

Physical Analysis Report on CEN19FA018

Prepared by Binghamton University for the
National Transportation Safety Board

December 10, 2018

Summary of Analyses

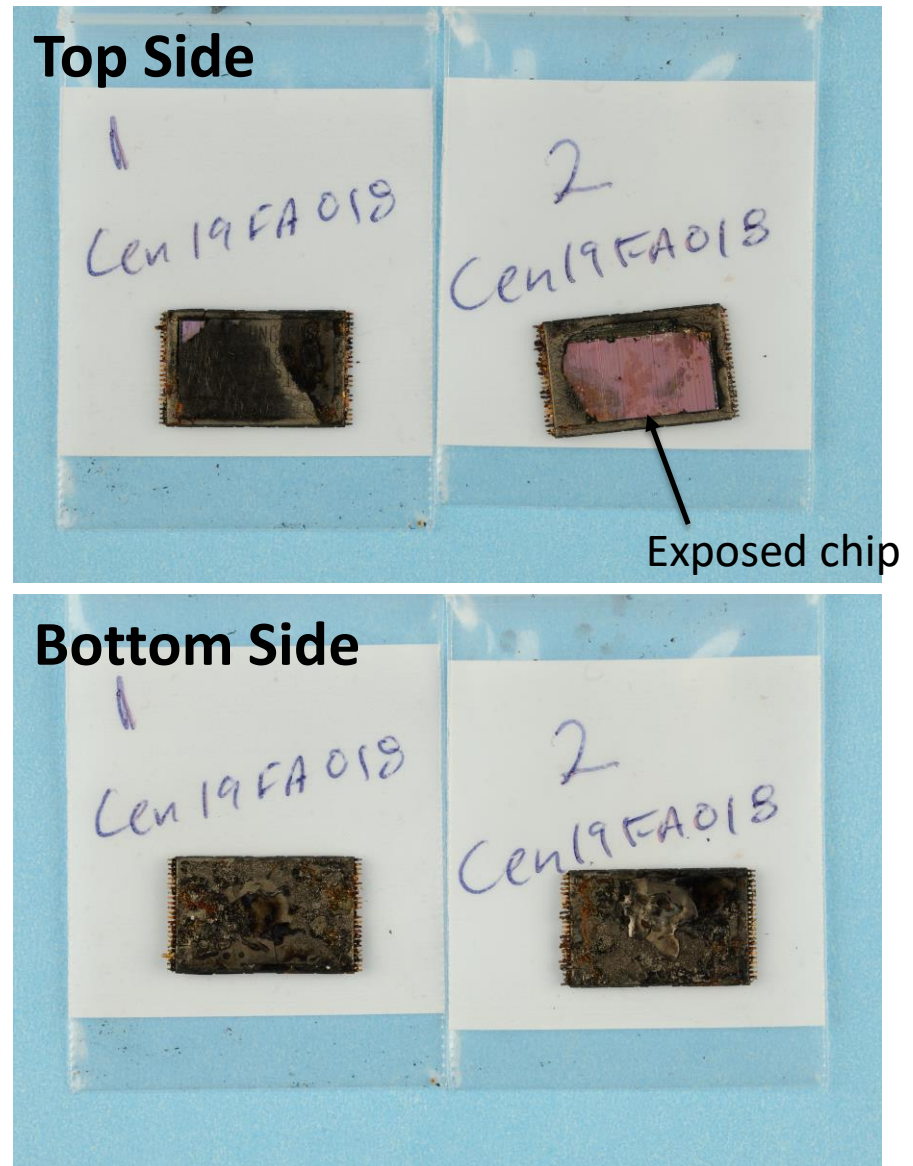
- **Analyst: Dr. Stephen R. Cain**
- **Techniques**
 - Optical microscopy
 - 2-d x-ray analysis (x-rays hardened with 8 sheets of Al foil over the source)
 - Acoustic microscopy
- **Samples**
 - Two memory modules received
 - Both showed signs of an extreme thermal event – no identifying markings could be read
- **Summary of Findings**
 - Configuration of the modules
 - NTSB indicated that the modules were duplicates
 - Both modules had a wire bond configuration; wire bonds connecting the chips to pins from a lead frame
 - Double sided mounting of chips (both sides of the lead frame)
 - Chips were stacked; two on each side of the lead frame
 - Manufacturer's marking
 - Module 1: SAMSUNG OUG, K9WBG08U1M, ??? P1B0, ??? where ?? Indicates unreadable segment or line
 - Module 2: no overmold left on the package

Summary of the Analyses, cont'd.

- **Summary of Findings, cont'd.**
 - Optical inspection
 - Both modules were severely burned, such that the overmold compound cracked and was partially removed
 - Integrated circuit was exposed in one corner of module 1
 - Integrated circuit was almost completely exposed in module 2
 - Confirmed chip crack in the exposed corner (module 1)
 - Either a scratch or a crack was seen in the exposed integrated circuit of module 2
 - X-ray inspection
 - Top view indicated multiple wire bond breaks
 - Side view confirmed wire bond breaks and dislocations
 - C-SAM
 - No attempt to sonically image module 1 was made, owing to the severe surface damage
 - Only the top chip in module 2 could be sonically imaged; the layer between stacked chips showed a pattern that is consistent with severely interfacial damage, and likely damage to the bottom chip as well
- **Disposition: Neither module is a good candidate for data retrieval**

Initial Images of the Two Modules

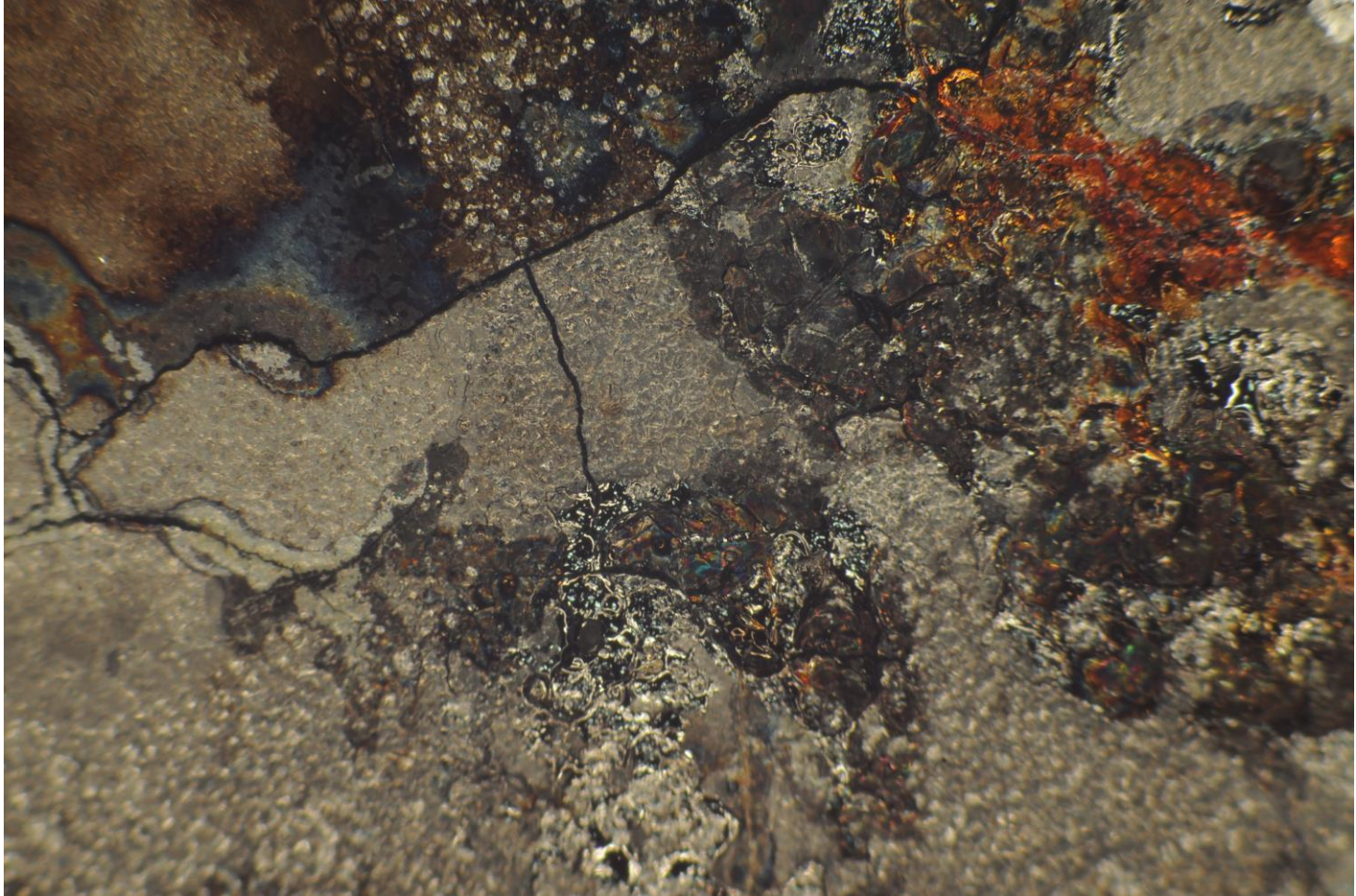
Modules were removed from their plastic bags and photographed from the top and from the bottom



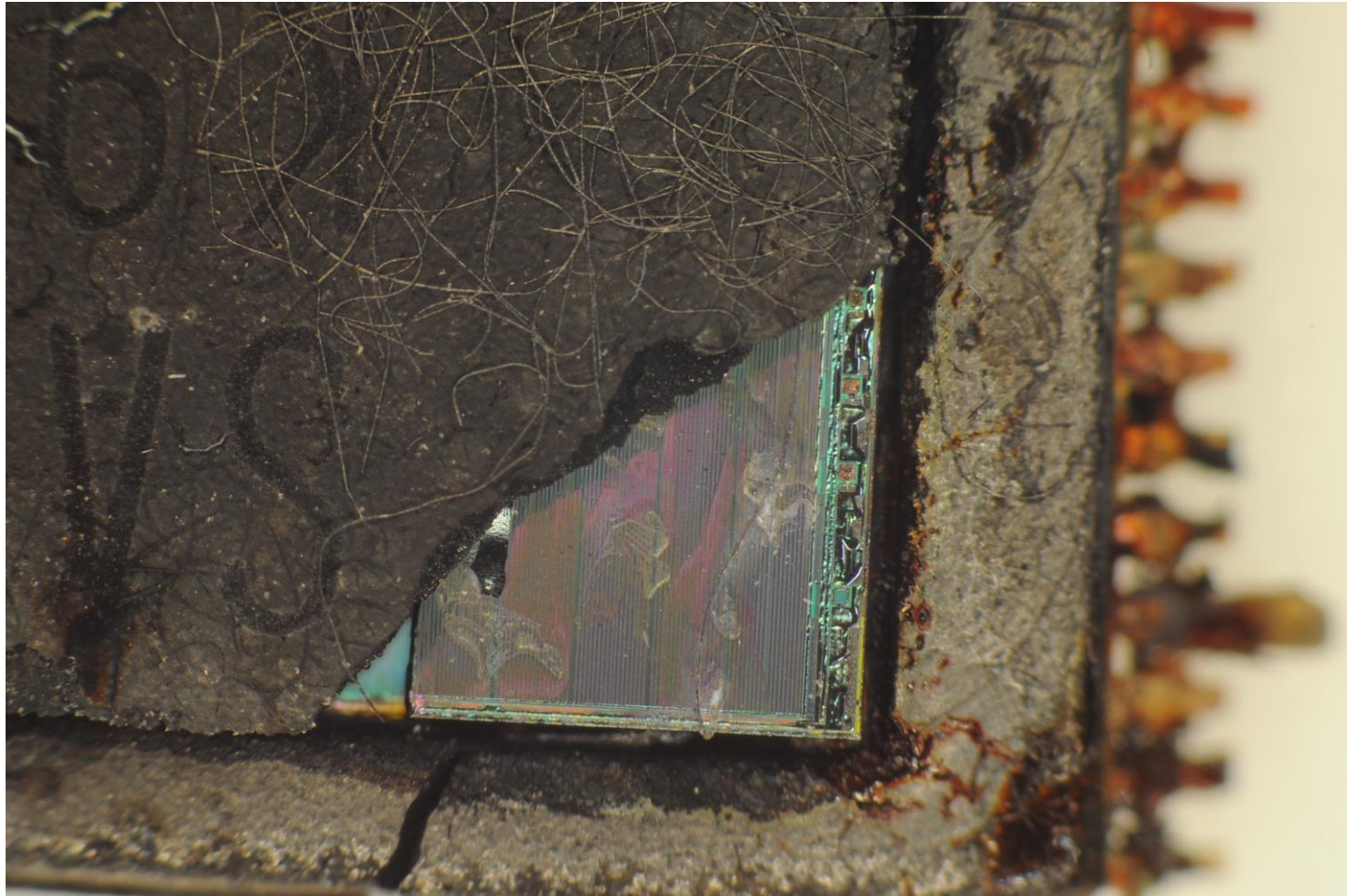
Section 1

OPTICAL INSPECTION

Bottom of Module 1: Note the Cracks in the Overmold

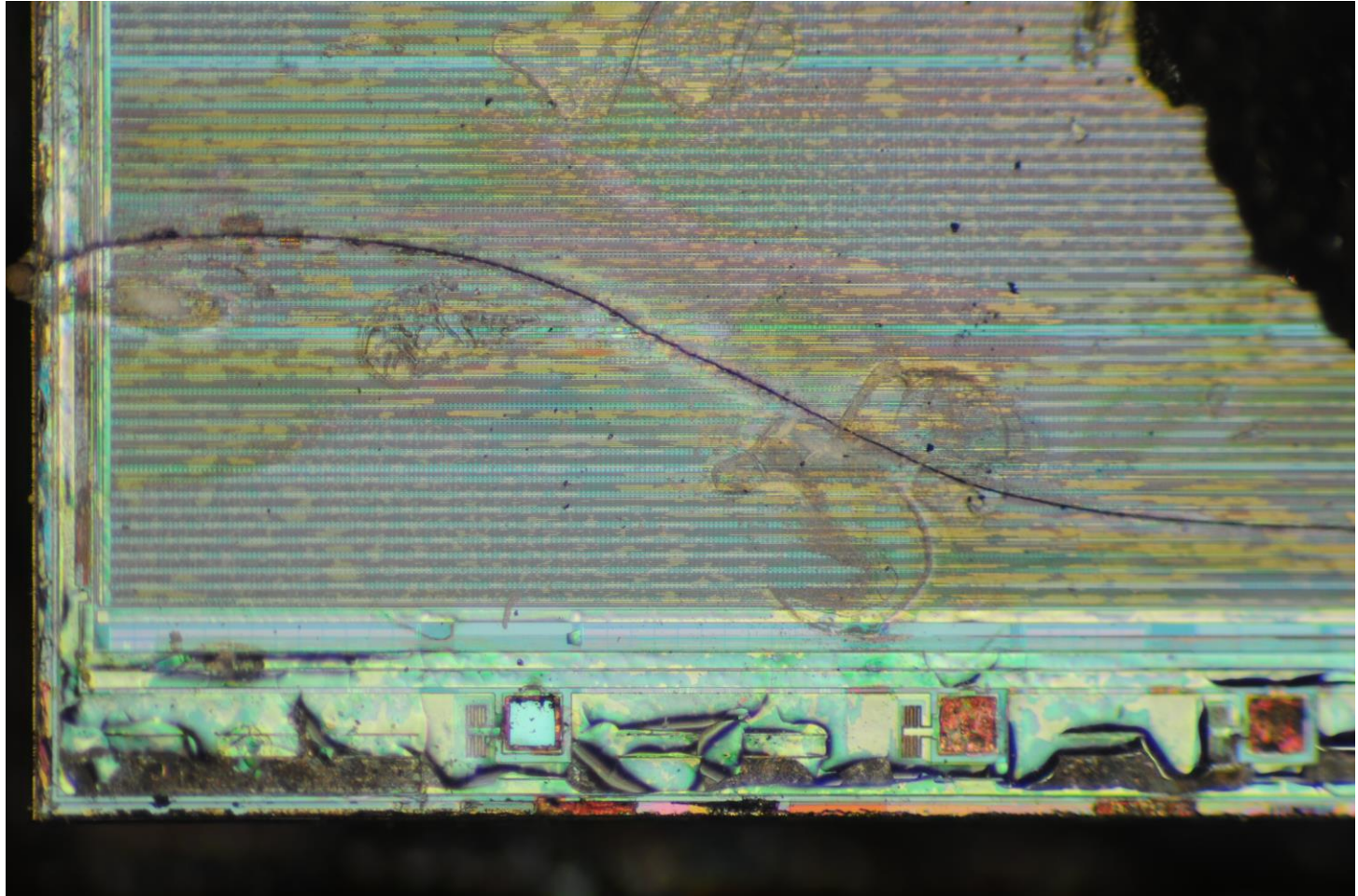


Top of Module 1: Note the Exposed Chip

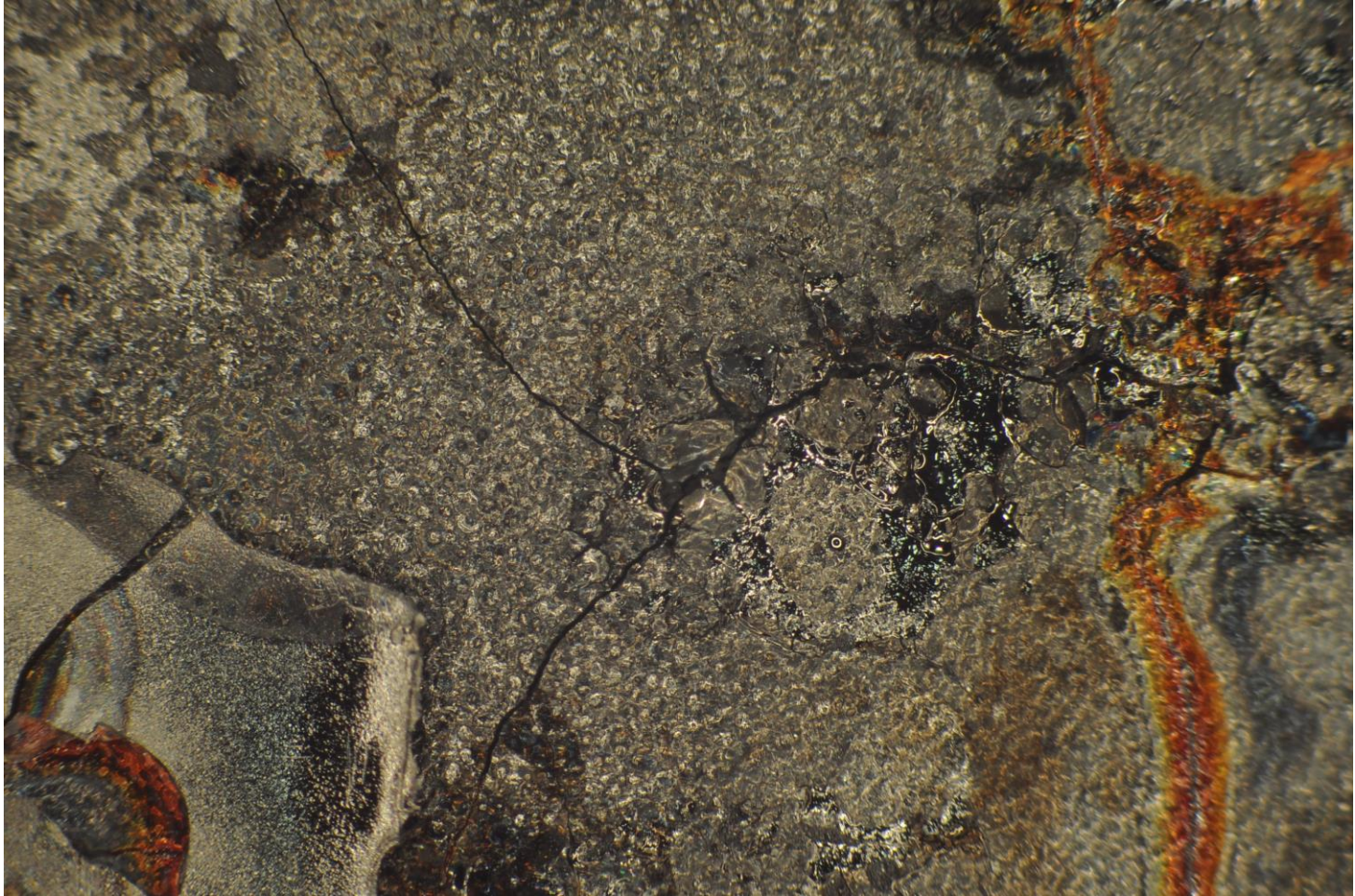


Large crack in the overmold

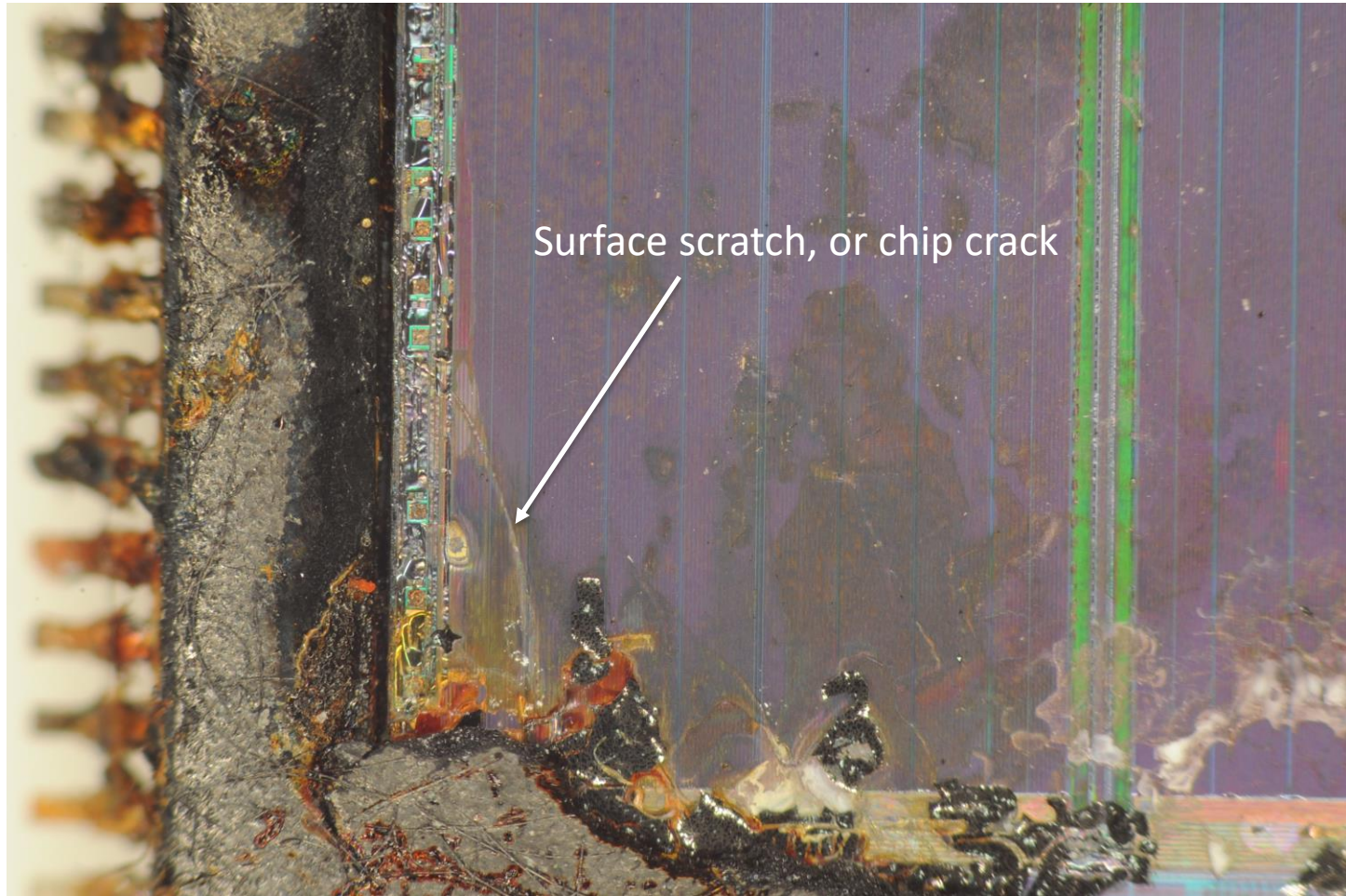
Surface Crack in the Chip in Module 1



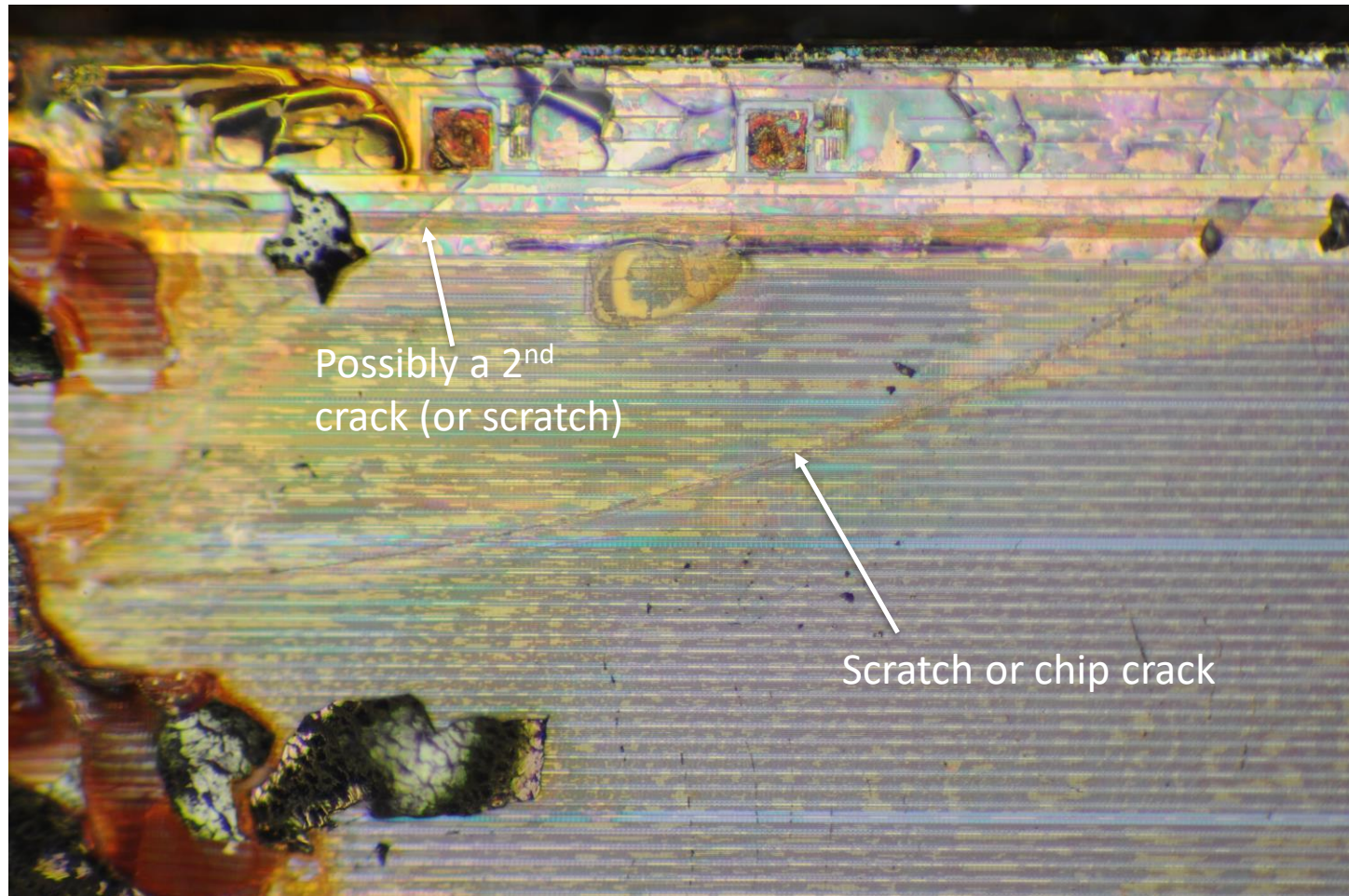
Bottom of Module 2: Note the Cracks in the Overmold



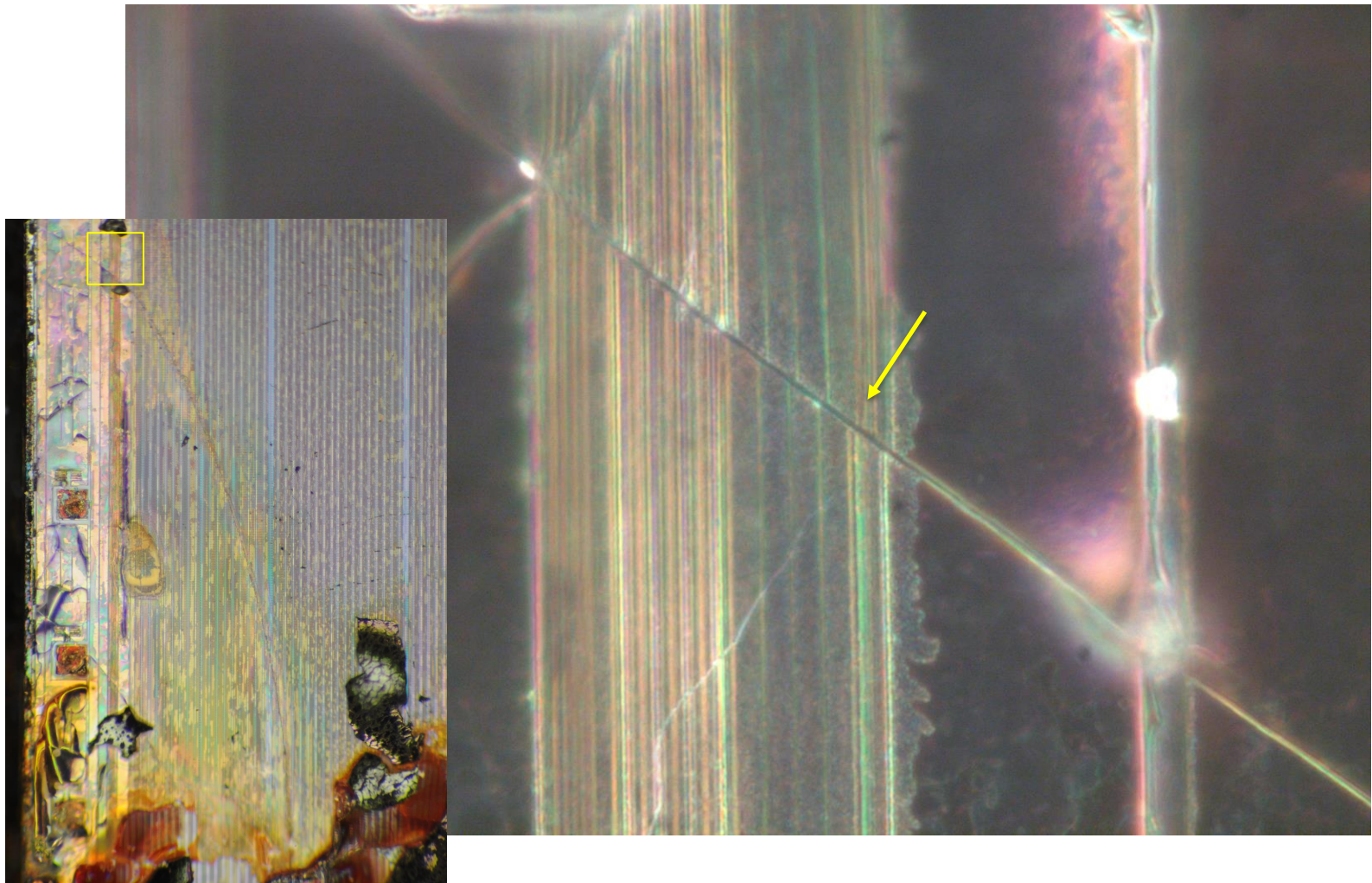
Top of Module 2: Note the Exposed Chip



Module 2, Suspect Area at Higher Magnification



Module2: Confirmation of Crack – Note the Dislocation

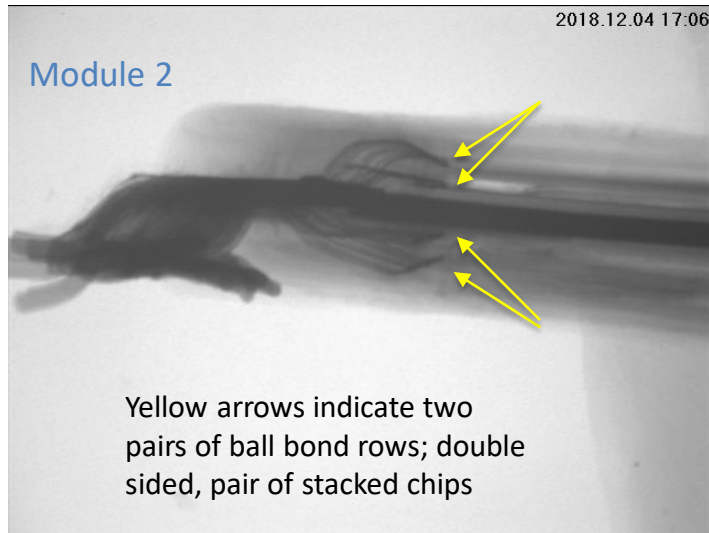
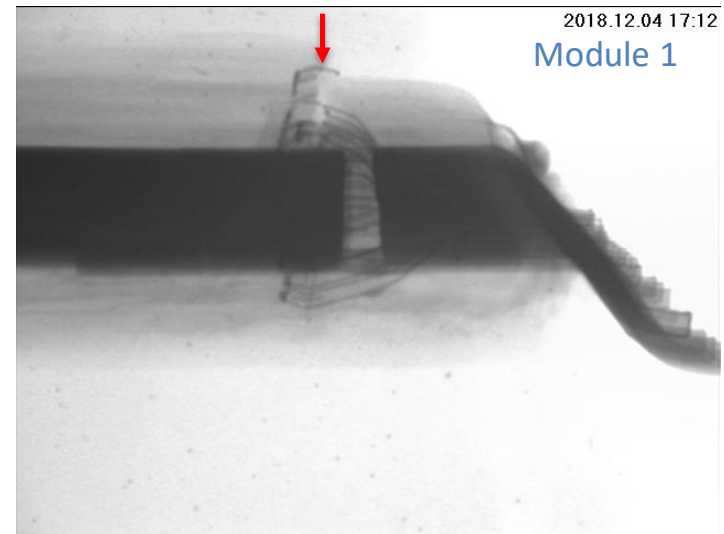
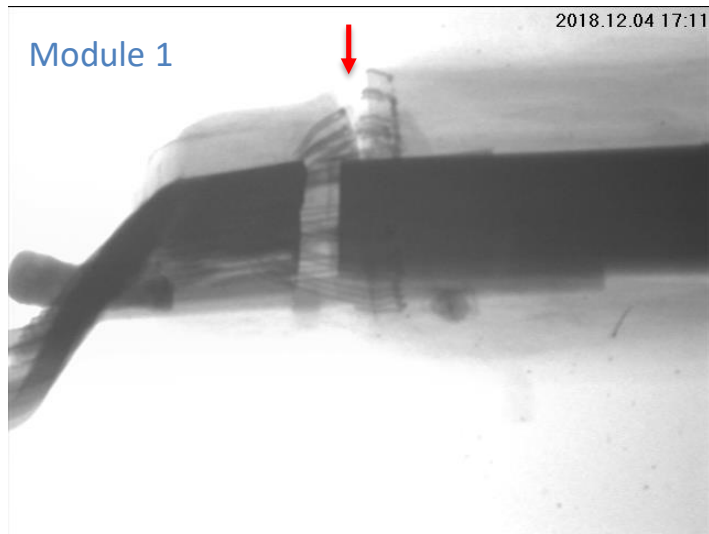


Dark field image at 1000x, showing dislocation of lines at the crack

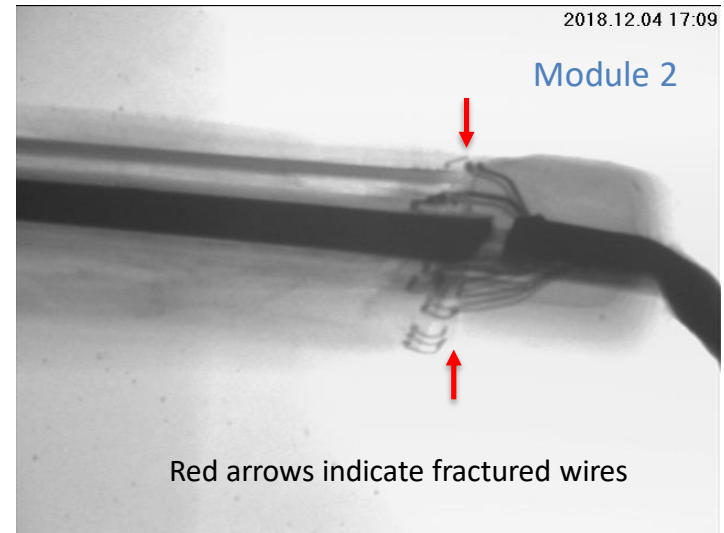
Section 2

X-RAY INSPECTION

Side View of Modules 1 and 2 at Each End



Yellow arrows indicate two pairs of ball bond rows; double sided, pair of stacked chips

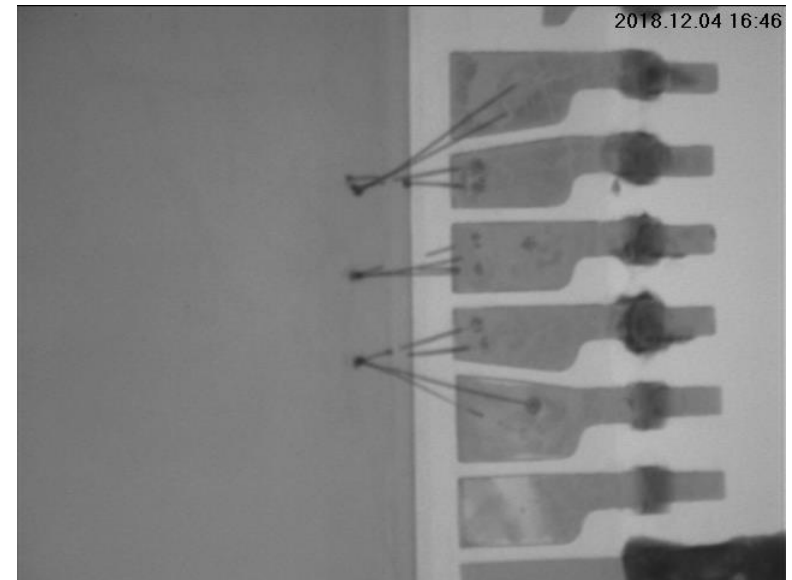


Red arrows indicate fractured wires

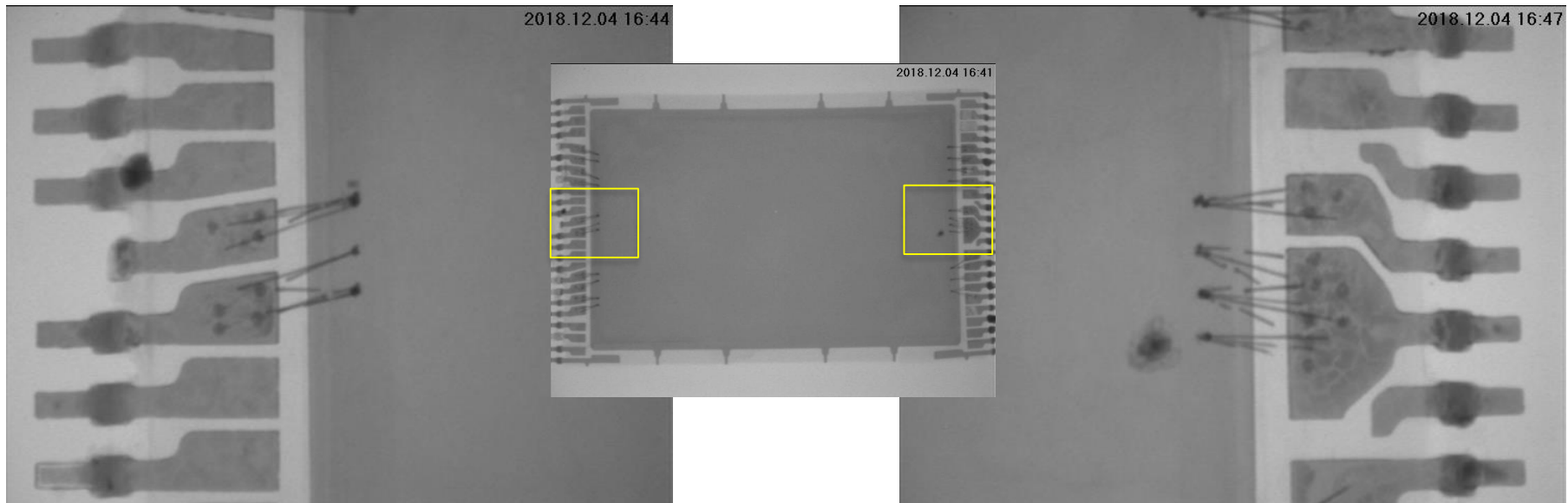
Top View X-ray of Module 1 (Global)



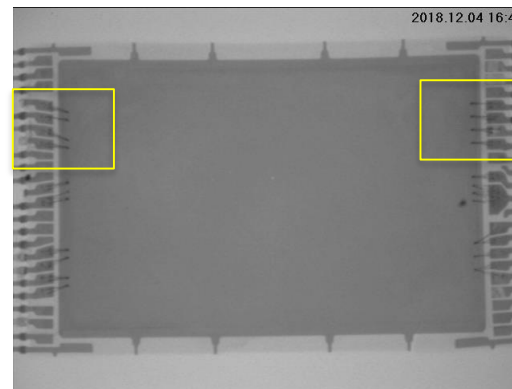
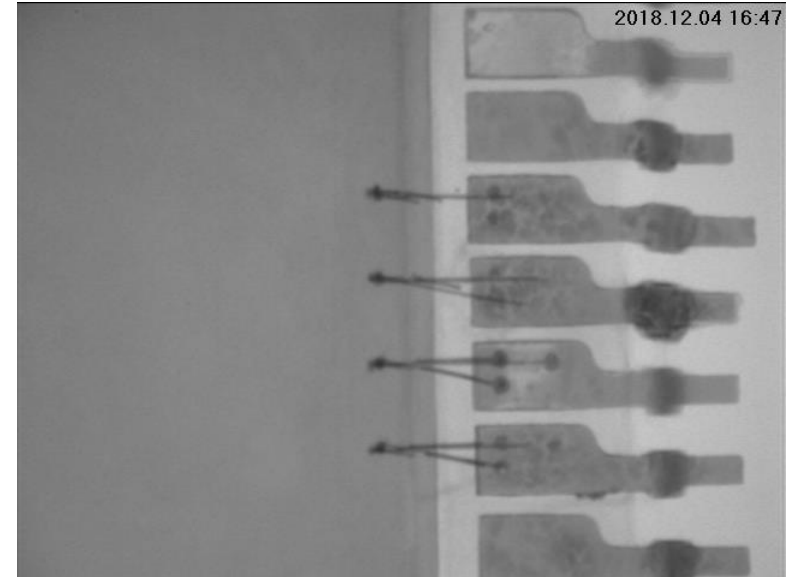
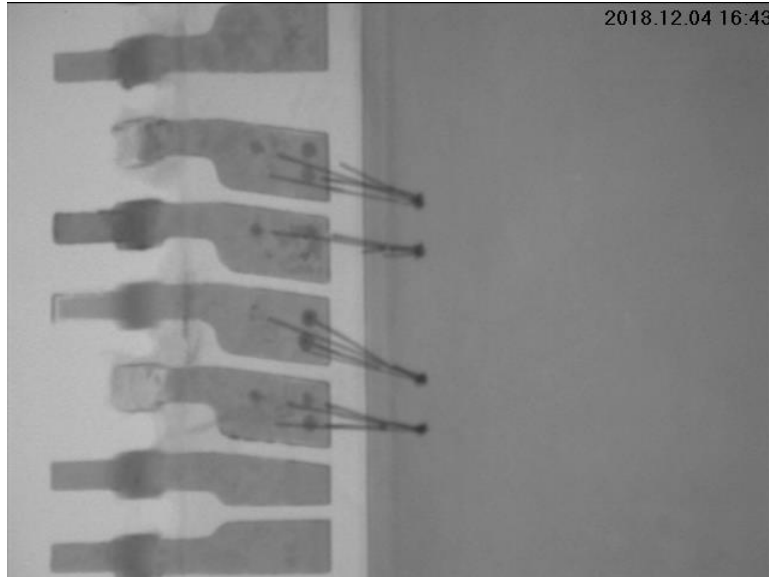
Close Up of Wires in Module 1: Broken Wires



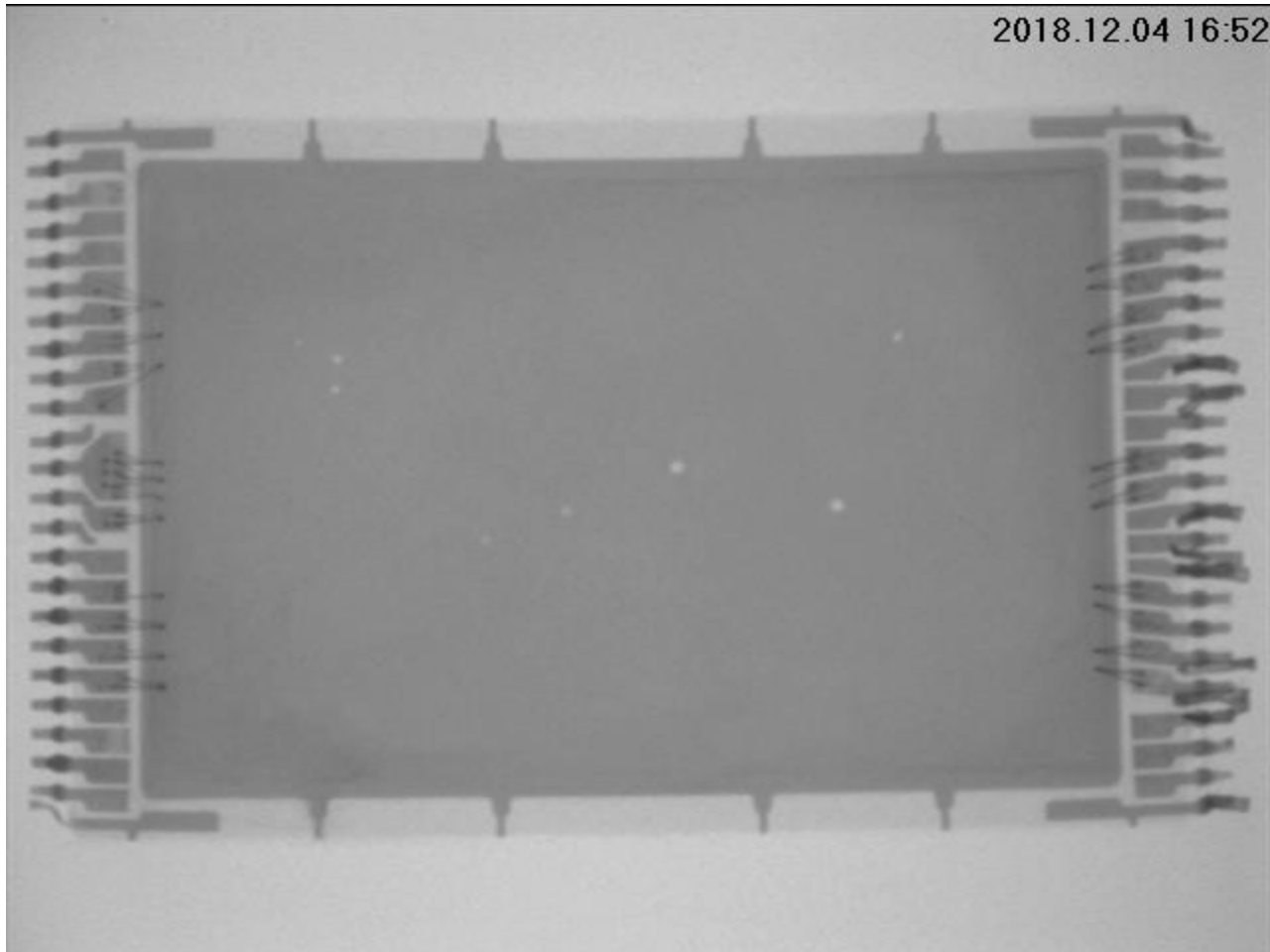
Close Up of Wires in Module 1: Broken Wires



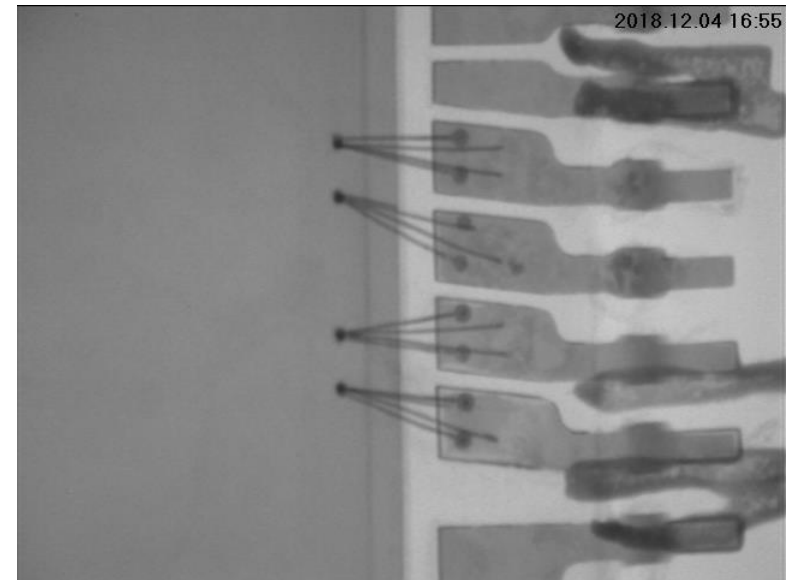
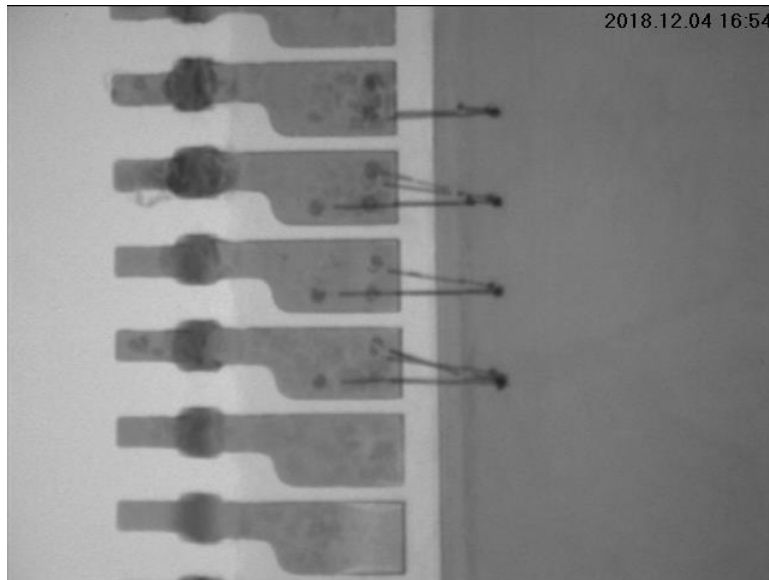
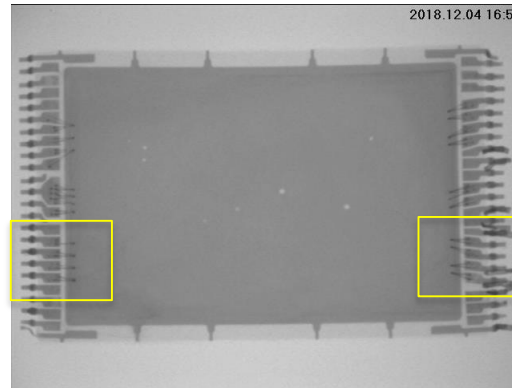
Close Up of Wires in Module 1: Broken Wires



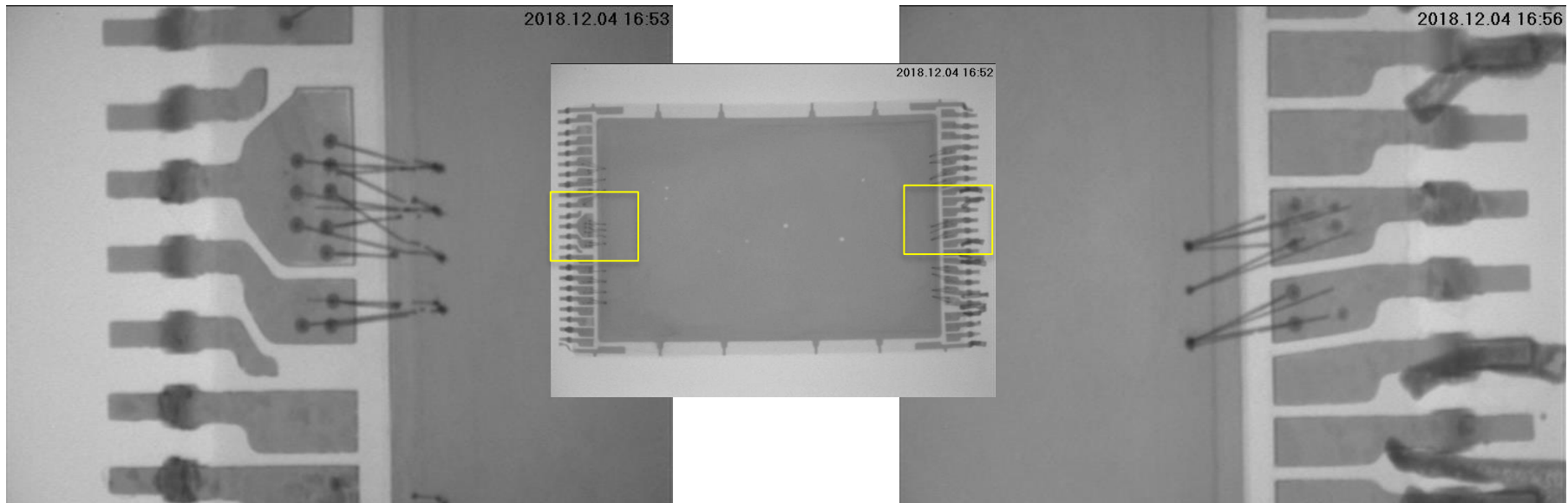
Top View X-ray of Module 2 (Global)



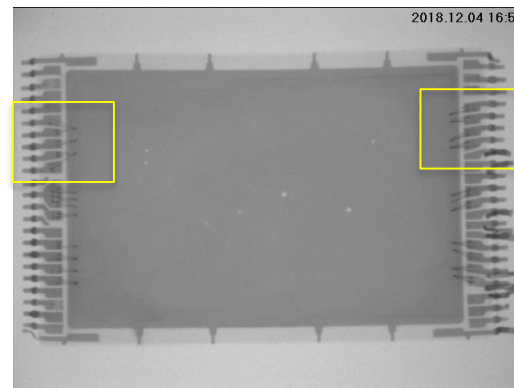
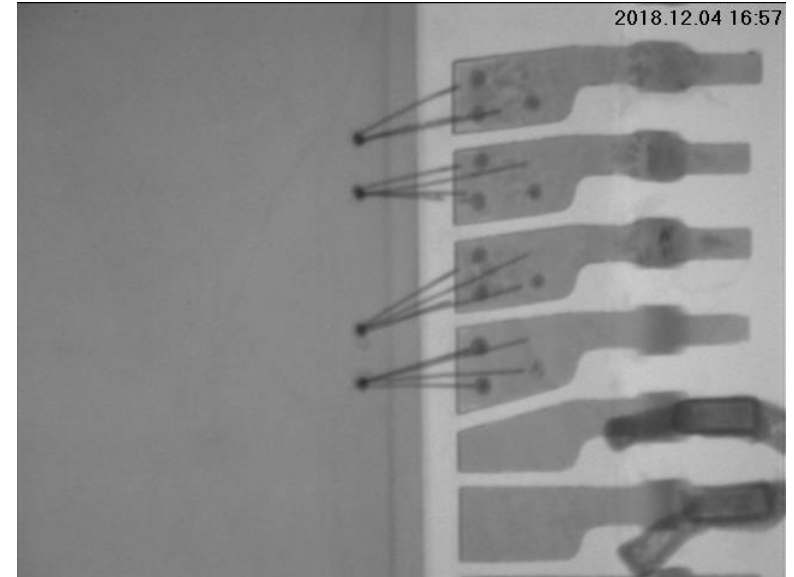
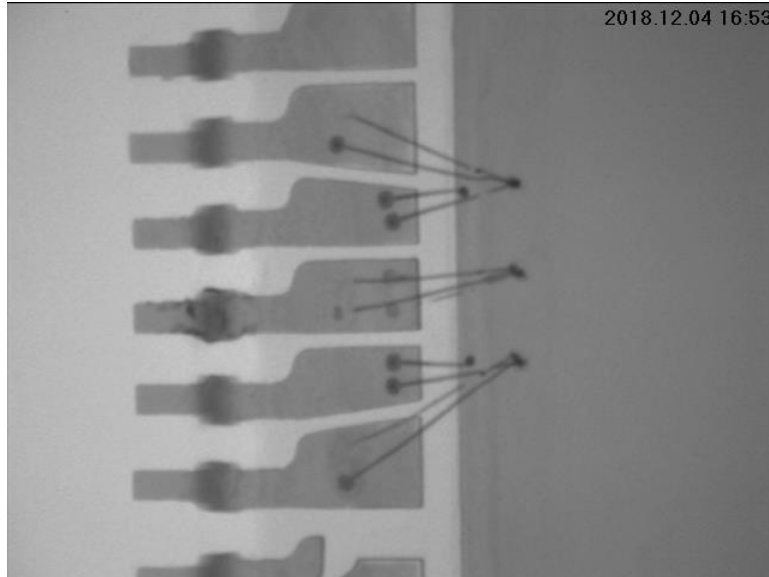
Close Up of Wires in Module 2: Broken Wires



Close Up of Wires in Module 2: Broken Wires



Close Up of Wires in Module 1: Broken Wires



Section 3

ACOUSTIC MICROSCOPY

Surface of the Exposed Chip in Module 2

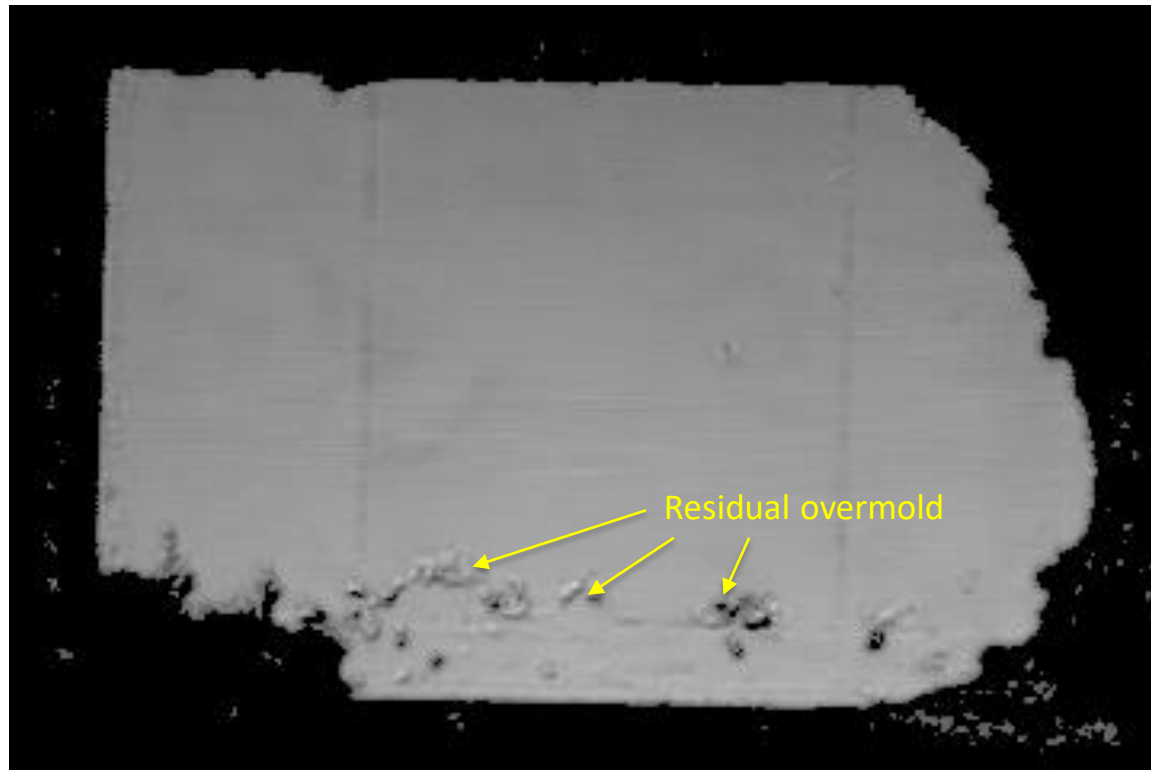
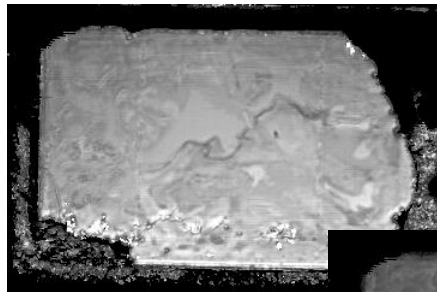
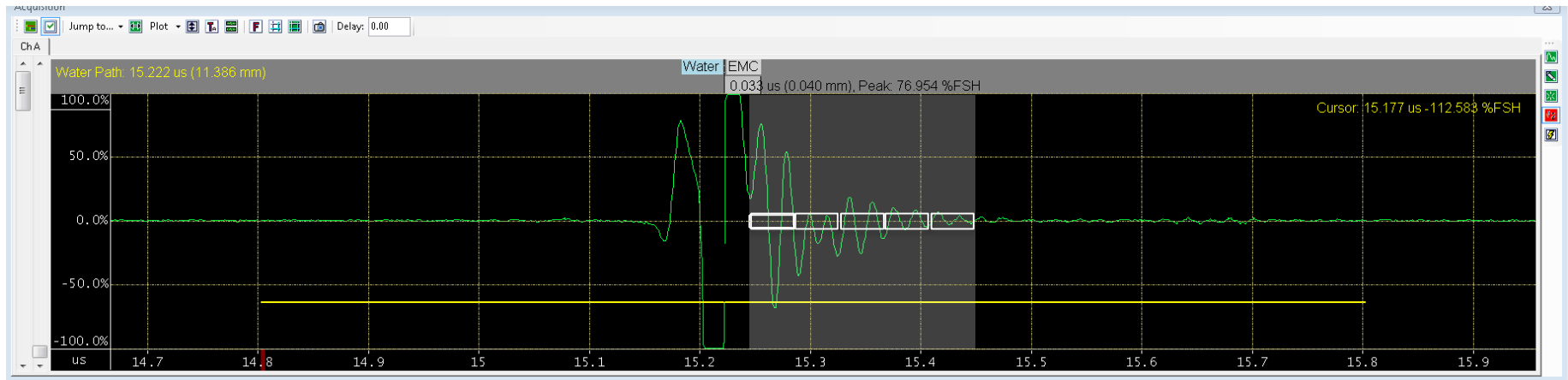


Image taken with a 50 MHz transducer in pulse echo mode

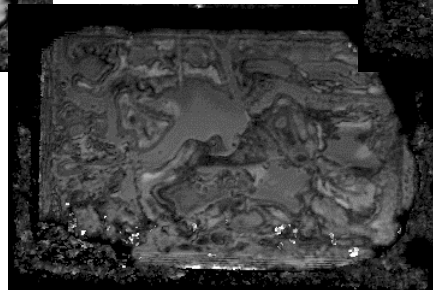
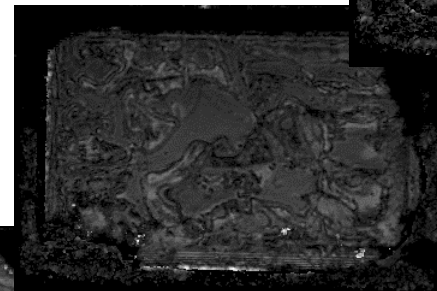
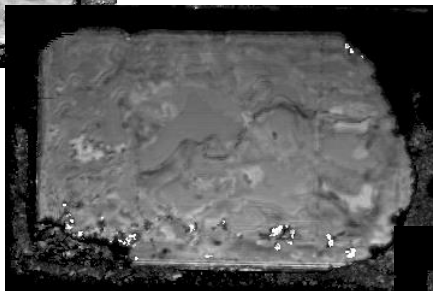
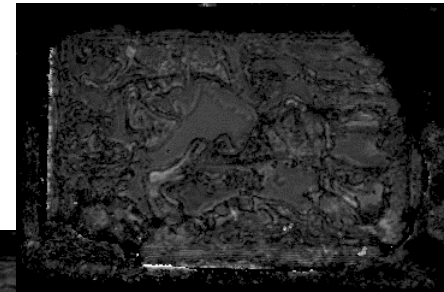
- Black area is the overmold remaining on the outer lead frame
- Spots in the chip area are residual overmold that did not completely burn or flake off

C-SAM Setup – Five Gate Settings for Pulse Echo

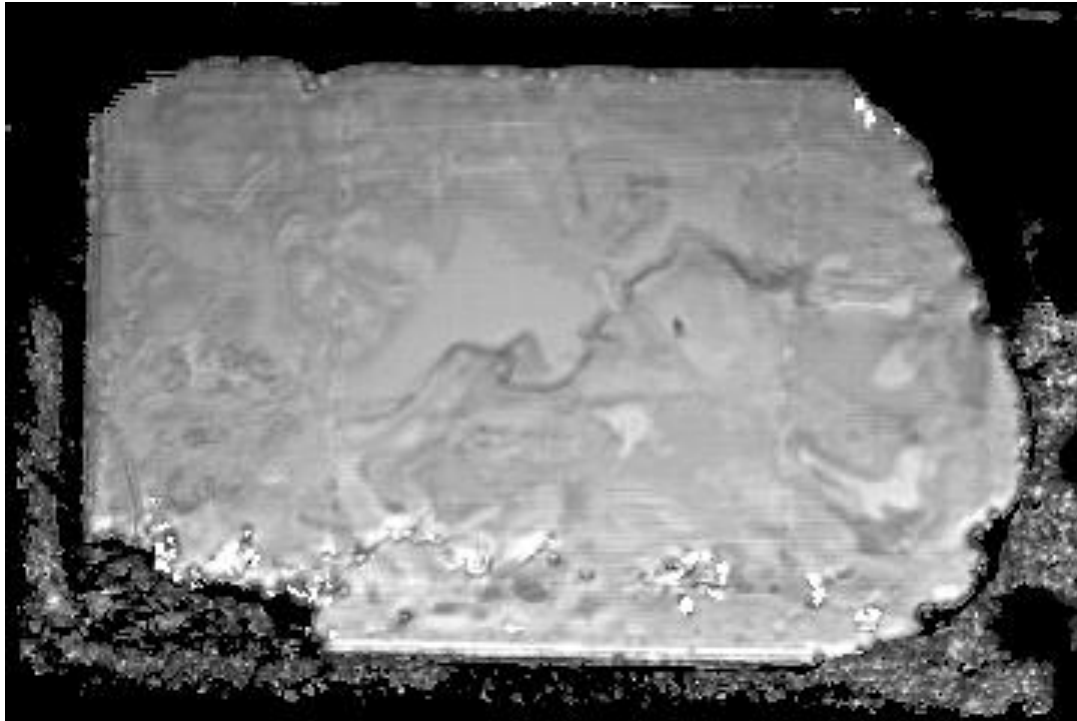


All images are essentially the same, and spaced at equal time delay intervals

- Likely echoes of the first image
- Cannot image below the 1st interface below the surface



Larger View of the First Subsurface Interface



- Odd pattern – suggests deformation of material between the chips
- Deformation would lend the chip integrity to be suspect