Non-destructive testing of a ANC20LA004 Garmin memory package

Anju Sharma

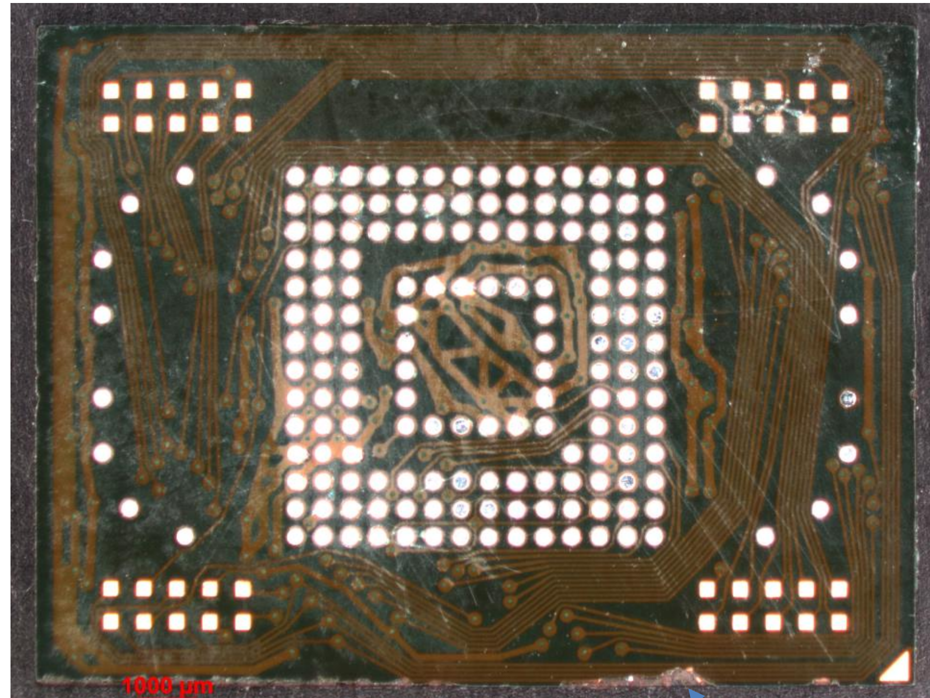
S3IP ADL Analytical and Diagnostic Laboratory
Binghamton University

Summary and Conclusions

- ANC20LA004 Garmin memory package, Samsung KLM8G2FEJA-A001 was received for non-destructive evaluation.
- The package was first imaged with a stereo optical microscope.
  - The front side of the package looks OK
  - The backside of the package has some external damage at the bottom edge. The solder mask on the chip carrier, is peeled off. There is damage to two Cu lines with missing portions making them open lines.
- X-ray inspection results
  - 94kV, 60μA, mode 1 beam size with Cu and Zn filters were used during imaging.
  - Images were taken with top down views as well as at oblique angles.
  - The package contains 3 stacked dies. All of them are wire bonded with wirebonds on one side.
  - No damage is detected in any wirebonds.
  - The damaged areas of the Cu line of the chip carrier were confirmed
- Acoustic inspection (C-SAM) results
  - 100MHz transducer was used for imaging in the pulse echo mode
  - Images of each die as well as the chip carrier, were collected.
  - No die cracks were found in any die.
  - There may be possible delaminations in the die attach and chip carrier.
- The only damage that is found, is the discontinuities of two Cu lines in the chip carrier. Since the damage is external, it can easily be fixed by metal deposition to make the two lines continuous.

Optical images of the memory package

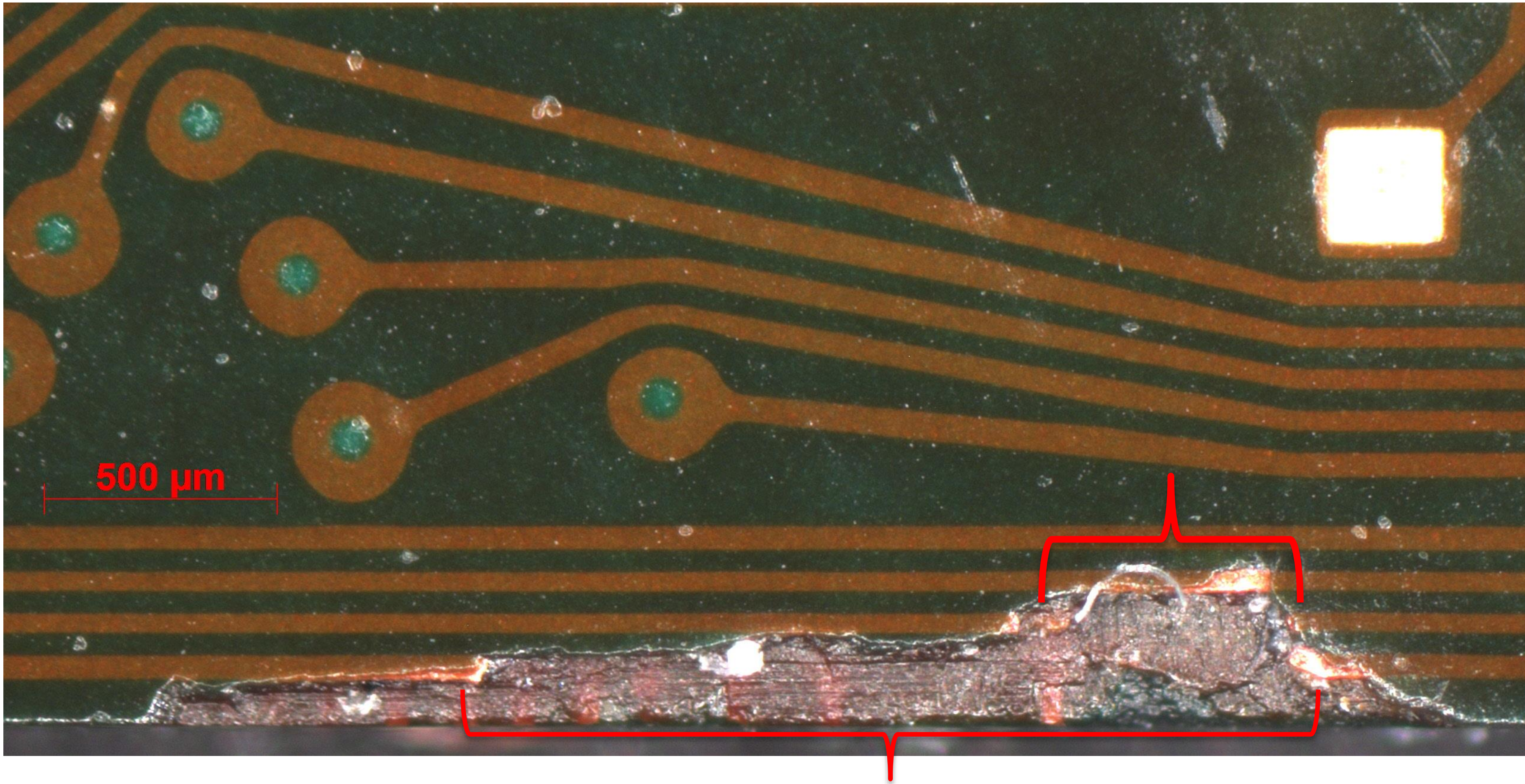
Front side of the package



Backside of the memory package showing the chip carrier.

- Lower edge has some external damage.

Optical image of the damaged area

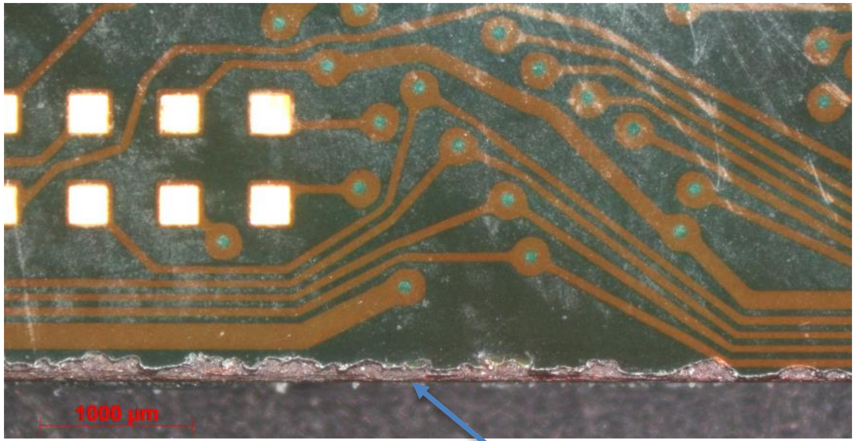


Discontinuities in two Cu lines

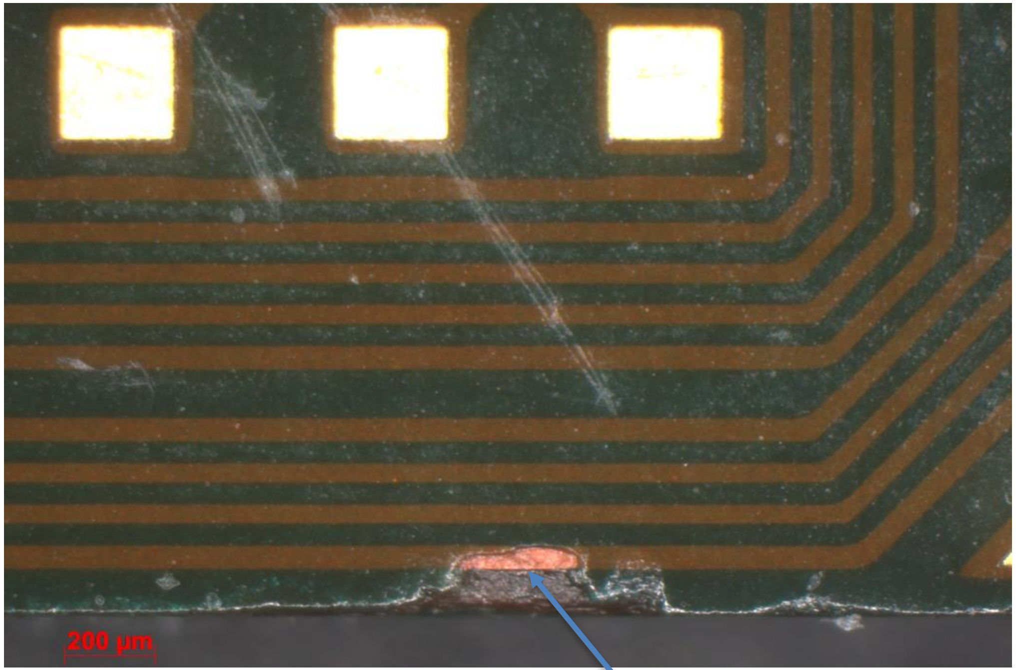
The chip carrier has external damage at the bottom edge.

- Surface solder mask is peeled off.
- Some parts of two Cu lines are missing, making them open lines.

Optical images of the damaged area

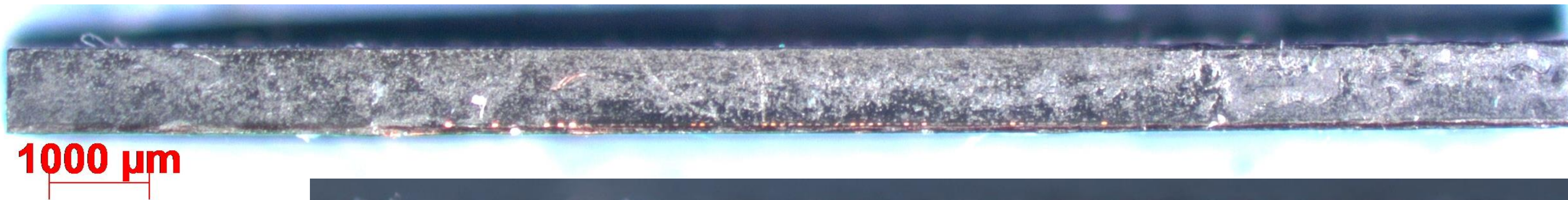


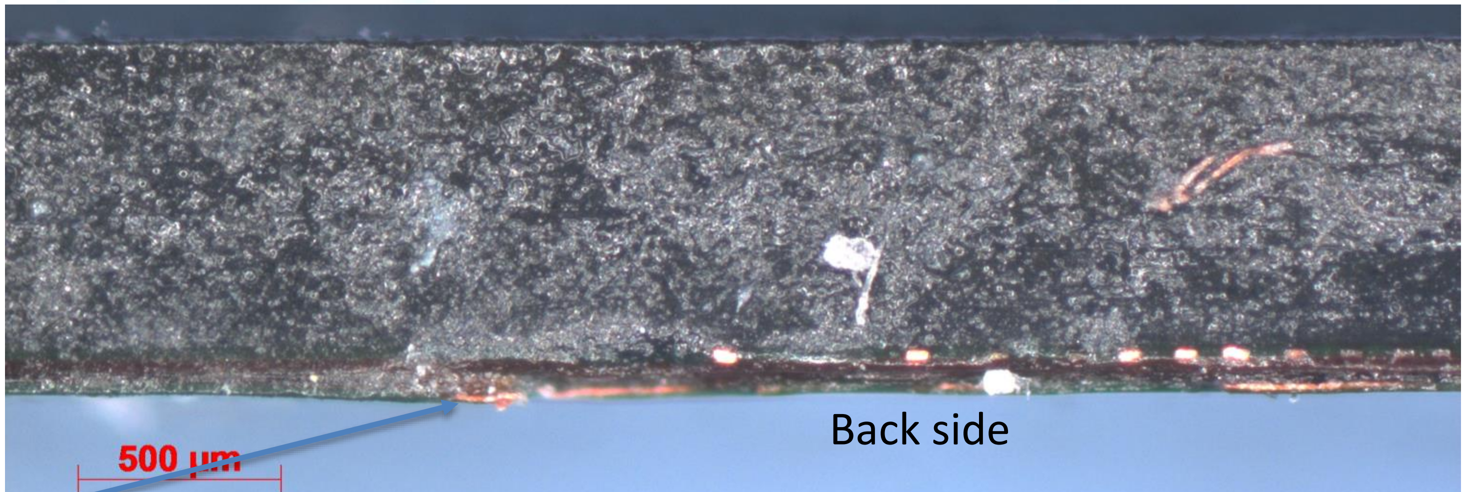
Backside of the package has external damage at the bottom edge.



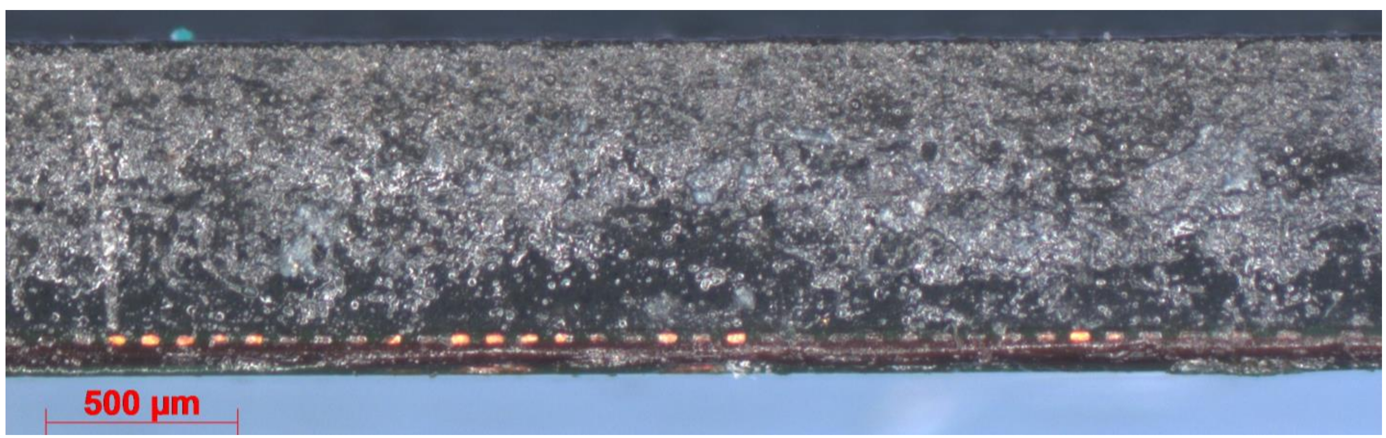
- Surface solder mask is peeled off exposing a Cu line.

Bottom side of the package

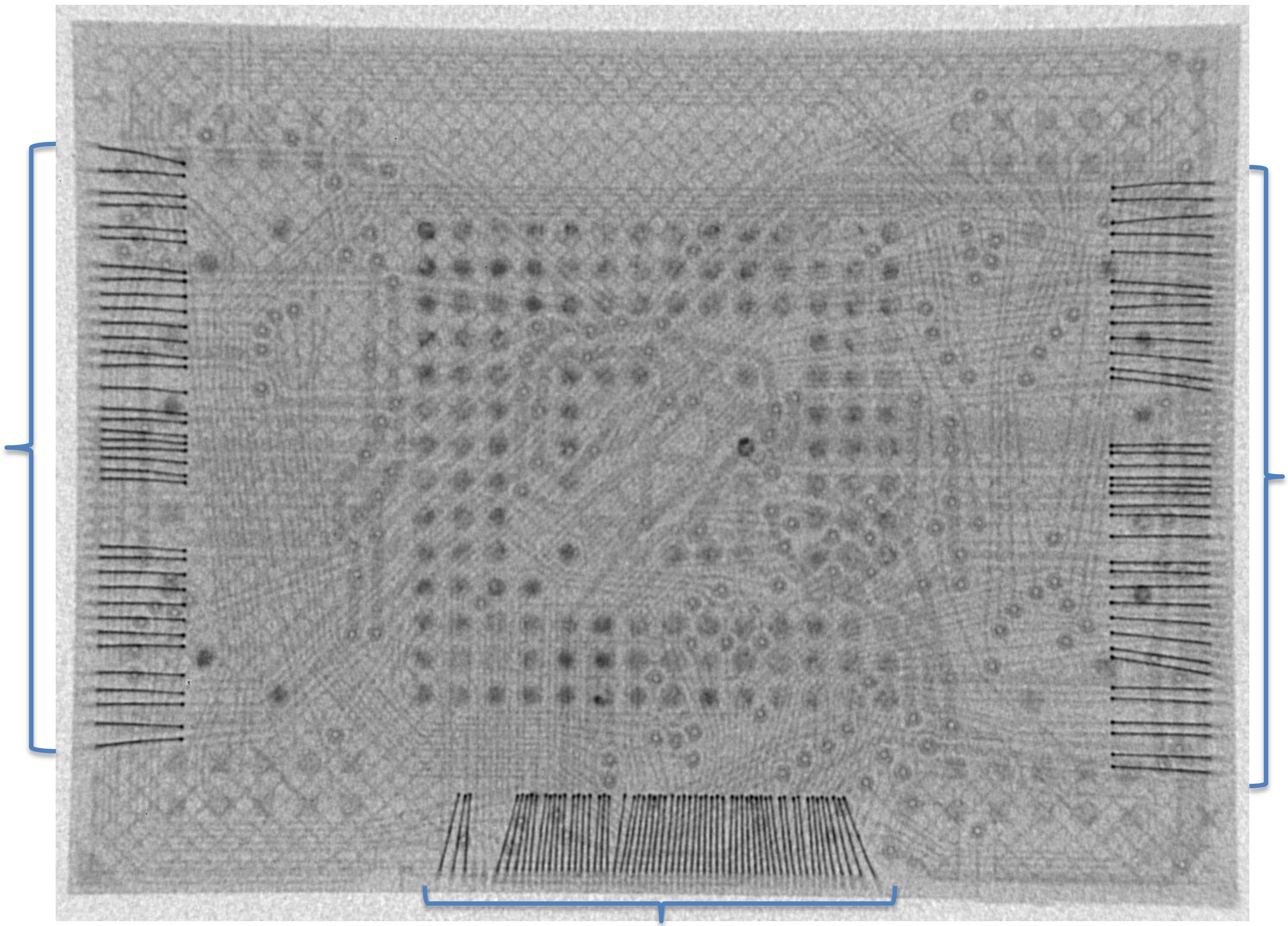




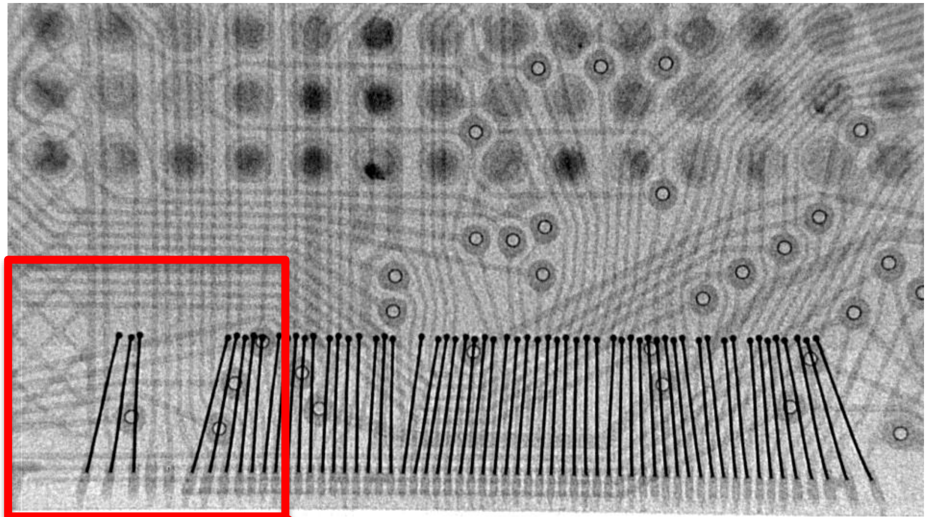
Damage to the chip carrier



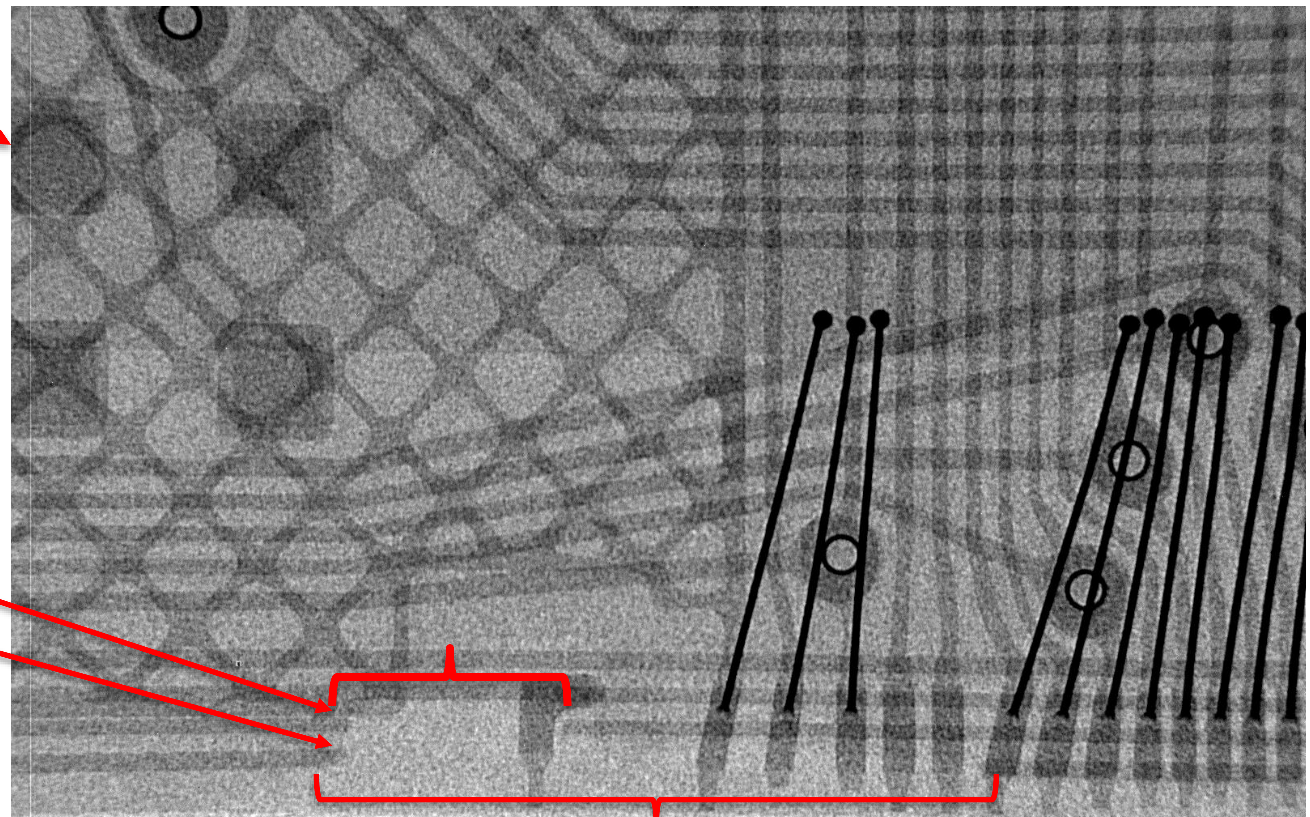
X-ray image of the package



Possibly contains multiple wire bonded dies



X-ray images of the package showing discontinuities in two Cu lines



Discontinuities in two Cu lines

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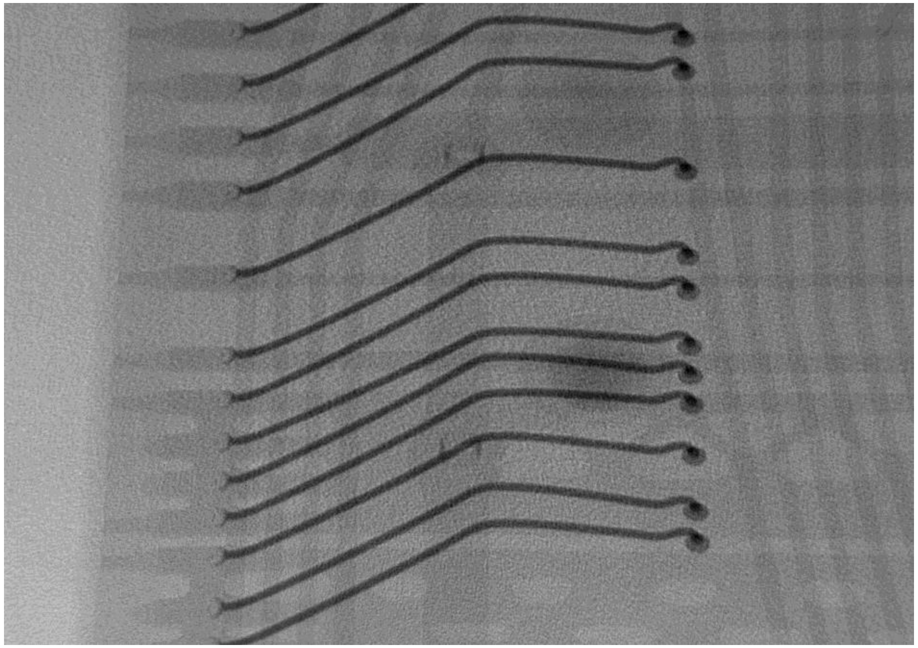
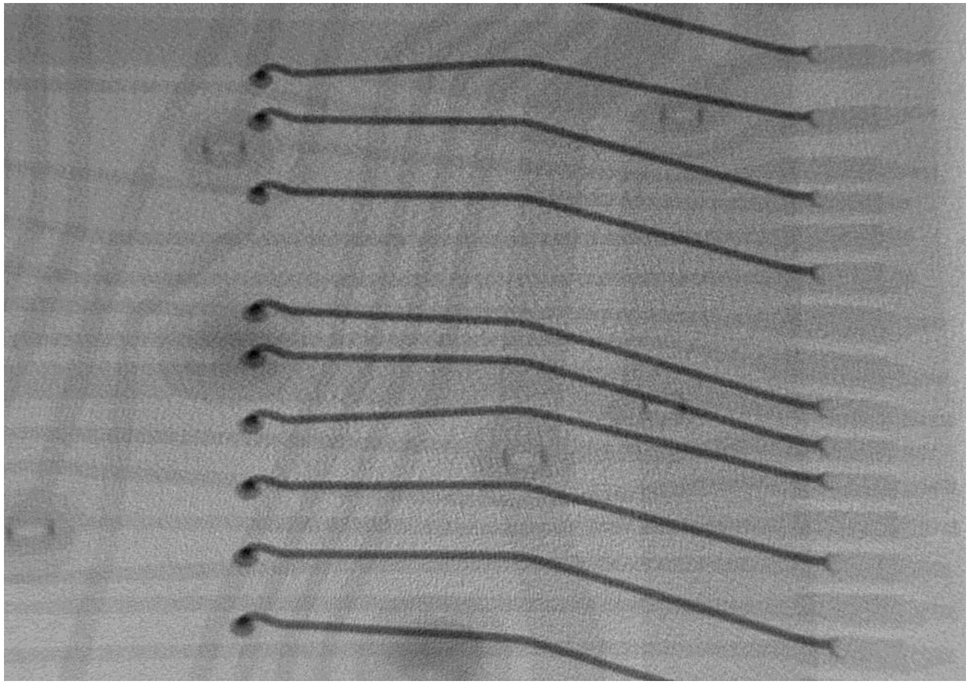
X-ray images of wirebonds



Wire bond images at oblique angles and high magnification.



No anomalies found in any wirebonds

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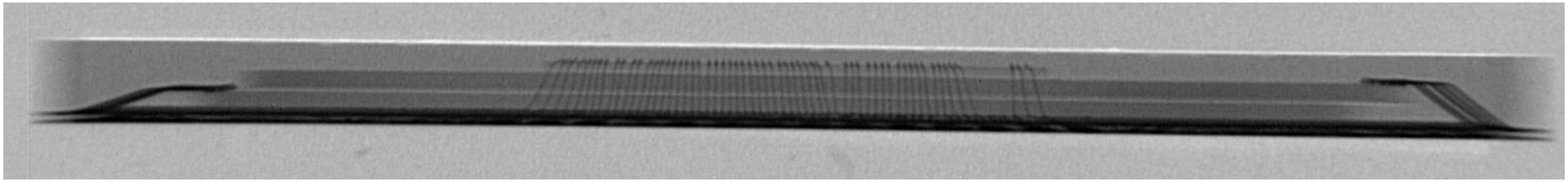
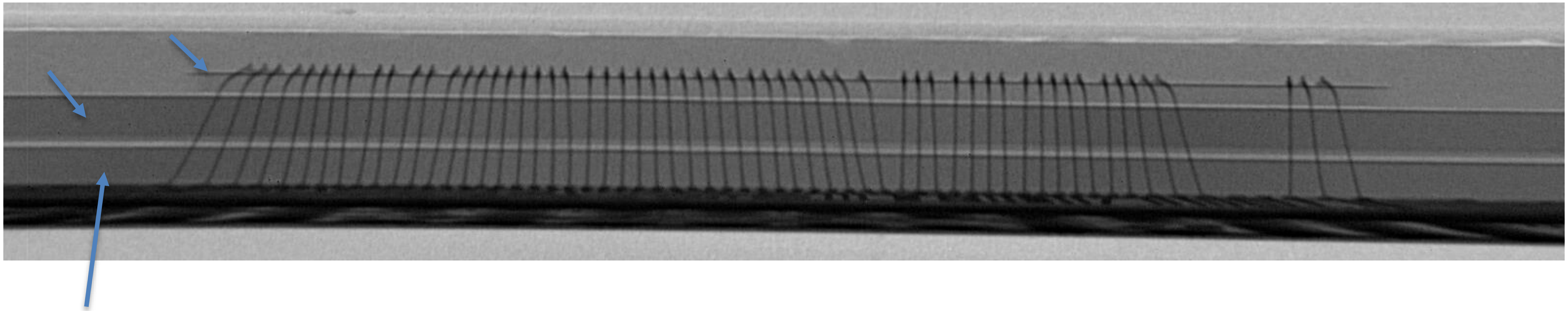
X-ray images of the package showing side 1 views

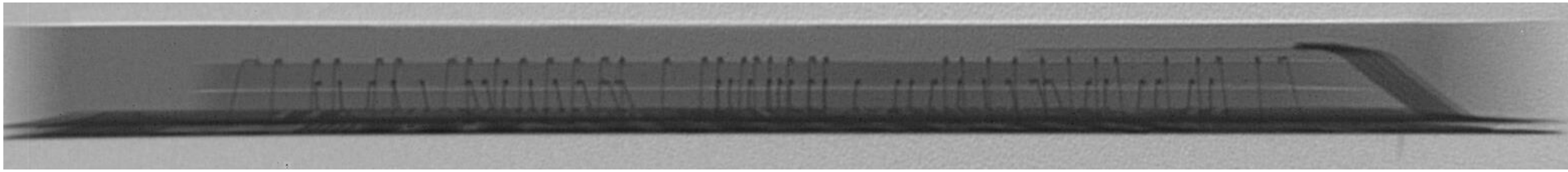


The package has 3 stacked dies. Each die has wire bonds on one edge

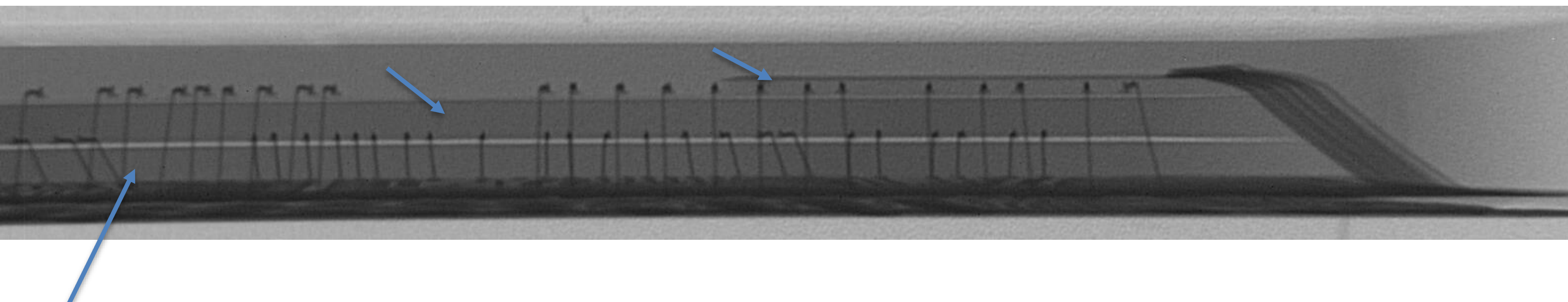


Arrows pointing to three stacked dies

X-ray images of the package showing side 2 views

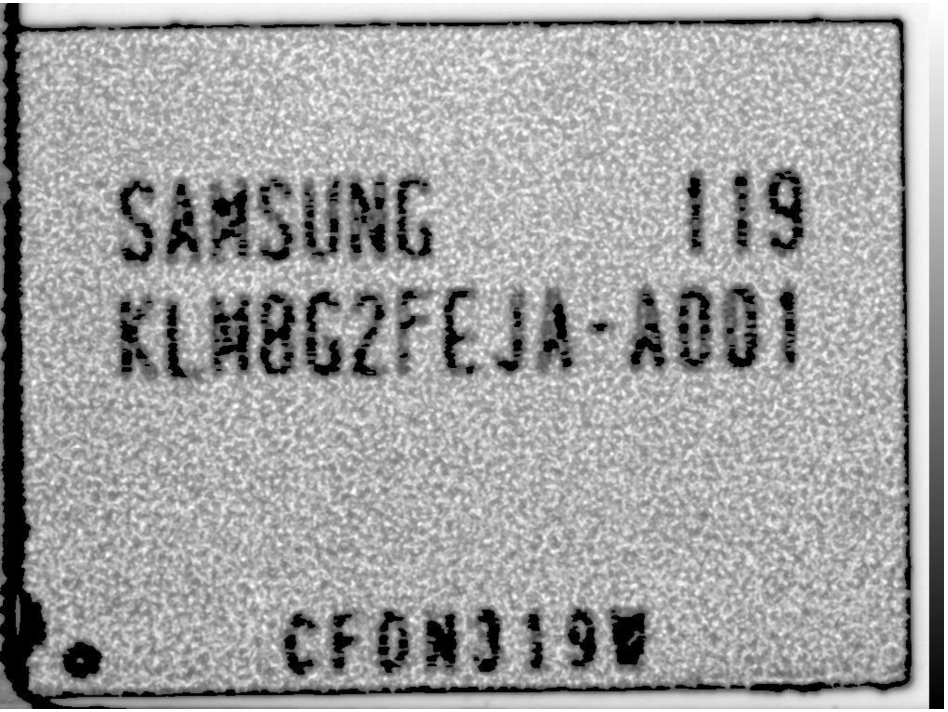


The package has 3 stacked dies. Each die has wire bonds on one edge

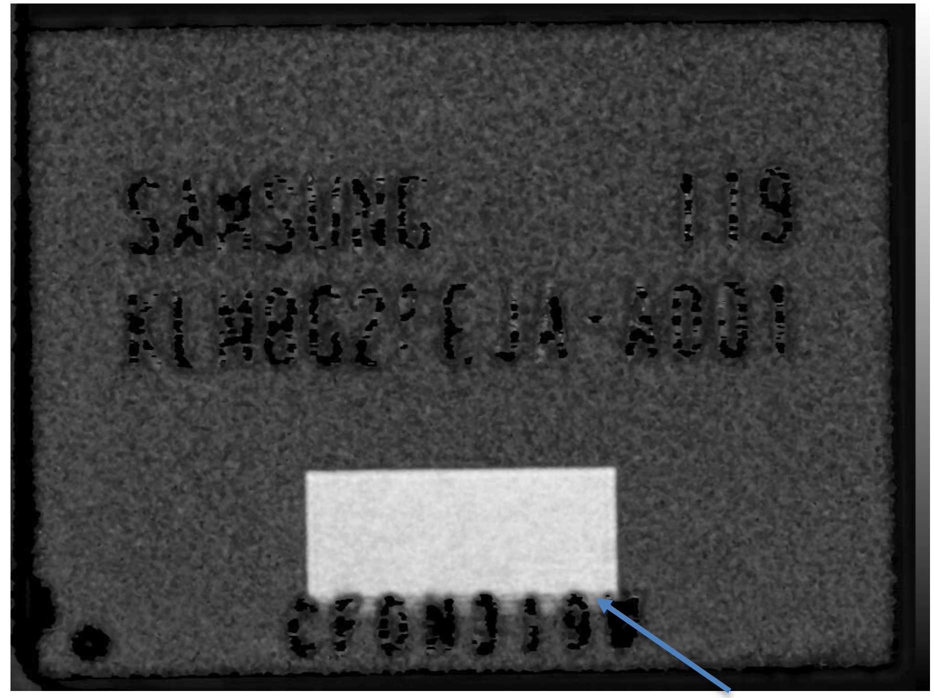


Arrows pointing to three stacked dies

C-SAM images



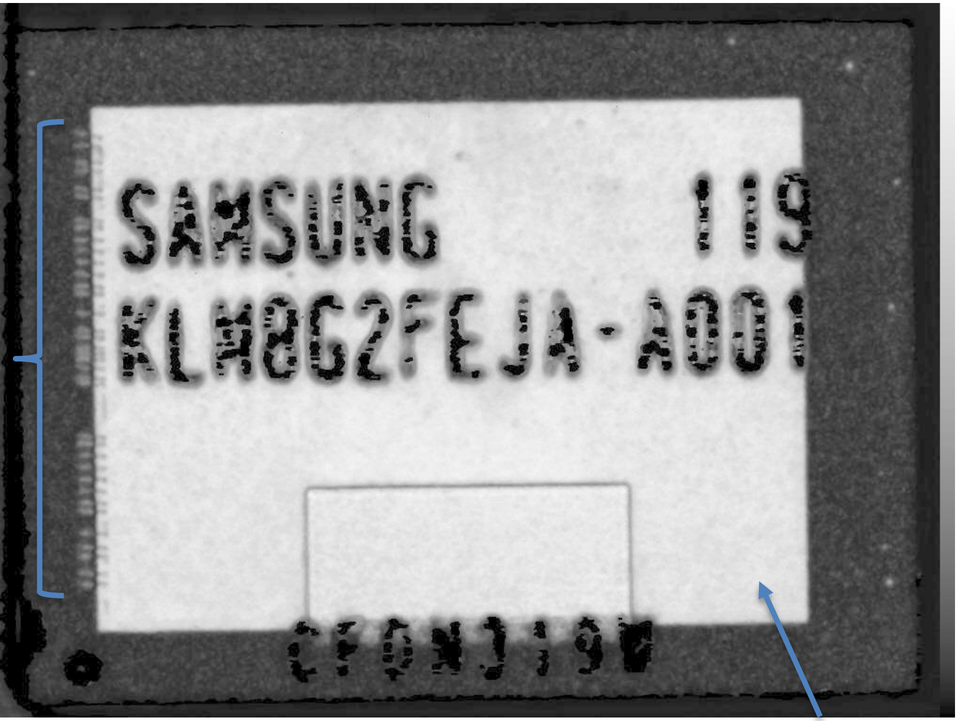
Front surface of the package

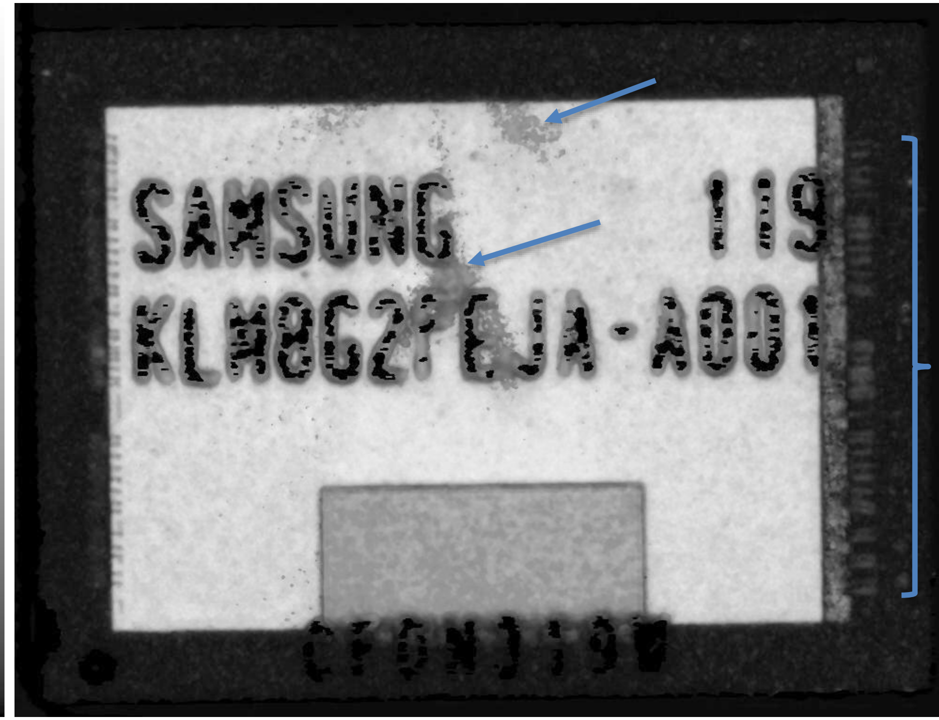


Small die (#1) with wirebonds on the bottom edge

Topmost, small die in the package. No die cracks found.

C-SAM images





Die #2

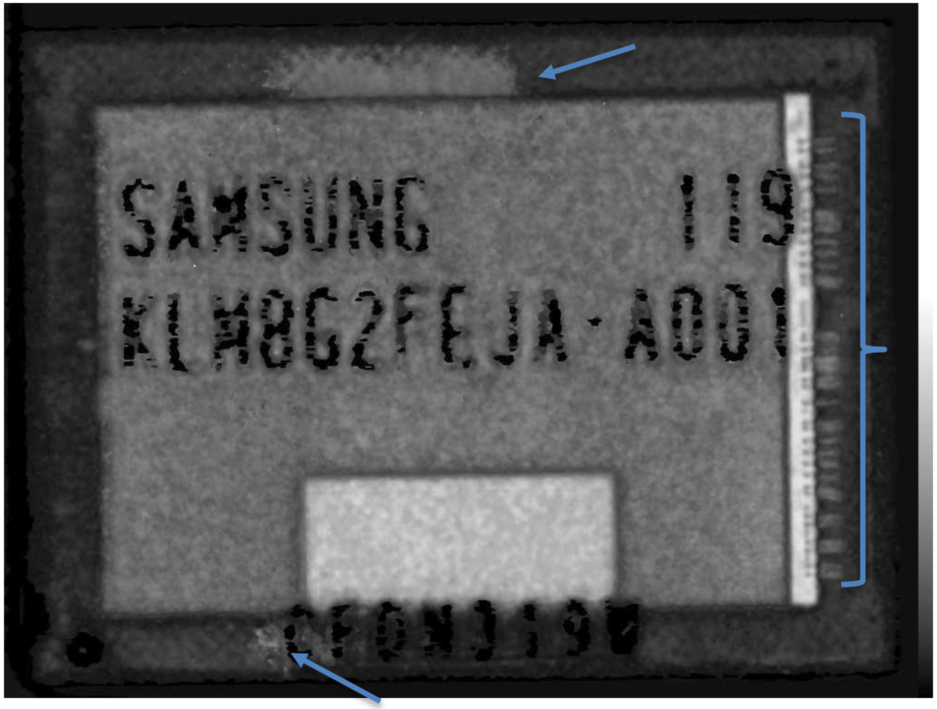
Image of die # 2.

- No die cracks detected.
- Wire bonds on left edge

Backside of die#2

- Arrows indicating possible die attach delaminations
- Wirebonds of die#3 can be seen on the right edge

C-SAM images



Chip carrier damaged area

Image of die # 3

- wirbonds on the right edge.
- No die cracks found
- Arrows pointing to brighter areas: may be possible delaminations.

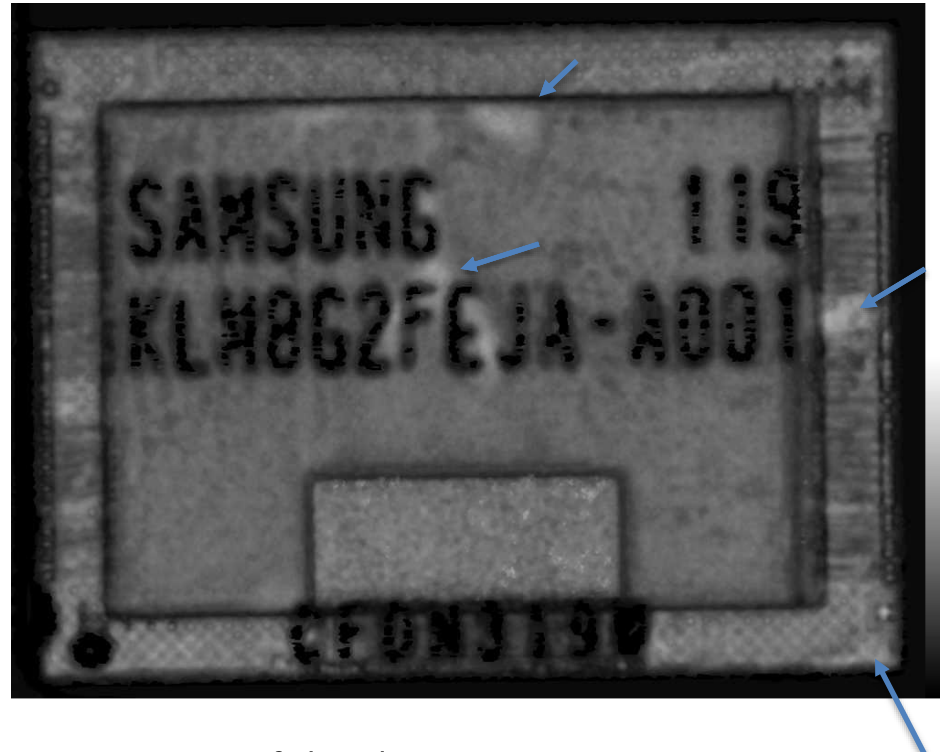


Image of the chip carrier.

- Arrows are pointing to brighter areas that may be possible delaminations

C-SAM image

Composite image
No die cracks detected in any die.

Repair Report for ANC20LA004

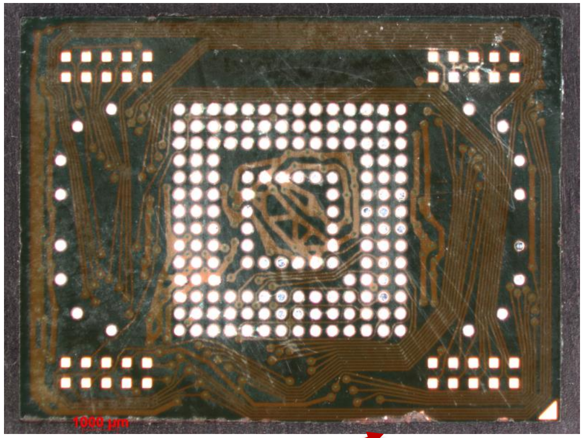
S.R. Cain, M. Alhendi, and A. Sharma

Overview

- **Key staff**
  - S.R. Cain – project manager, repair, optical microscopy
  - M. Alhendi – conductor deposition
  - A. Sharma – initial analyses: optical microscopy, X-ray imaging, acoustic microscopy
- **Results of initial analysis**
  - X-rays confirmed integrity of wire bond and chip connections
  - Accoustic micrographs confirmed the integrity of the chips and overmold bonding
  - Optical microscopy revealed damage to the chip carrier circuitry on the bottom side
- **Approach to repair**
  - Optically confirm the location of the defects
  - Remove debris from circuit lines to be reconnected
  - Print circuit lines to restore connections
- **Results**
  - Damaged area was successfully cleaned as preparation for printing circuit lines
  - Lines were successfully printed in the designated areas
  - Optical inspection and electrical probe confirmed connection without excessive cross line leakage
- **Disposition: reading data may now be attempted with reasonable likelihood of success**

Top side

Bottom side



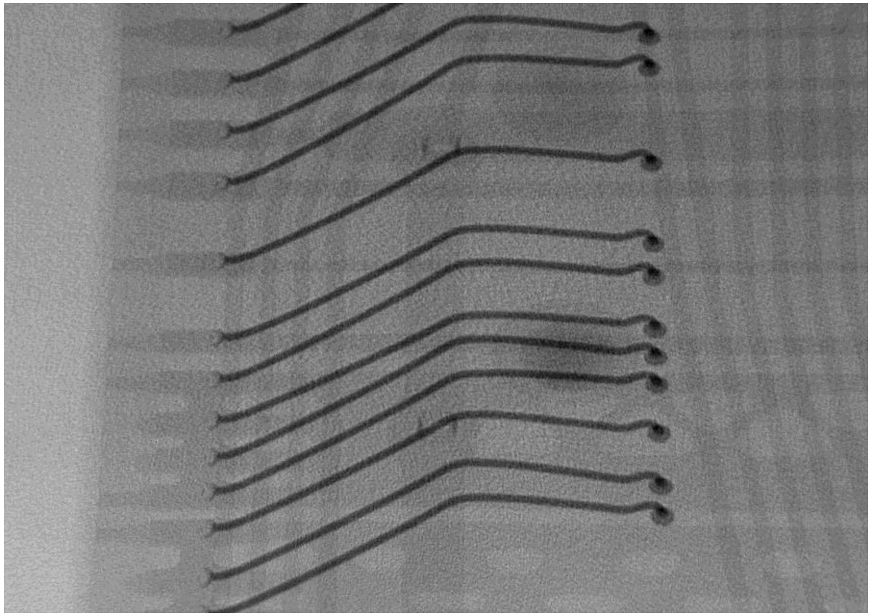
Damaged area

Section 1

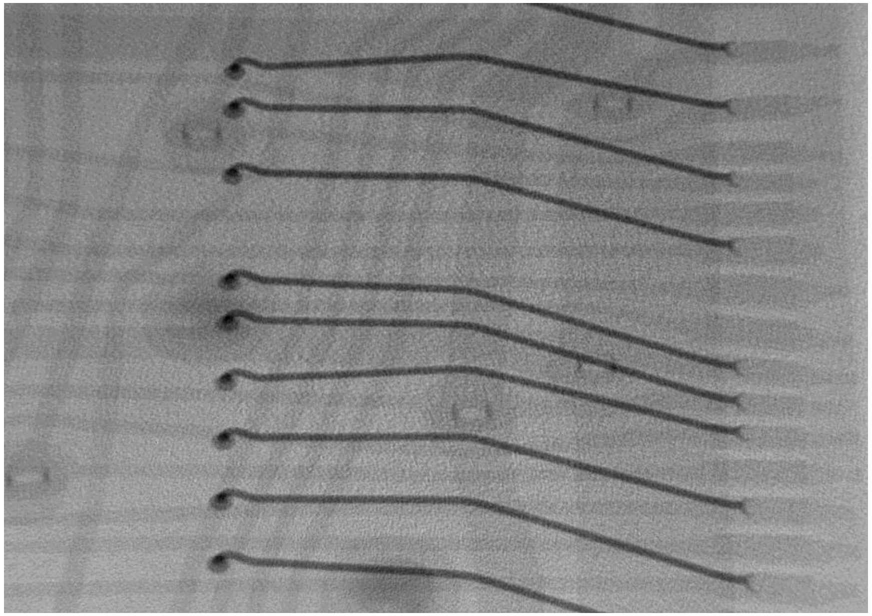
SUMMARY OF INITIAL ANALYSIS

Typical X-ray Images of the Wire Bonds

Tilted view of wire bonds

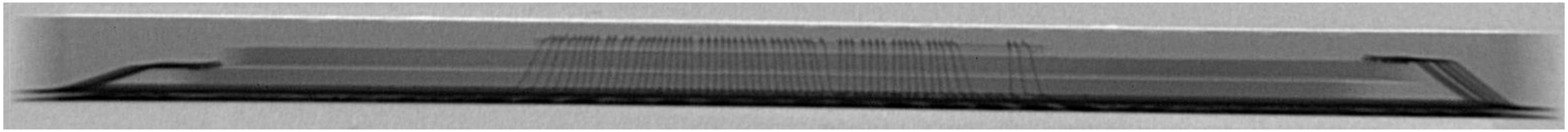


Tilted view of wire bonds



No evidence of broken or lifted wires; the “kinks” are from low-height loop processing, not deformation of the package

Edge view of the memory module



All wire bonds are in line, and show no evidence of out-of-plane distortion

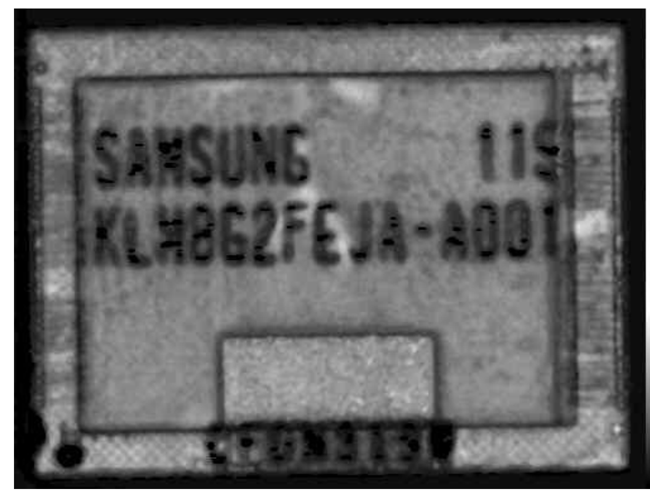
C-SAM Images of the Chips and Carrier

Top chip

Second chip with shadow of the top chip and wirebonds

Bottom chip with shadow of the second chip and wirebonds

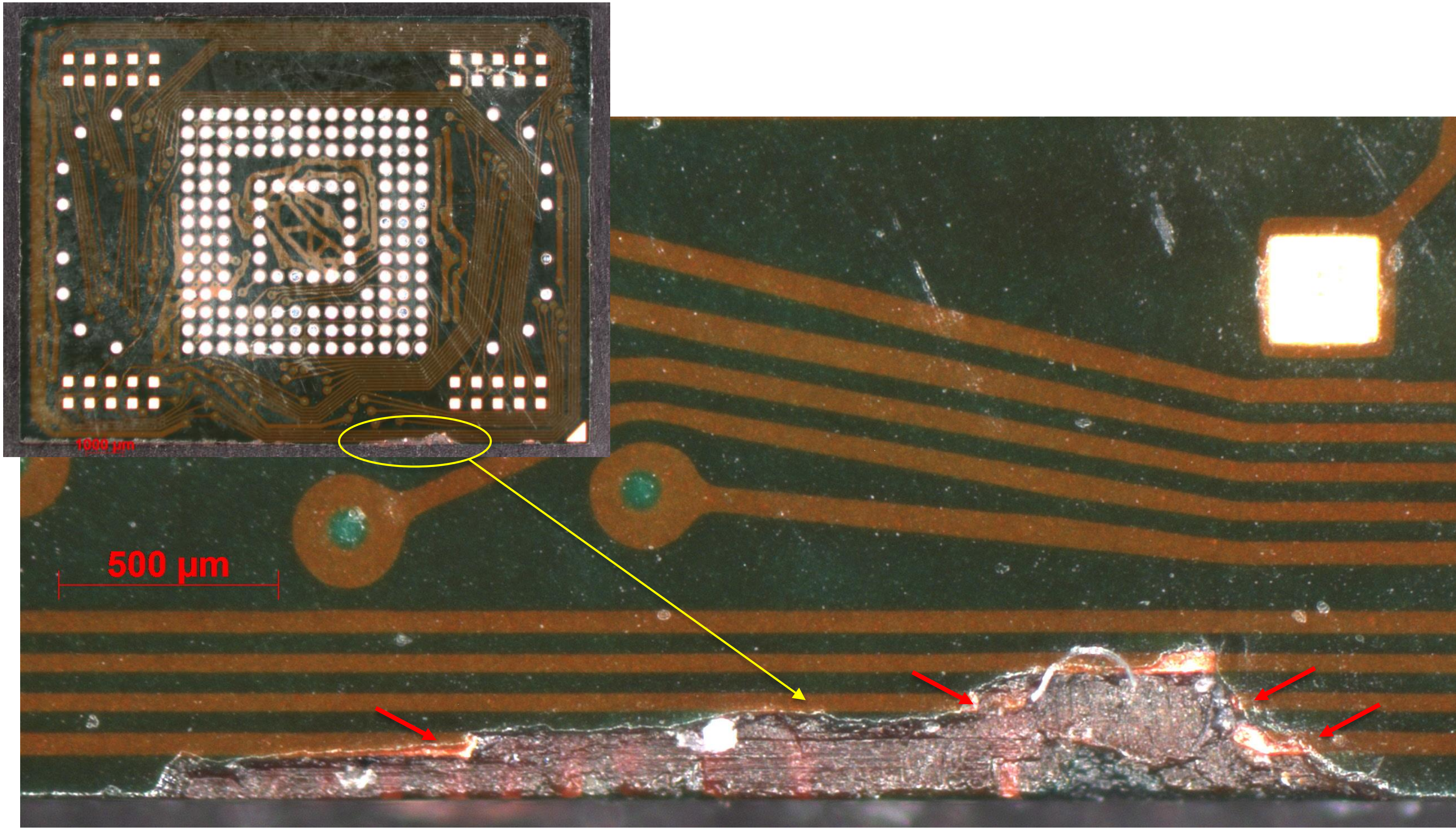
Chip carrier with shadow of the chips and wirebonds



Composite C-SAM Image

No evidence of cracking in any of the chip layers
Minor delaminations, but not catastrophic

Optical Image of the Damage to the Chip Carrier

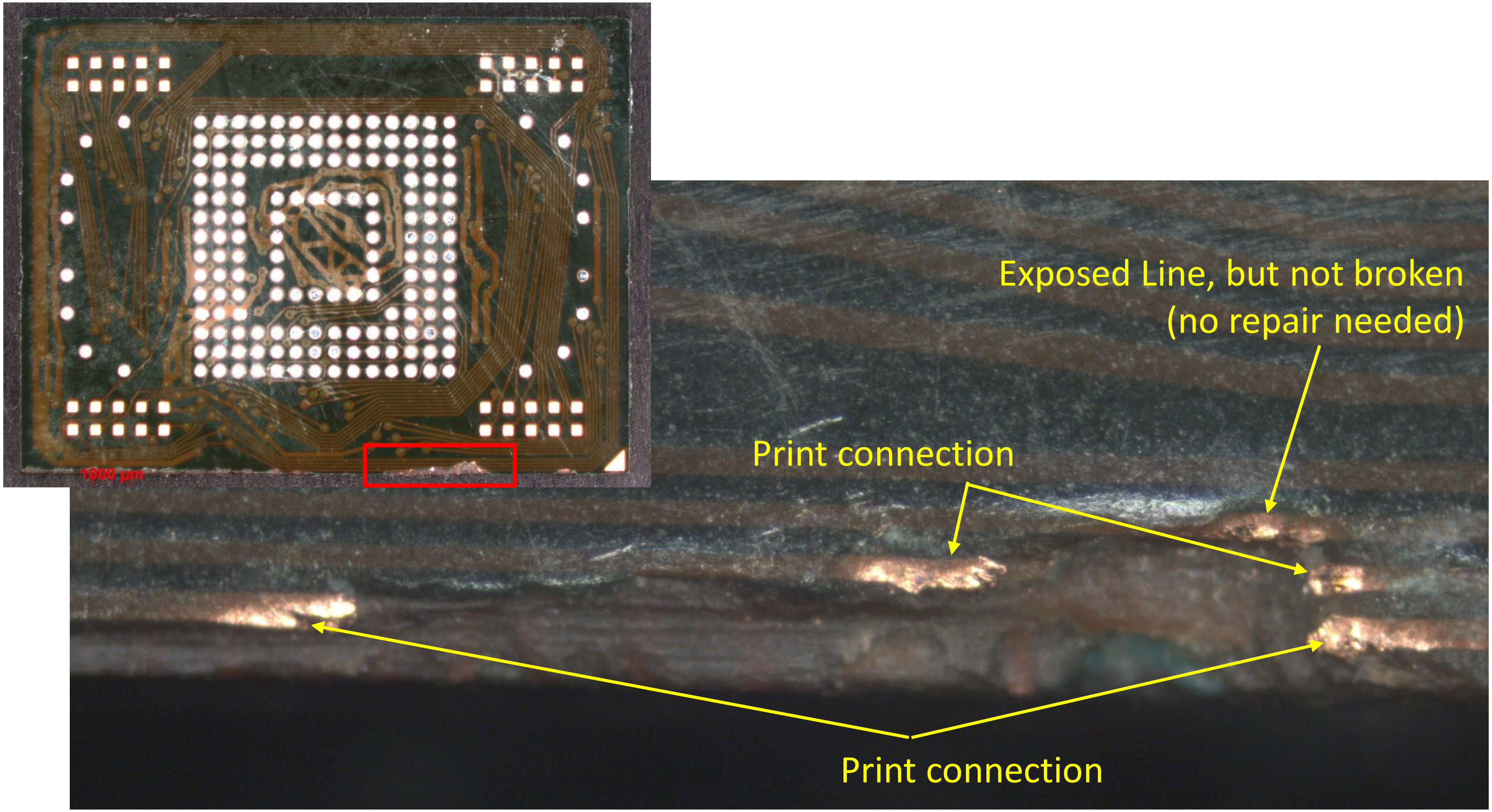


Red arrows indicate circuit lines that were broken
No other areas showed this level of damage

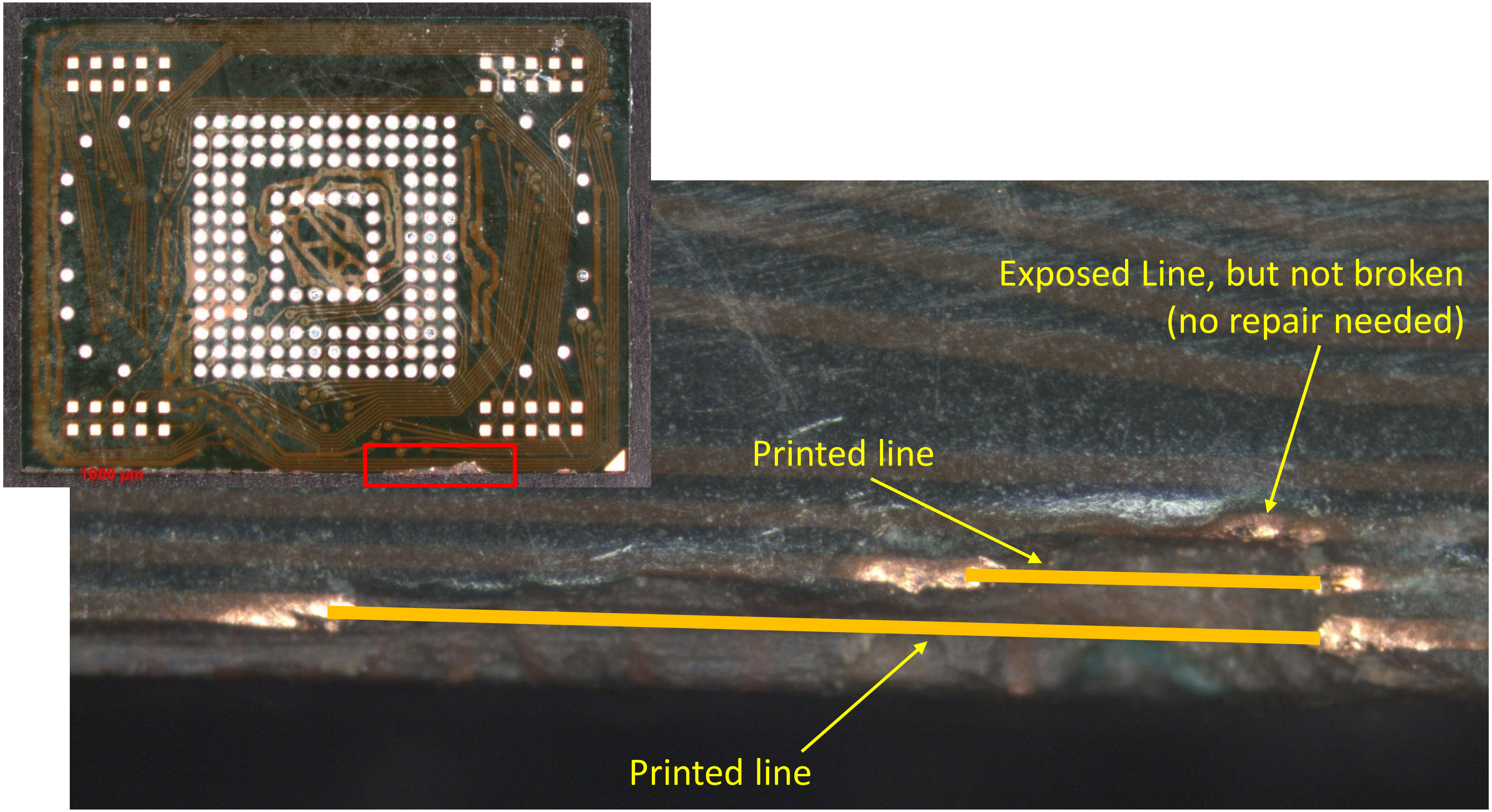
Section 2

PREPARATION OF THE DAMAGED AREA FOR REPLACEMENT OF TRACES

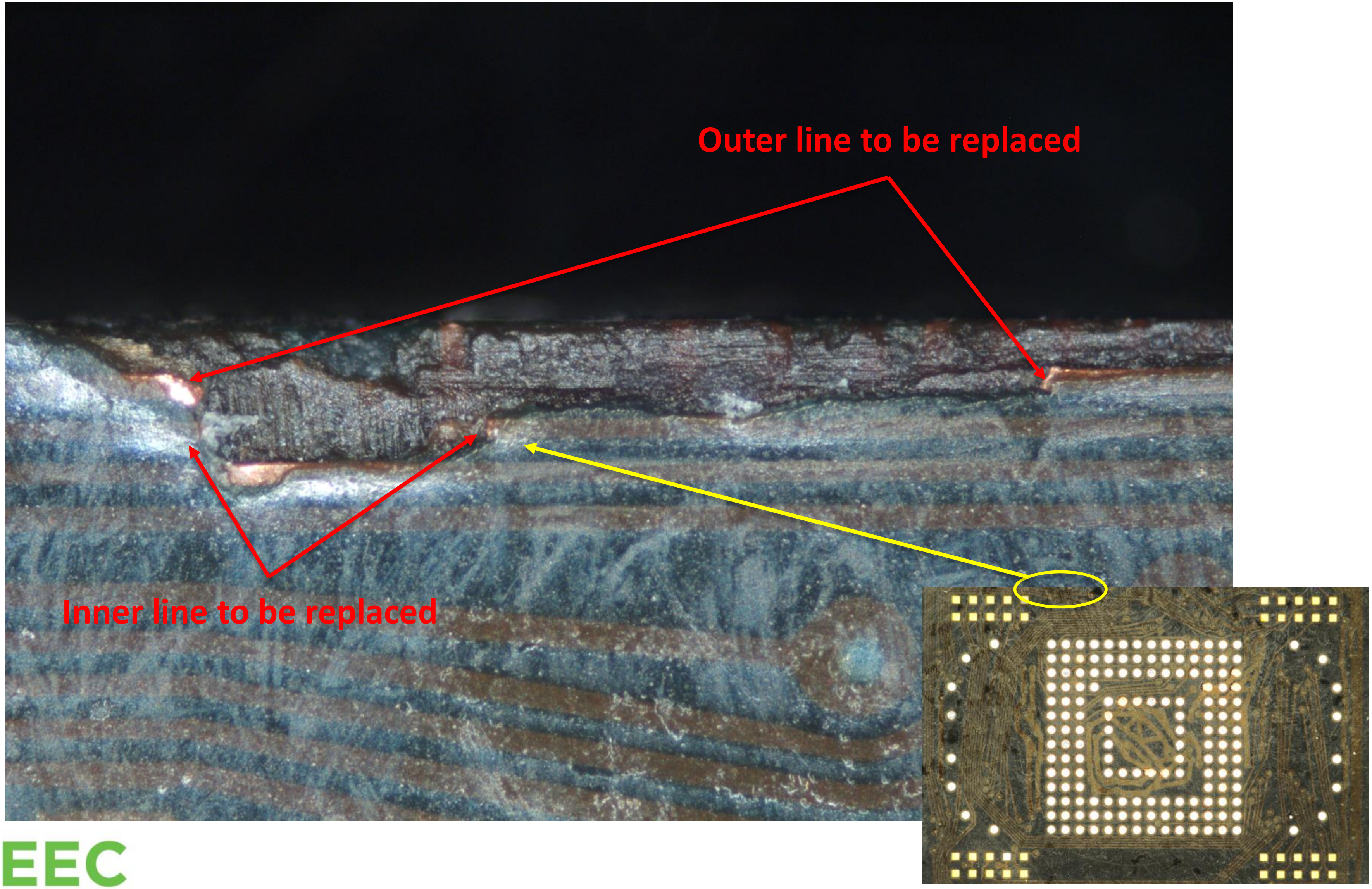
Repair Scheme Without the Printed Traces



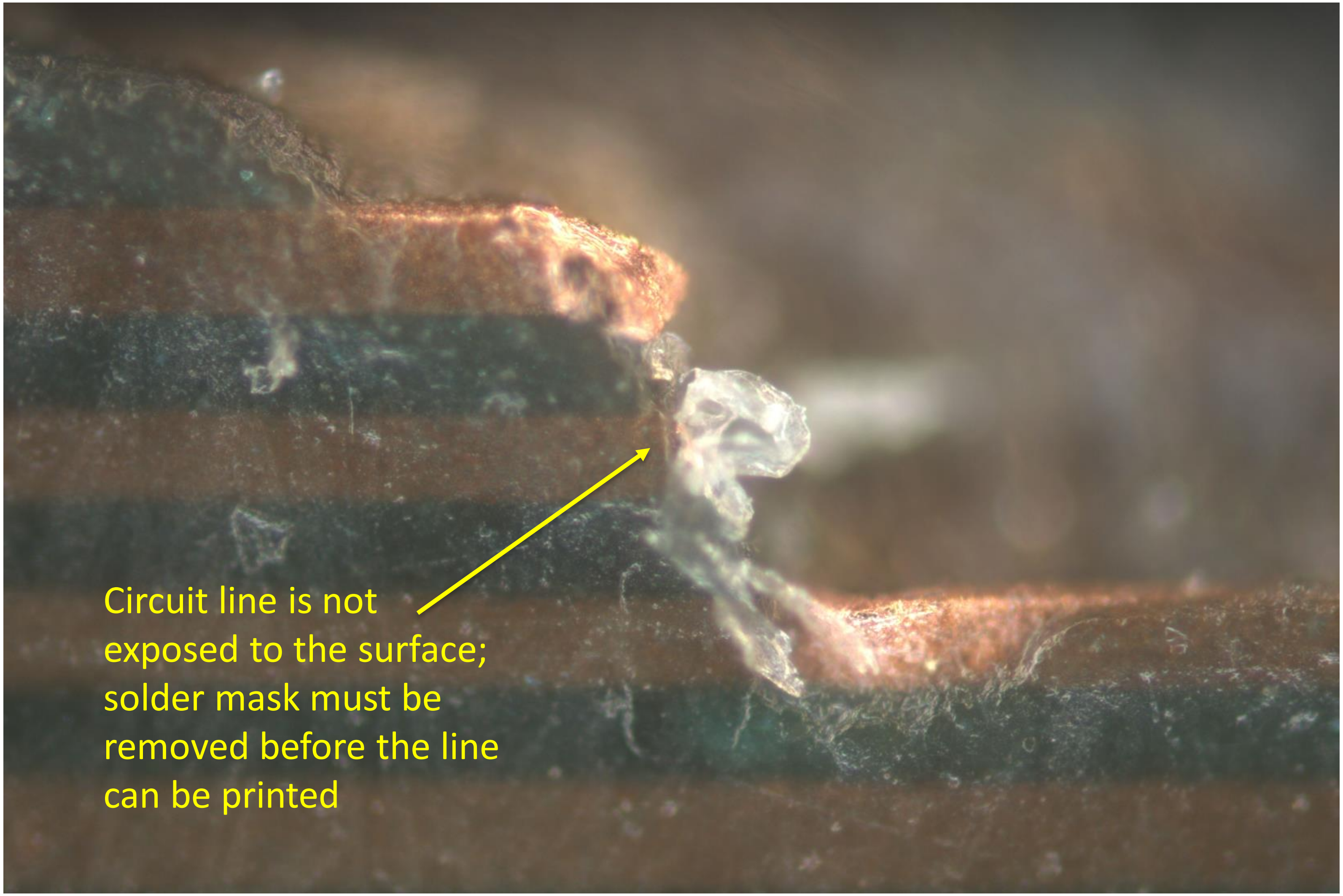
Repair Scheme With Specified Traces



Damaged Area Prior to Repair (Mag. Is 50x)

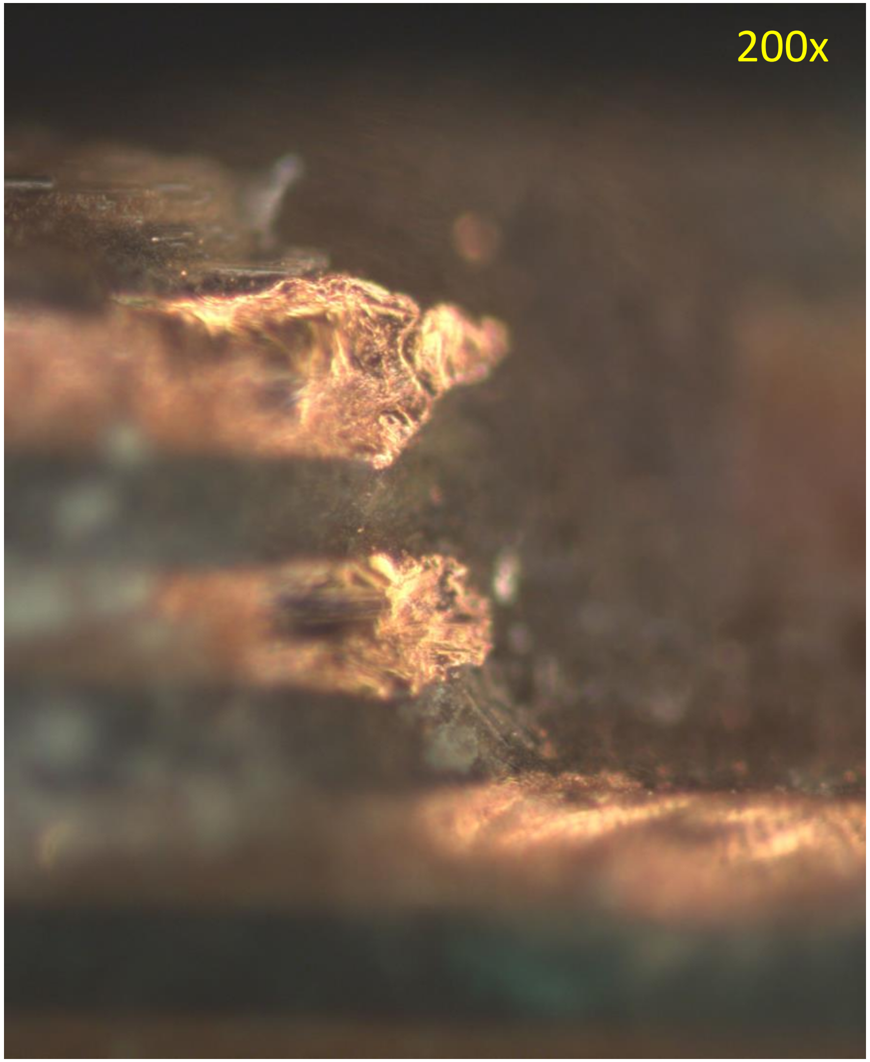


Segment of Damaged Area at Higher Mag. (200x)

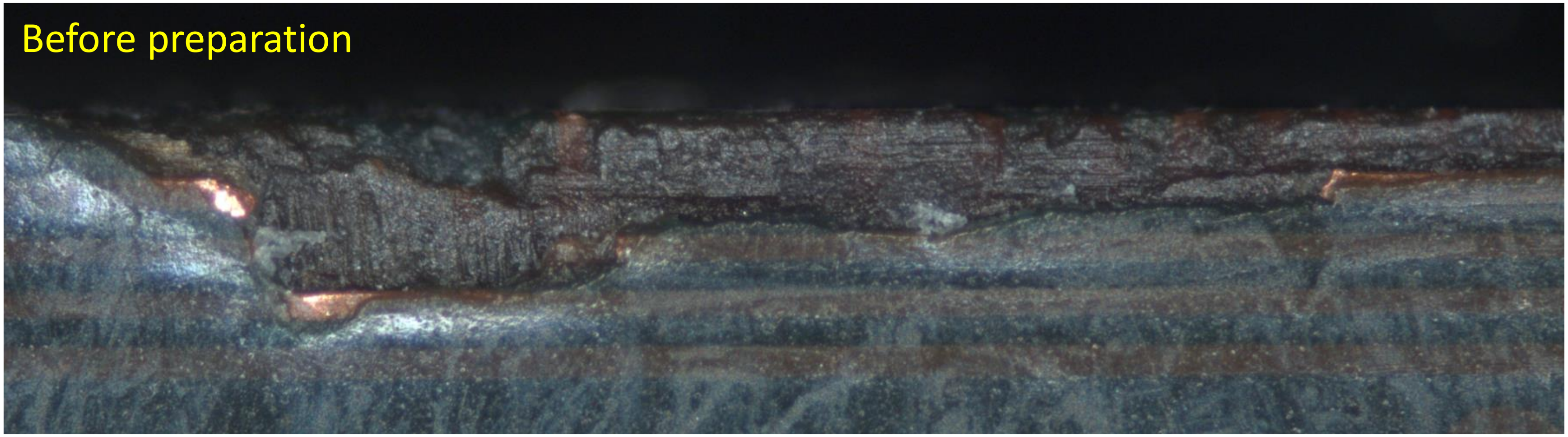


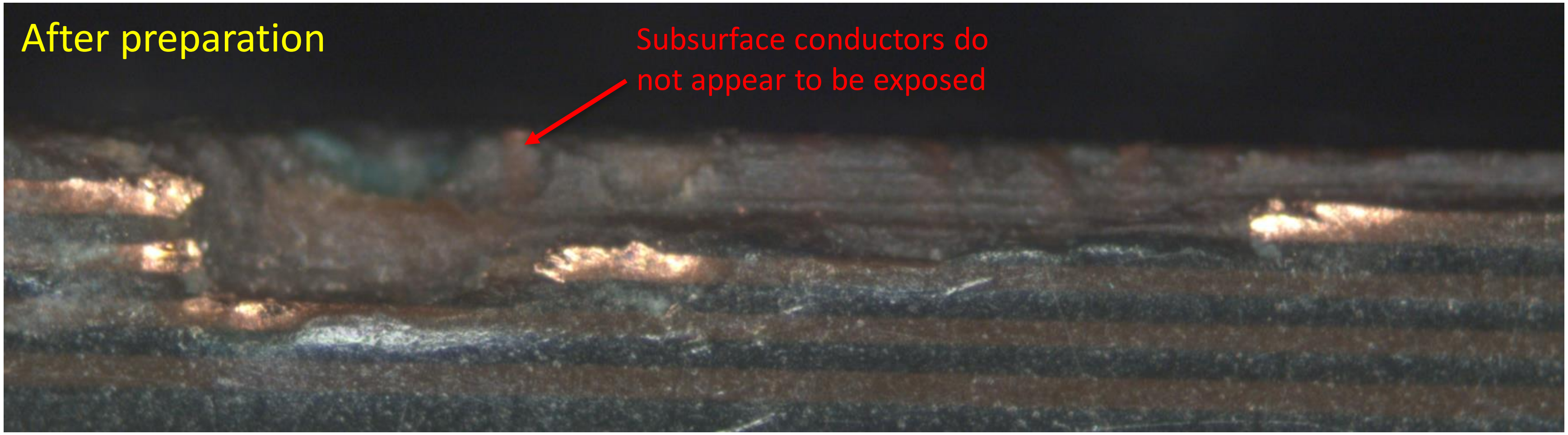
Removal of Solder Mask to Expose Ends of Damaged Traces

- **Equipment**
  - Scalpel
  - Wild 420 Zoom Stereoscope
- **Procedure**
  - Solder mask was gently scraped from the damage circuit lines
  - Area was viewed through the stereoscope while scraping was being done
  - To avoid damaging subsurface circuits, only enough solder mask was removed to expose the copper traces



Global View of the Prepared Area



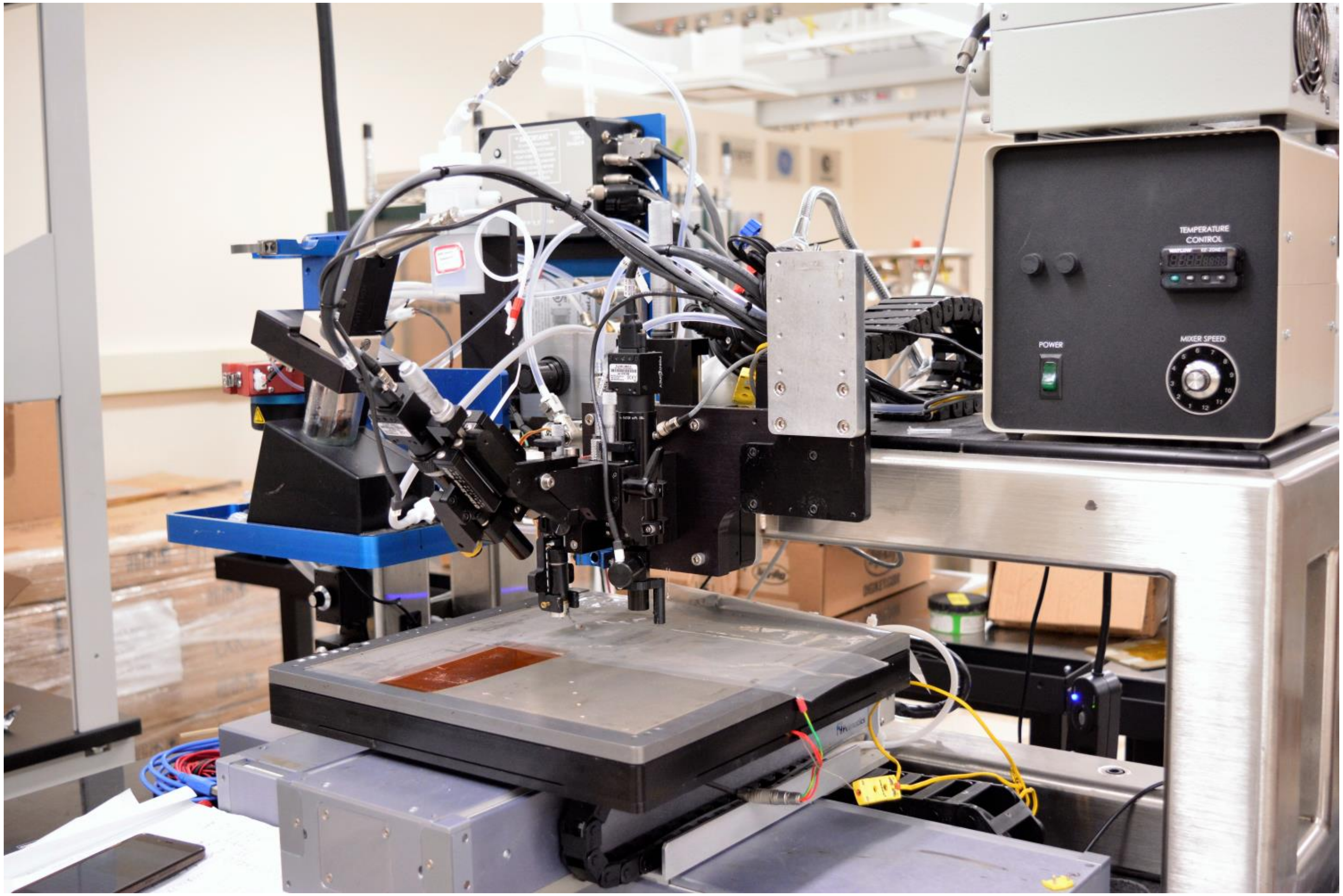


- Solder mask has been removed from the ends of the broken lines
- Oxides have been scraped from the ends of the lines
- No apparent exposure of subsurface circuitry

Section 3

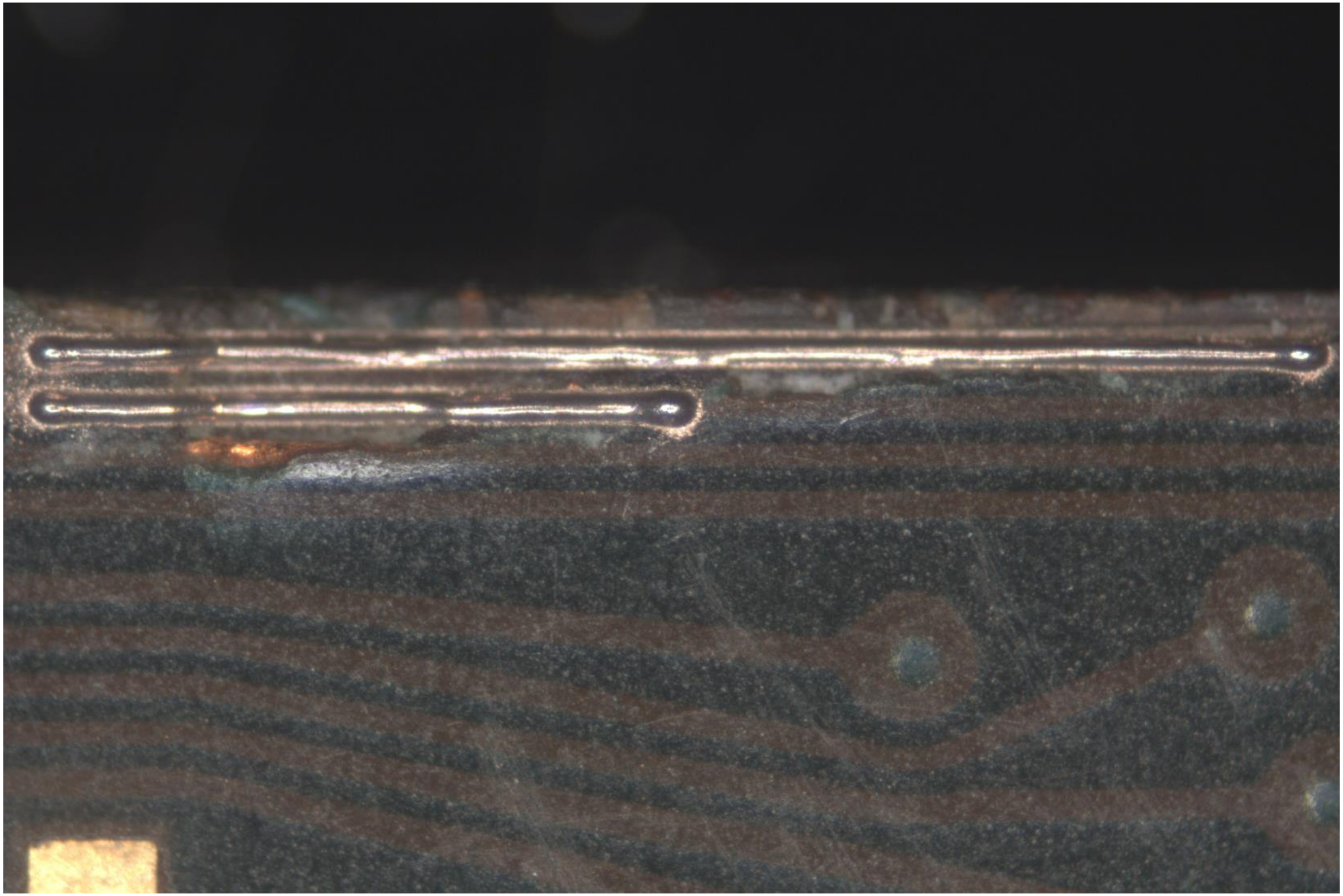
REPLACING THE CIRCUIT LINES

Precision Printing with the Aerosol Printer



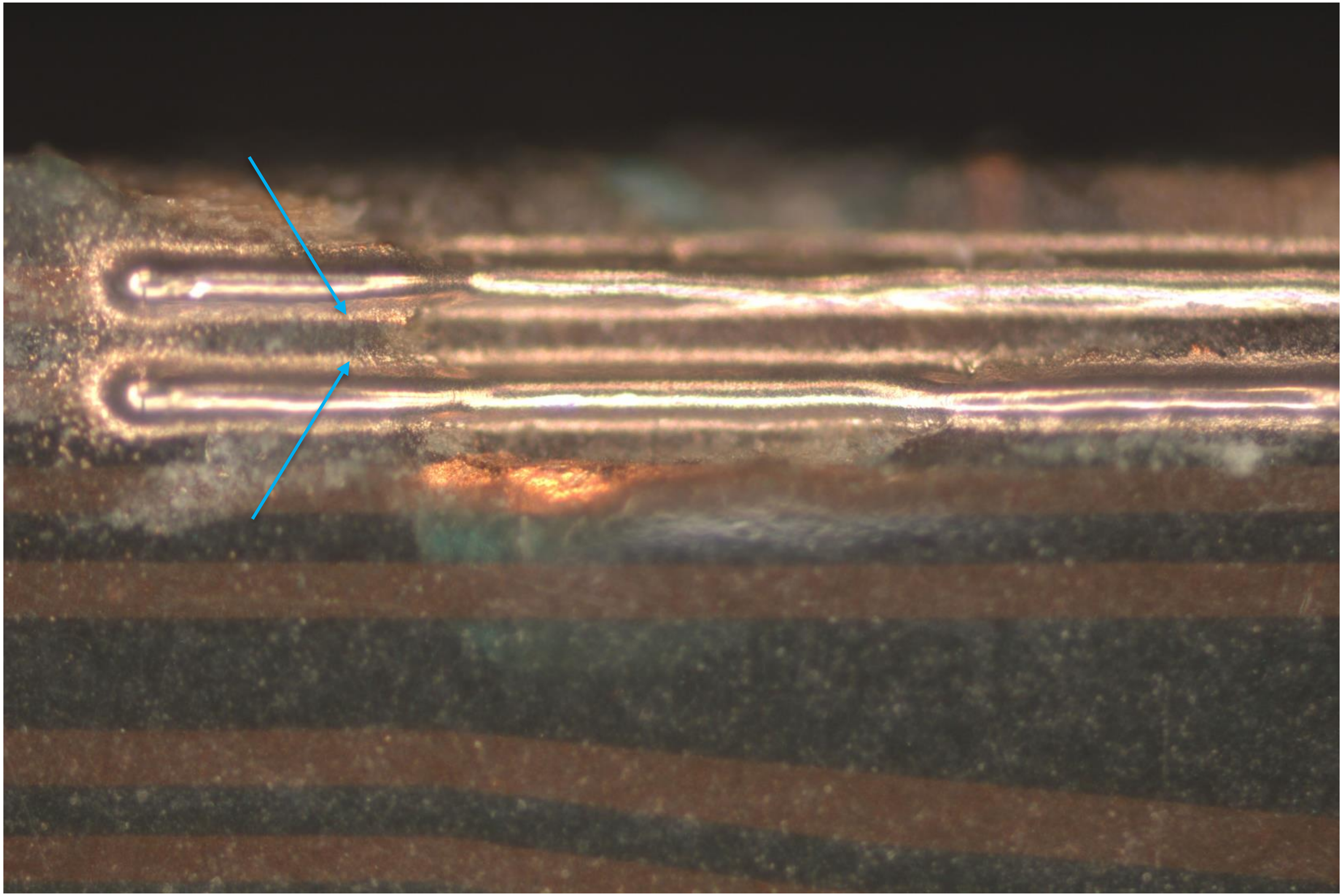
- Precise deposition of the conductive material
- Silver nano particle based ink (Paru PG 007)
- Deposited in multiple passes to build up the pad
- Cured for 1 hour at 125 C

Global View of the Final Repair



The two connections were successfully printed, with no apparent shorting between traces

Printed Traces at Higher Magnification (100x)

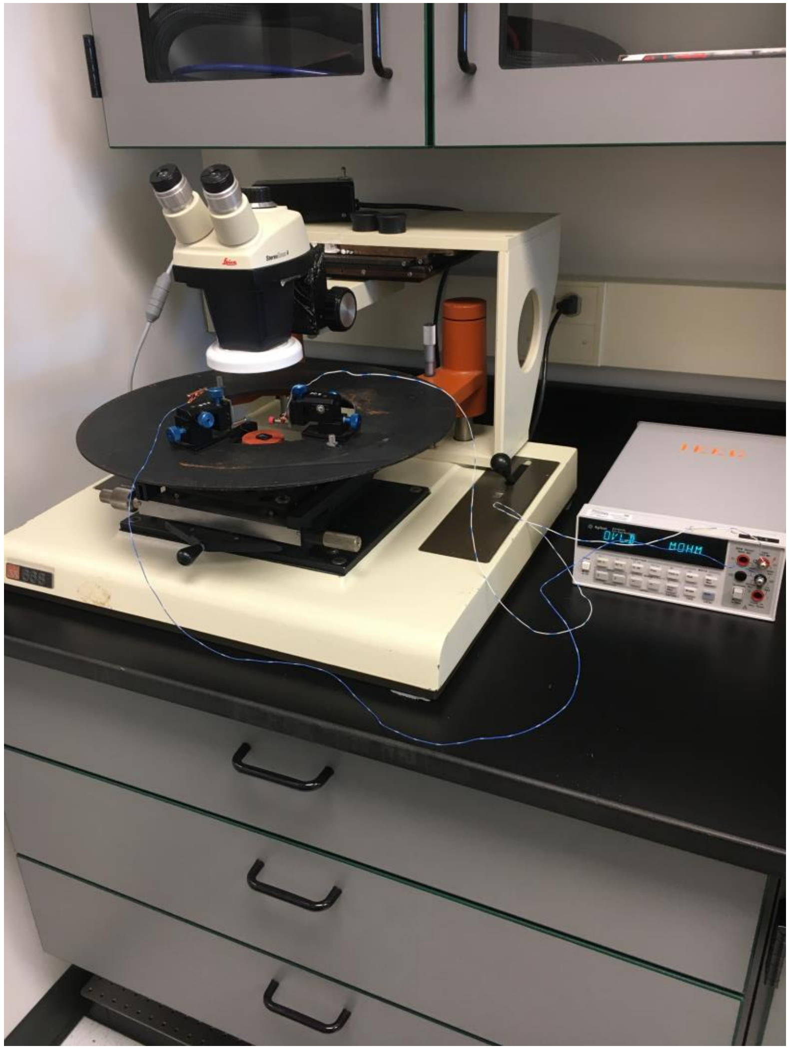


No apparent bridging between circuit lines, even by the printed "halo" (blue arrows)

Section 4

CONFIRMATION OF THE ELECTRICAL CONTINUITY

Electrical Measurements with a Mini Probe Station



- **Probe Station**
  - Two xyz positioners were used to touch probe point to the traces
  - Two-point resistance measurements were made
- **Results**
  - Each trace read 14 Ω (much of which is likely probe contact resistance)
  - Resistance between traces read 1.4 MΩ
  - Low resistance along traces, high resistance between traces