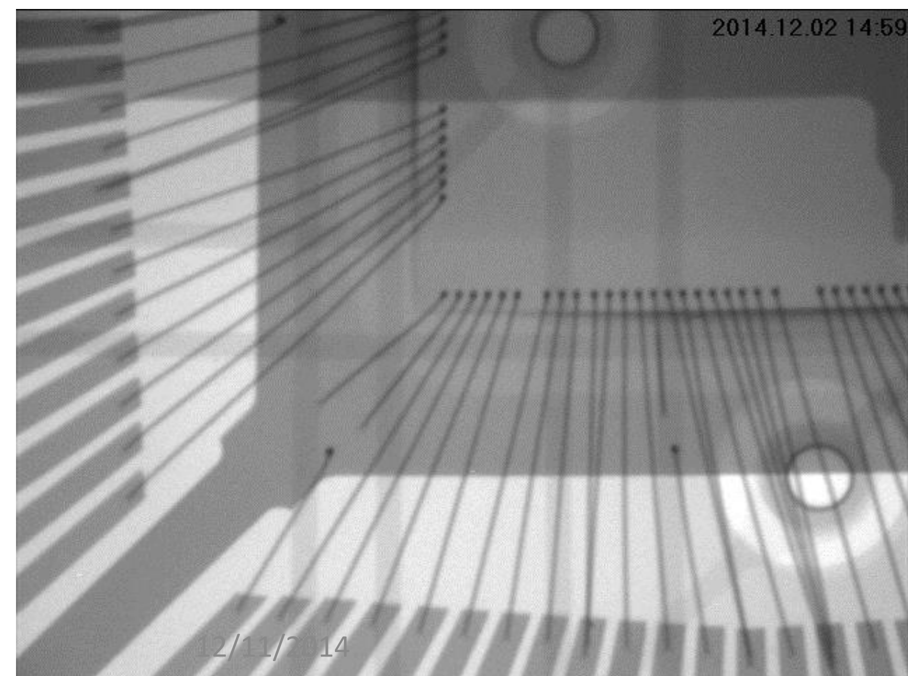
Bend appears to miss module U5

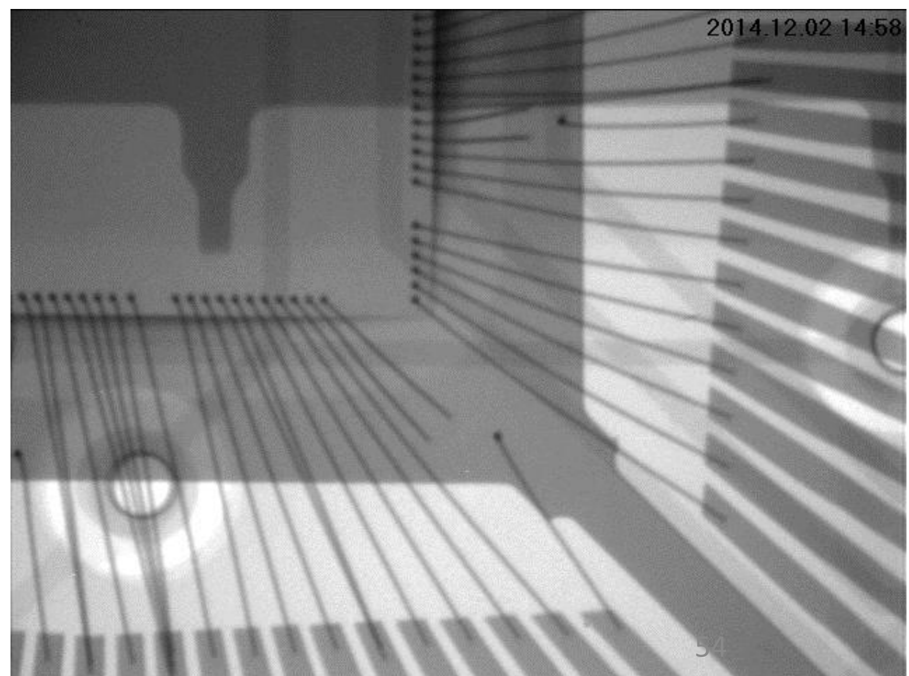
X-rays of U5







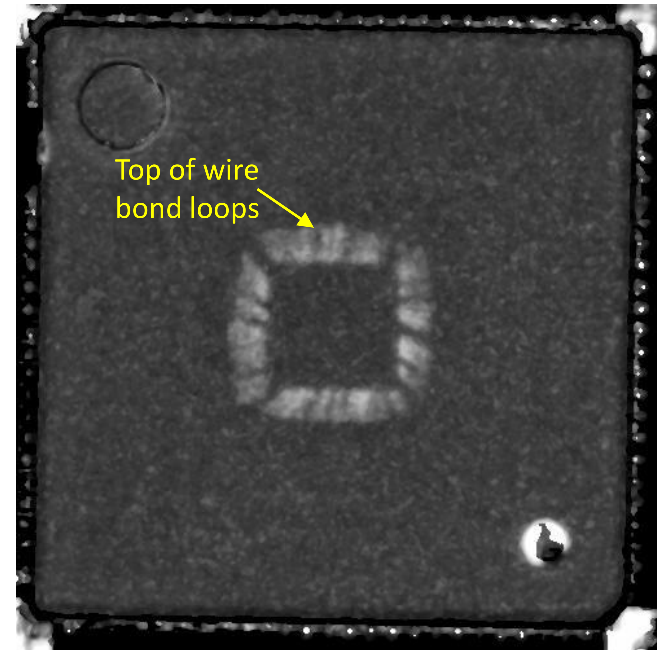


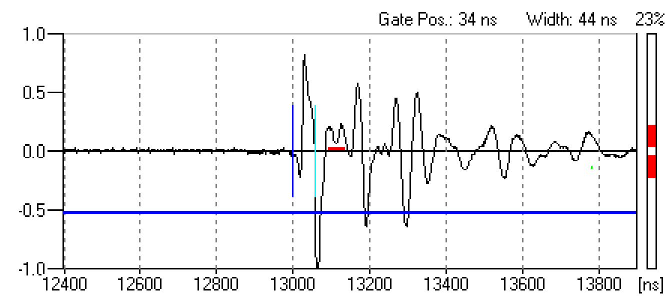


All wire bonds show good integrity (high mag X-rays are given in the corners)

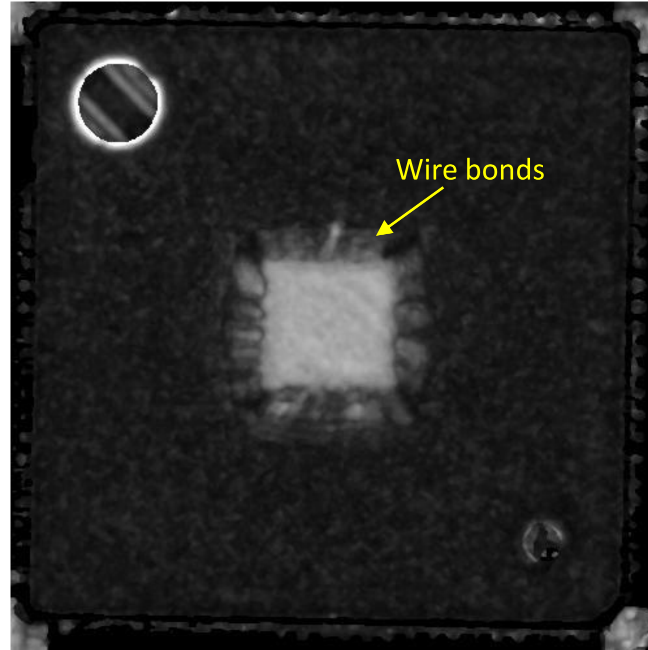
Module U5 C-SAMs

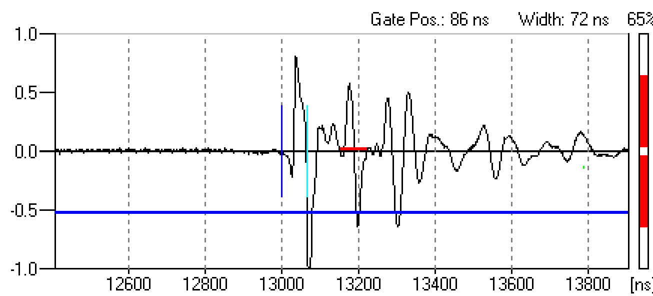
In overmold



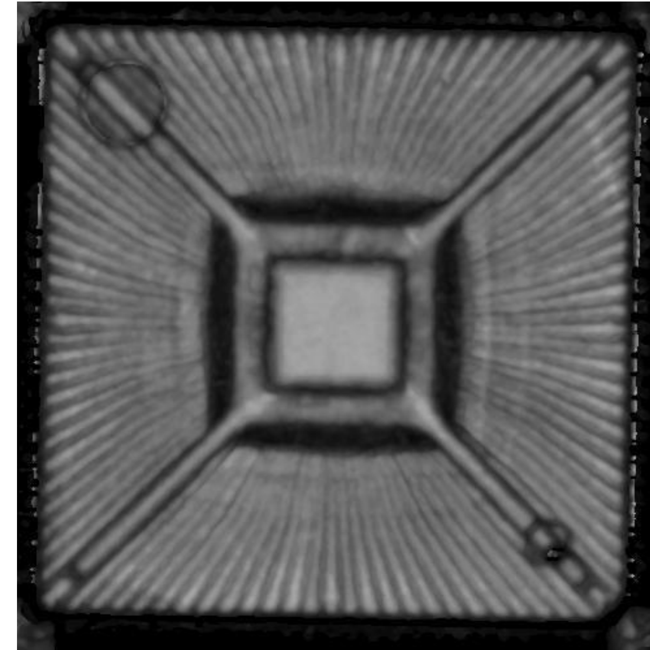


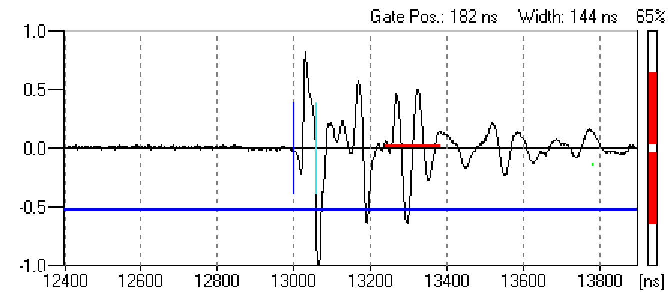
Top of chip





Top of laminate



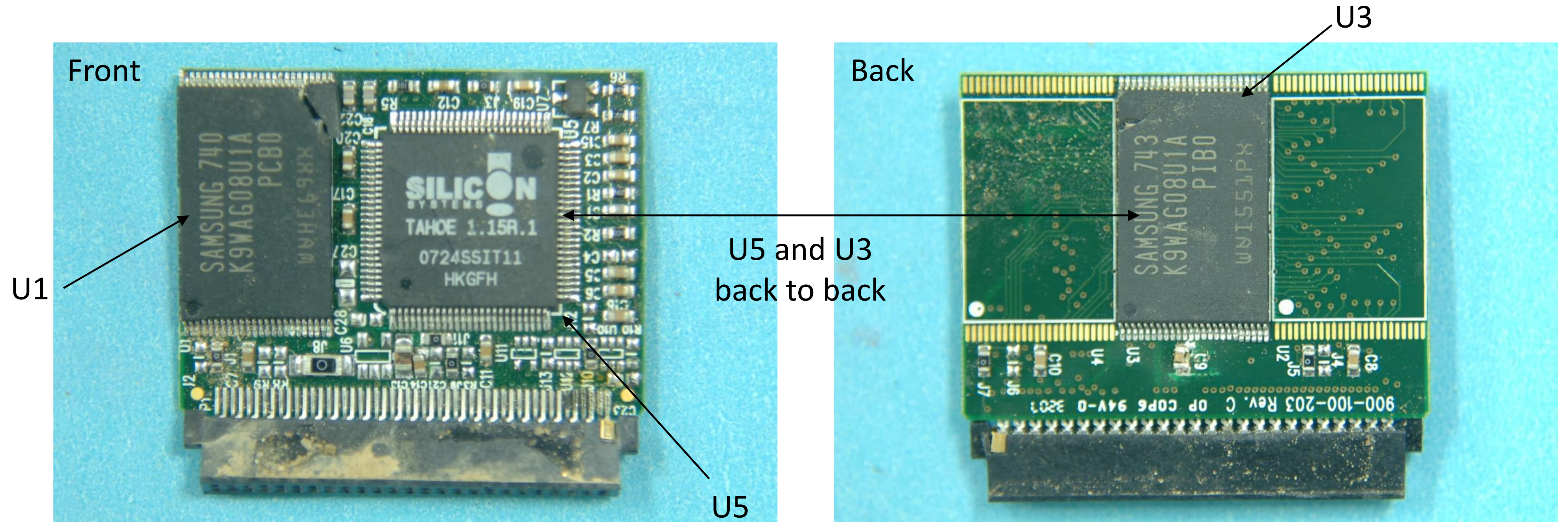


No evidence of cracking or delamination

Section 5

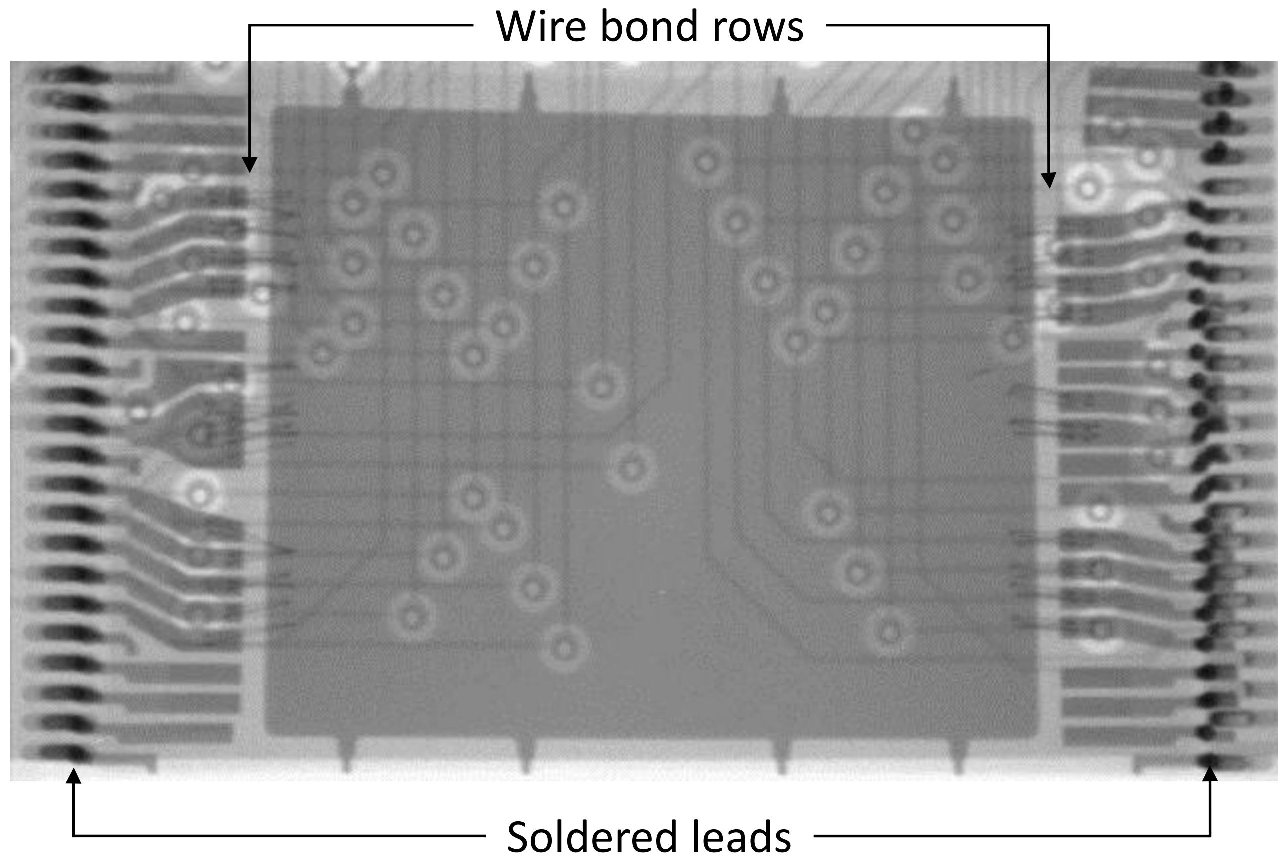
Modules in Bag 3

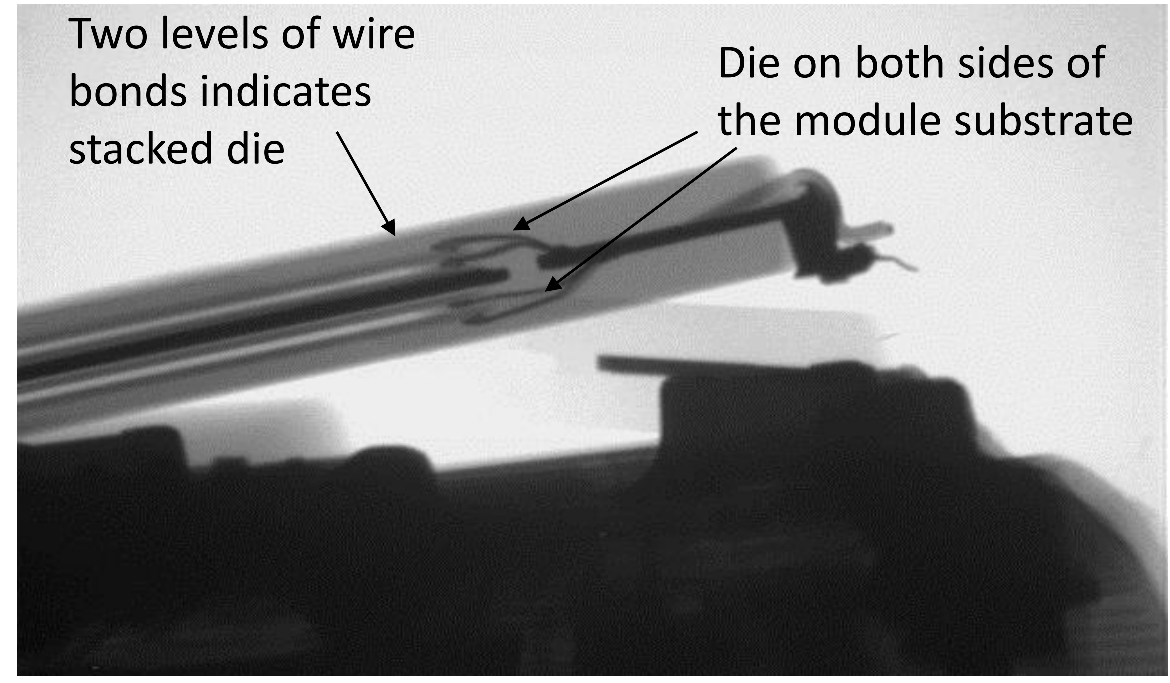
Layout of the Card

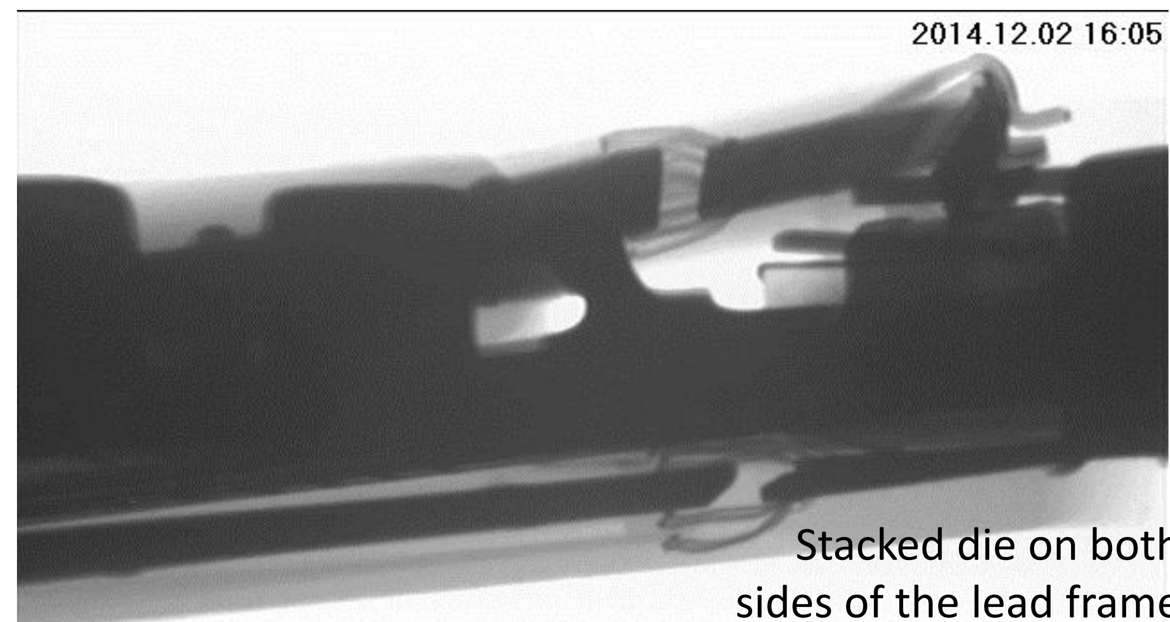


U1 and U3: Samsung Memory Modules
U5: Silicon Systems Processor

Basic Construction from U1 (and U3) X-rays

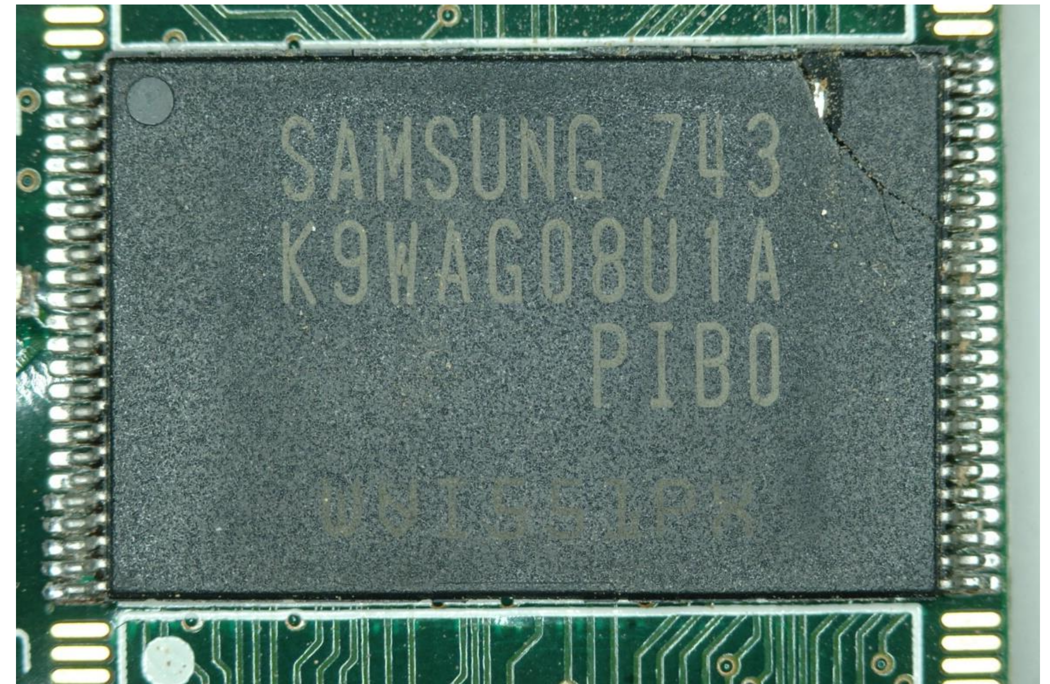






Micrographs of U1 and U3

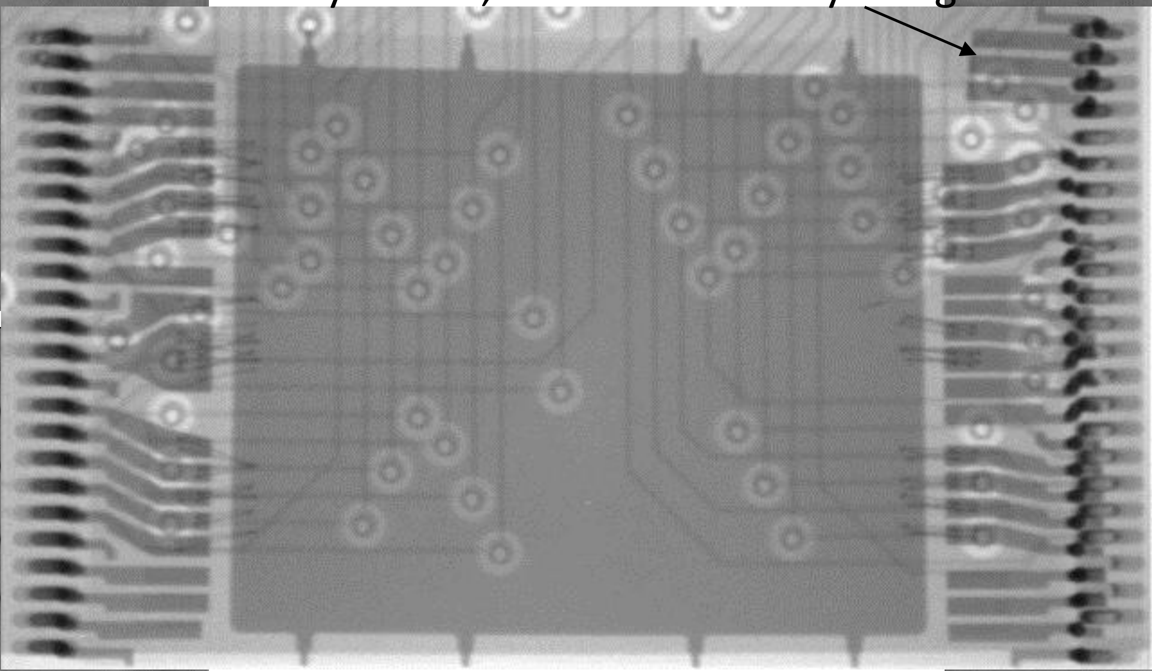
Crack in U1 exposing internal features



Crack in U3 exposing internal features

X-rays of U1

Displaced leads, but these seem to be "dummy" leads; not connected by design



All wire bonds show good integrity
(high mag X-rays are given in the corners)

2014.12.02 15:55

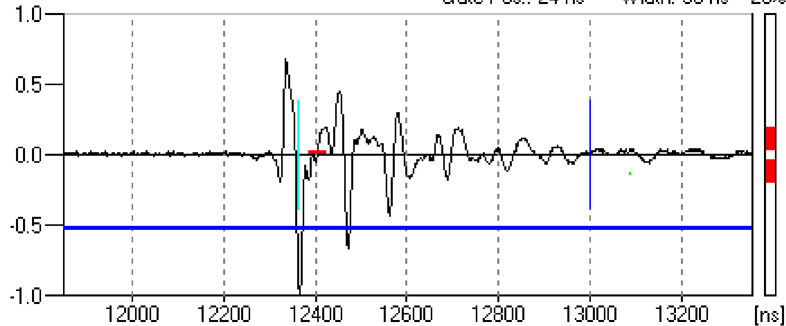
2014.12.02 15:58

2014.12.02 15:59

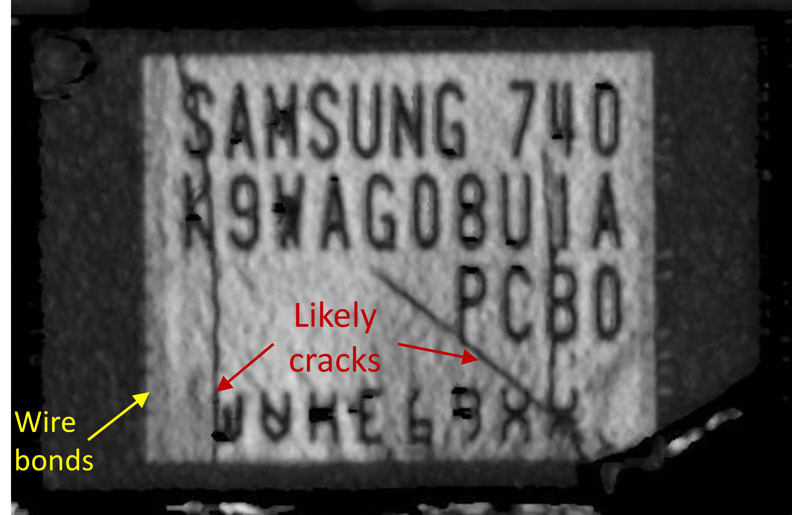
Broken solder joints

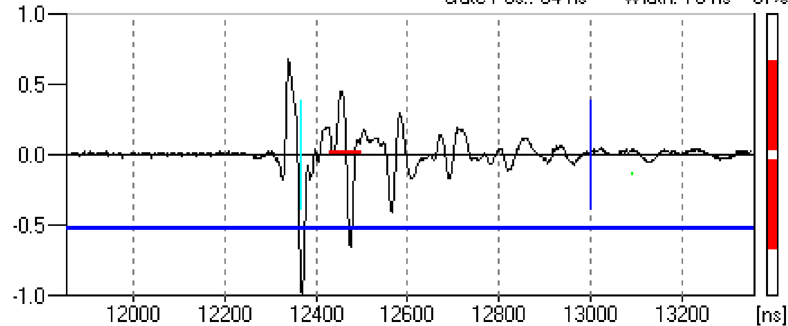
Module U1 C-SAMs

In overmold

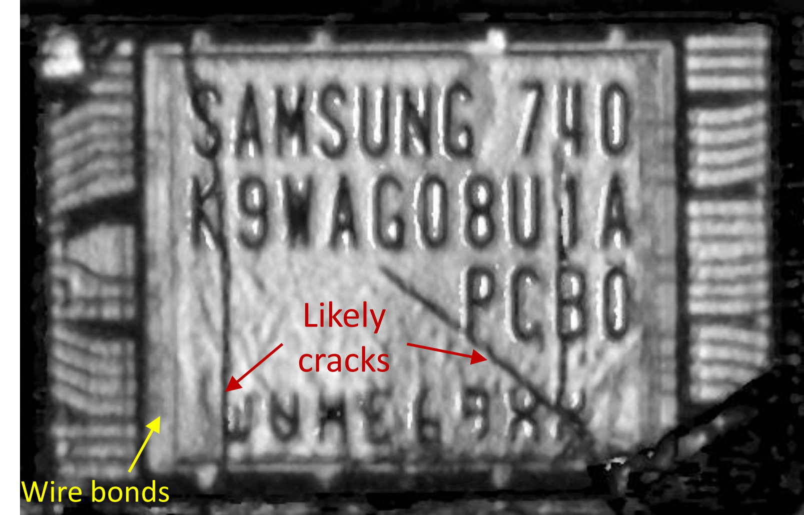


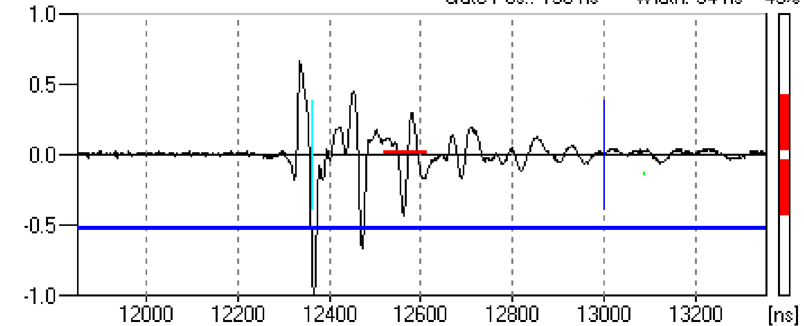
Top chip (taken with low gain to avoid saturation)





Lower chip and leads



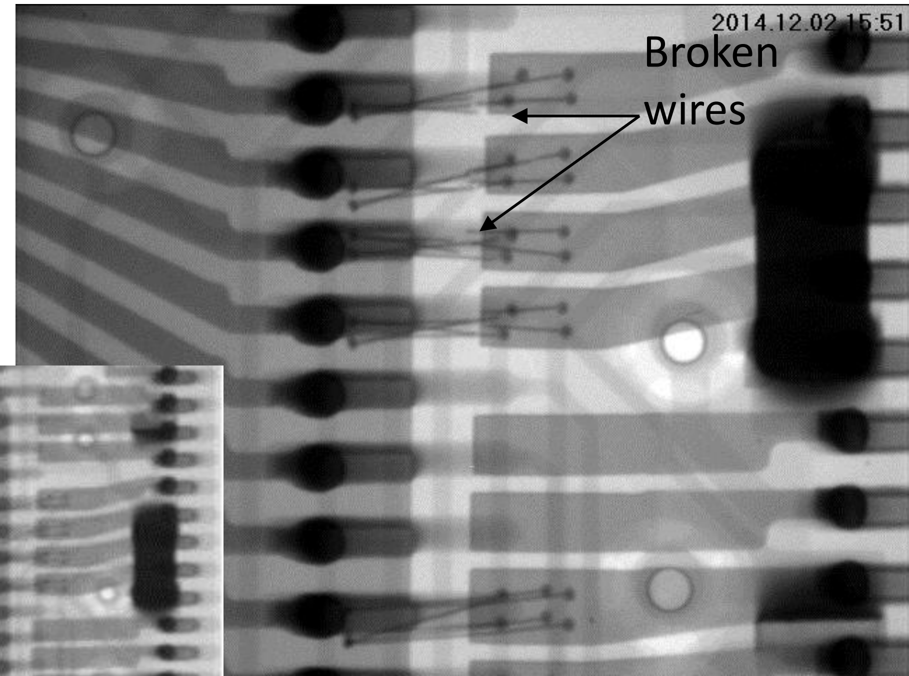


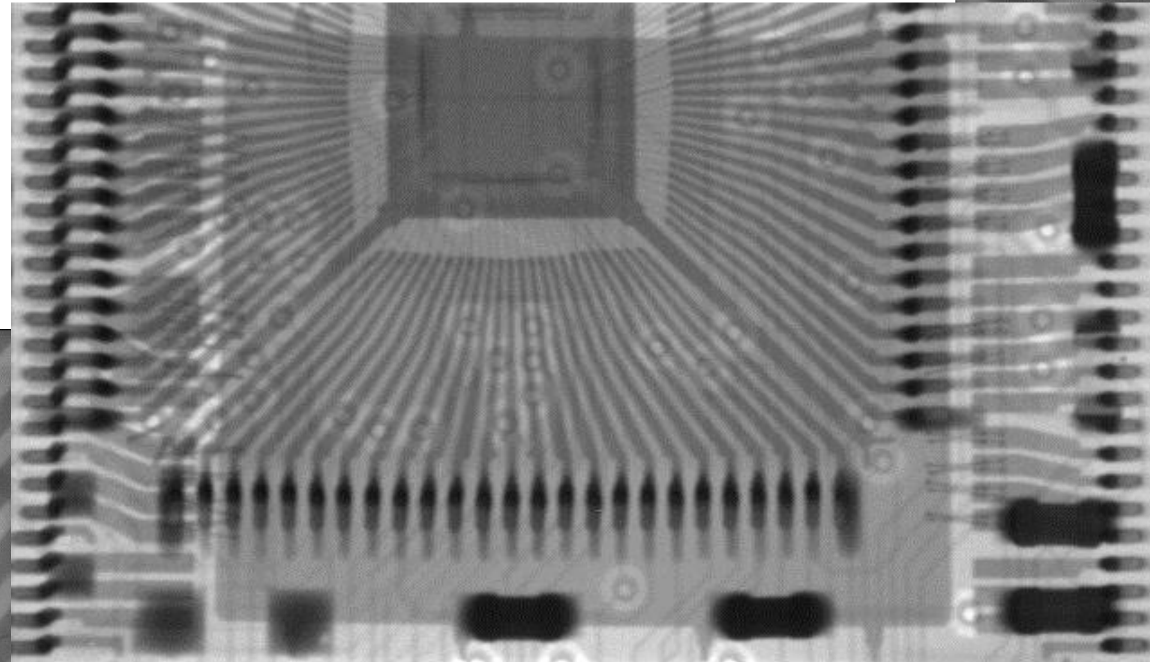
C-SAMs of deeper levels were taken, but gave no additional information

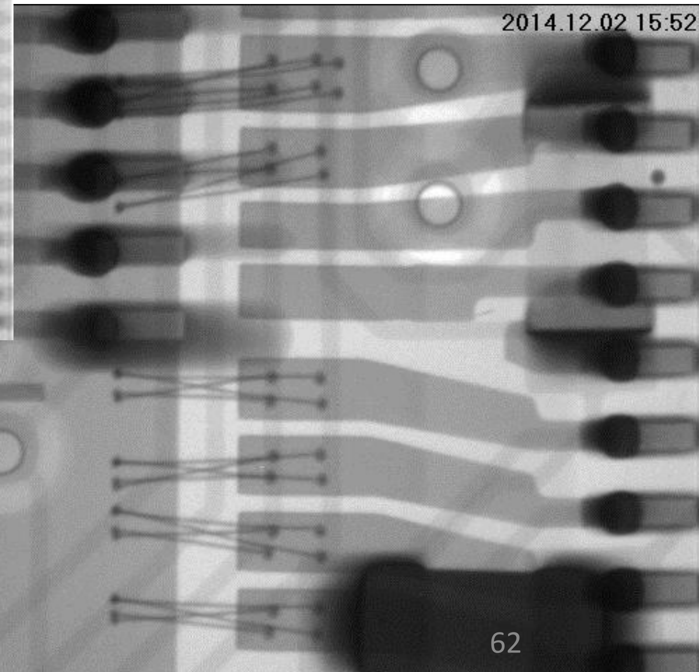
The anomalies may be imaging artifacts, but it is more likely that they are cracks

X-rays of U3

Circuitry is obscured by module U5, but the wire bonds are not

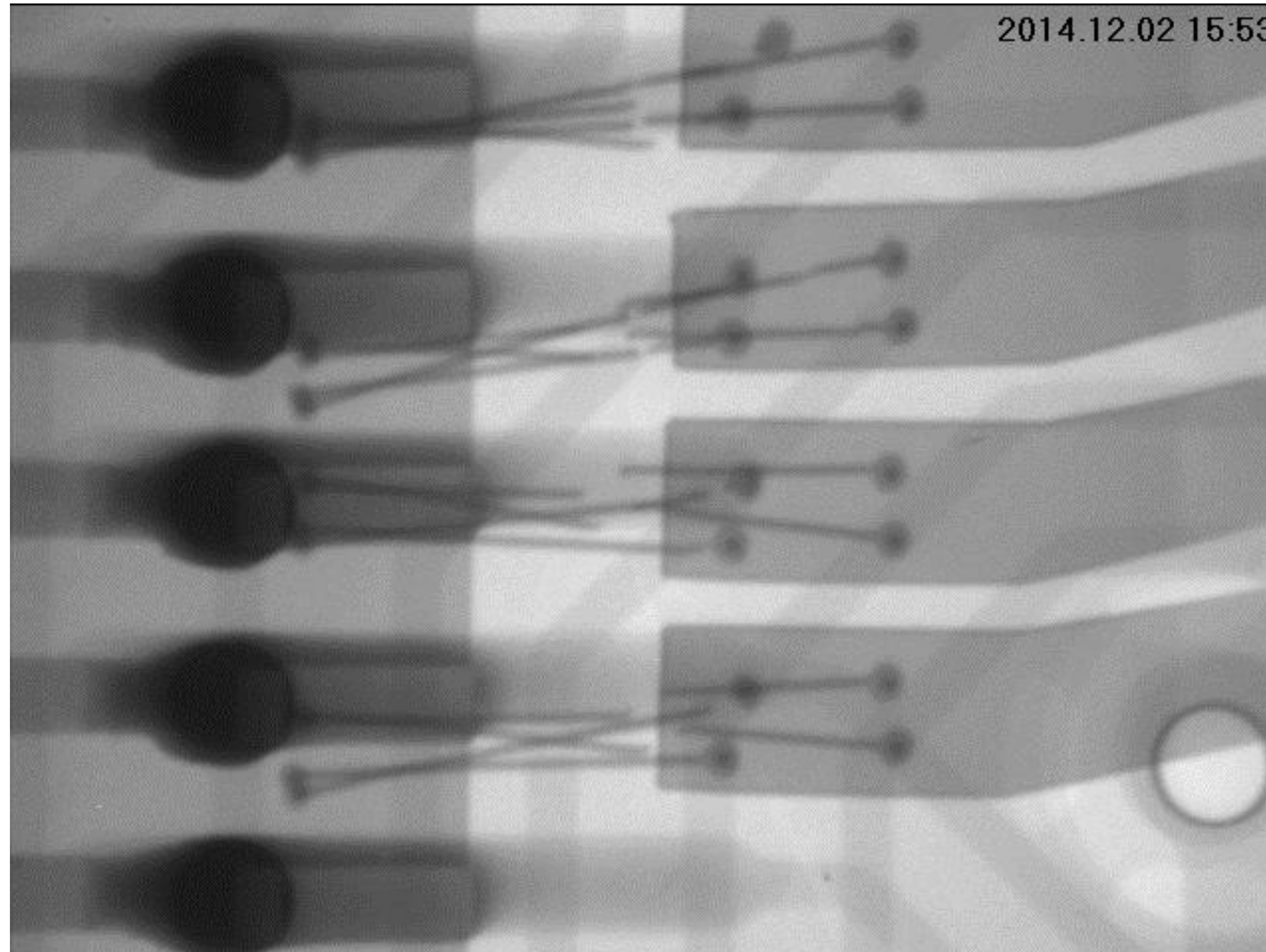




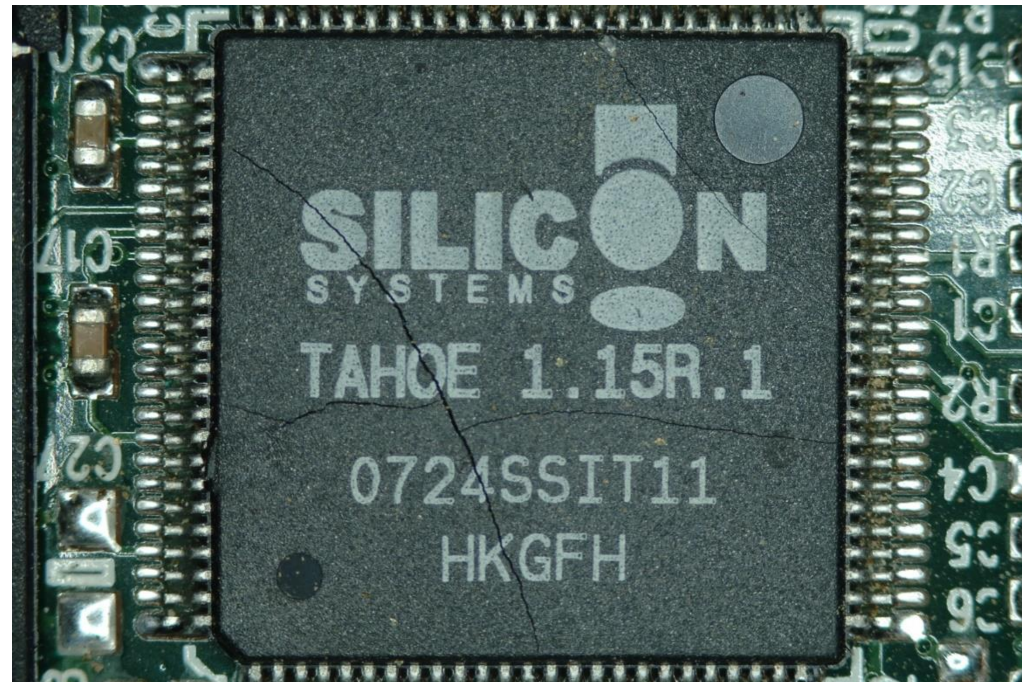


Broken wires were found in U3

High Mag X-rays of Broken Wires in U3



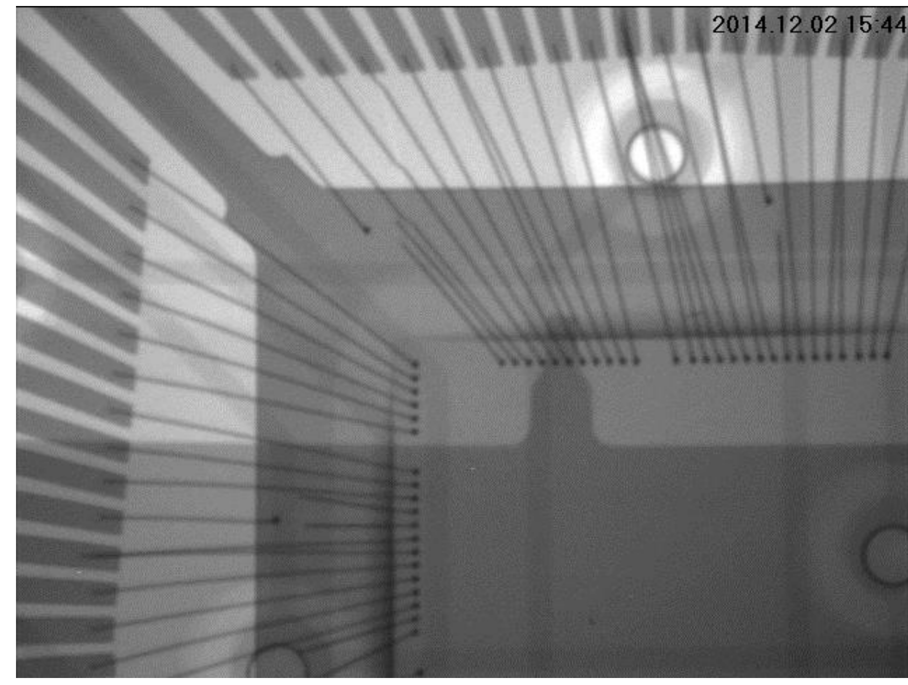
Micrograph of U5

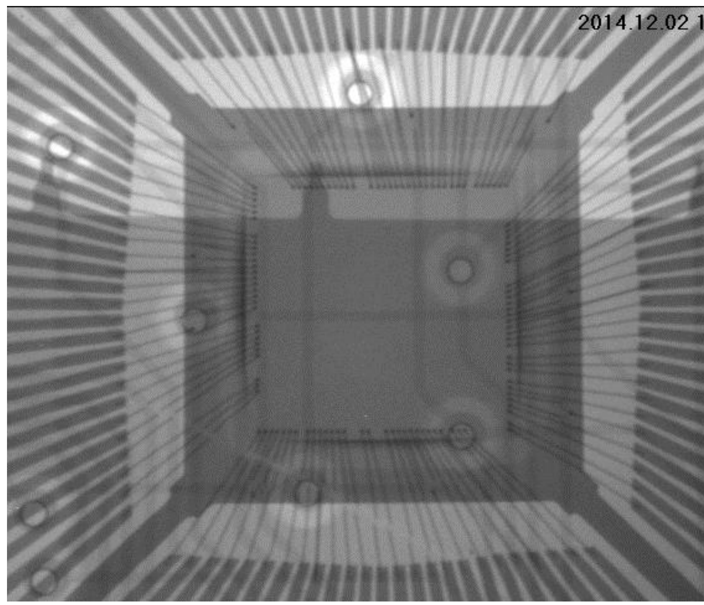


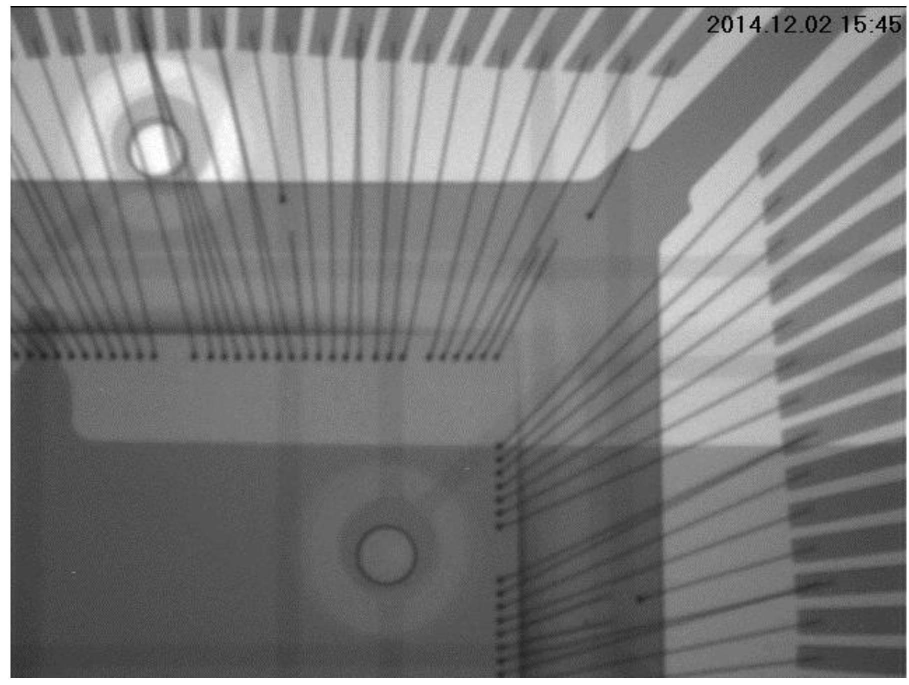
Obvious cracks in U5

X-rays of U5

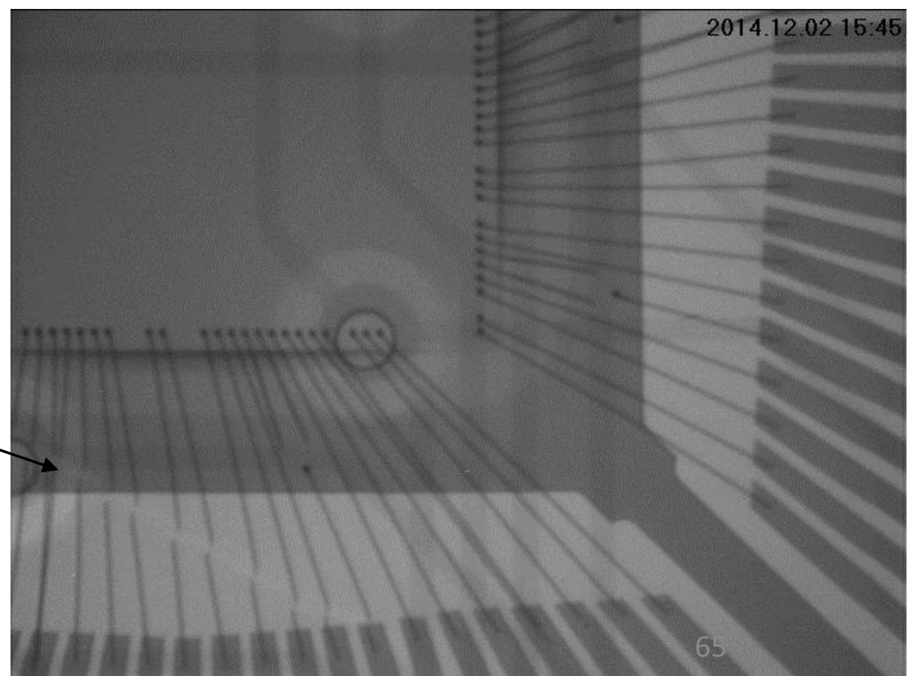
Broken wires found







Broken wires



Broken wires