CASE STUDY: Analysis of Ohmic Leakage

Background:

One device was submitted for analysis with approx. 2K leakage between pins VDD and ADIO.

Equipment Used:

Probe station configured with FA Instruments diagnostic system including:
Crystal Vision® 2 emission microscope with extended range NIR sensor with parametric controller and integrated cooling (-40C), nanostep motors and drivers for X, Y, and Z axis.
FA Instruments Microscope with Mitutoyo NIR objectives.
SIFT® laser scan with 780nm and 1480nm lasers up to 200mW.
FMI with dual UV sources and thermal controller for liquid crystal.

Analysis:

The parts were first curve traced using the FA Instruments Parametric interface to verify the reported leakage. Photo 1 shows the IV characteristics up to 3 volts with AD18 swept positive wrt. Vdd3.3 at gnd. Photo 2 shows the IV characteristics up to 3 volts with VDD3.3 swept positive wrt. AD18 at gnd. A gradual increase in leakage was observed for increasing bias with minimal difference observed between curves. Temperature stability was measured using the thermal controller in conjunction with the parametric controller. Resistance was measured at 25.000C and again at 35.000C to determine the suitability for thermal laser induced stimulus methods such as SIFT. At 0.183 volts the current was measured at 84.65 uA for 25C and changed to 86.2uA at 35C. The defect calculates for a negative temperature coefficient of 3.89 ohms/C. Instability (1/f noise) was observed to be proportional to bias voltage.

CCD Photon Emission Topside: No emission detected at room temp. Heating the substrate to 150C provided weak emission results, but clearly CCD is not the best choice for ohmic failures. The linear nature of the leakage suggests thermal rather than recombinant radiation. The 1/f noise suggests possible emission but may be blocked by multiple layers.

InGaAs Photon Emission Topside: Weak emission detected at room temp. Heating the substrate with our thermal controller enhanced the emission results as shown in photo 3.

Photon Emission Backside: No sample provided, however this sample can be prepared for backside analysis.

Moiré Thermal Backside: No sample provided, however this sample can be prepared for backside analysis.

SIFT Backside: No sample provided, however this sample can be prepared for backside analysis.

Stabilized FMI: A thin film of EUTTA in plastic was spun onto the part in under 1 minute and imaged for FMI using the solid state near UVsource at 385nm. The built in parametric controller was used to control biasing for the signal collection with the device. Acquisition time to begin to see the signal build during the process was 10 seconds. Total signal build time was approx. 2 minutes to noise average the signal using our proprietary stabilize process. The thermal spot builds before your eyes and the gain can be adjusted on the fly. The parametric controller displays the power consumed and resistance measured in conjunction with the process to protect the device under test as shown in photo 4 along with the full die view data. The FMI data was impacted by the polarity of the bias as shown in photo 5. The left FMI image is with AD18 biased positive wrt. Vdd. Right image is reversed polarity. Note the position of the hot spot has moved down in the right image. Forward biasing may be accompanying the leakage in photo 5 left. The 1/f noise does not impact FMI but will impact SIFT at higher bias voltages. Photo 5 right and photo 6 clearly show the location of the failure.

Stabilized LWIR Thermography: The FMI film was removed with an acetone rinse and imaged with a Stirling cycle cooled MgCdTe camera and Ge macro lens. The camera is interfaced to run with the emission software for image subtraction in stabilized mode. This technique is comparable to FMI in sensitivity but lacks the spatial resolution of FMI. IR thermography is especially useful for topographic features such as MEMS or stacked die analysis. The dangers and hassles of filling liquid nitrogen dewars are eliminated with the stirling cycle cooler. Photo 7 is a long wave IR thermal image of the die on the left and zoom view on the right of the ohmic short. This mode of imaging also allows the thermal spot to build before your eyes with the ability to adjust the gain on the fly.

SIFT: The part is first imaged to find a reference corner with the 1480nm laser. A 1320nm can also be used, if desired. The origin is set and the area of the scan defined as start and end points. Step size is specified thus defining the size of the resulting bitmap and the channels are selected. In this case, the photo detector for the background image and the SIFT amp for the signal. Unlike TIVA, XIVA style systems which steer the beam inside the objective, this system provides precise coordinates for the location of the beam for each data point steering either the microscope or stage with a precision nanostep control. Think of SIFT more like the way an AFM scanner works. Scan area is virtually unlimited so a 20x NIR objective can cover a 40mm square die! Having precise control of laser position allows navigation and control not possible in other beam based systems. Photo 8 is a full die scan of the 11.7999mm by 11.9461mm die with a thermal response shown in the lower left corner. Photo 9 is the signal portion only. The 1/f noise associated with the defect is apparent and is reduced by lowering the bias voltage. The circuit pattern begins to appear near the defect due to the difference absorption of the laser over different materials affecting the temperature local to the defect. The scan is repeated as shown in photo 10 for the lower left corner only. The location of the spot is apparent. Finally, the scan is reduced by simply entering new coordinates for start and finish, since the origin is still established for doing another scan. Using the reference origin as the edge of the die scribe, the defect is located at x=973.3um y=450.8um as seen in photos 11 and 12. For deprocessing, you will be able to drive to these coordinates in the SEM for imaging. Photos 11 and 12 all contain the same data represented with different user selectable color schemes.

Conclusion

This part has a thermally unstable ohmic short which was clearly identified using FMI, SIFT, Liquid Crystal, and Thermal IR methods. The short appears to be subsurface, near metal 1, based on the spatial resolution of the FMI results.

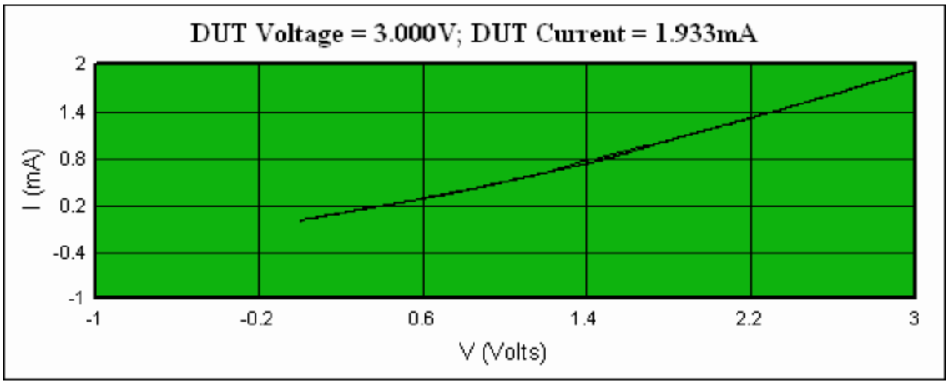


Photo 1. IV curve with AD18 swept positive wrt. Vdd3.3 at gnd.

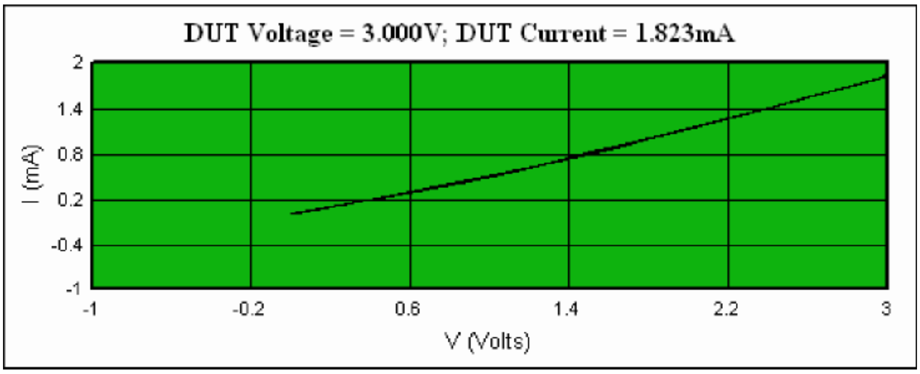


Photo 2. IV curve with Vdd 3.3 swept positive wrt. AD18 at gnd.

Photo 3. InGaAs image of ohmic short. Data obtained is thermal not recombinant.

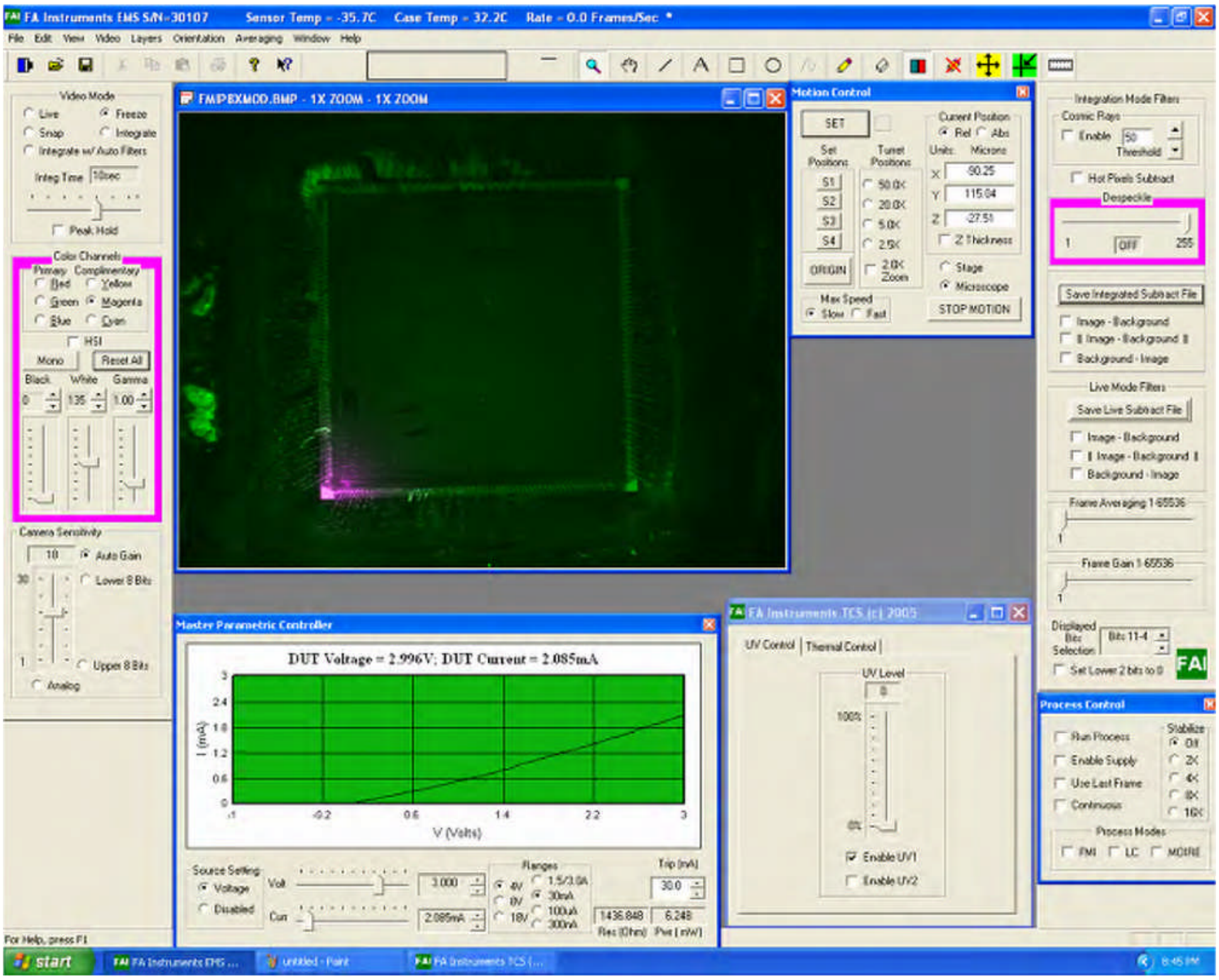
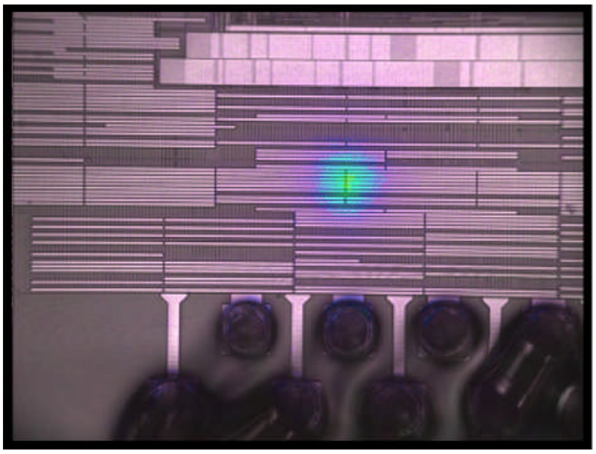


Photo 4. Screen shot in FMI mode with .8x macro view showing location of thermal failure.



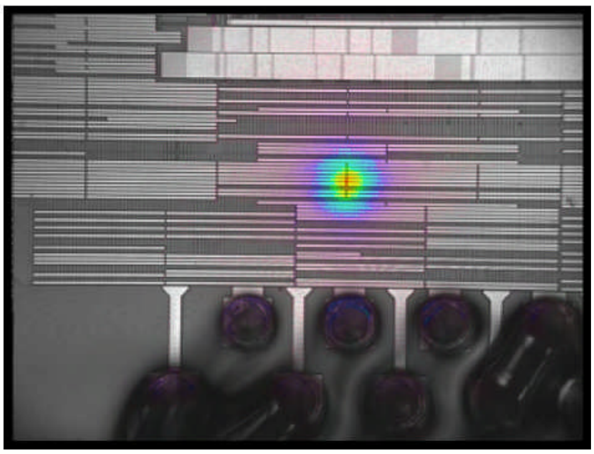


Photo 5. Left FMI image is with AD18 biased positive wrt. Vdd. Right image is reversed polarity. Note the position of the hot spot has moved down.

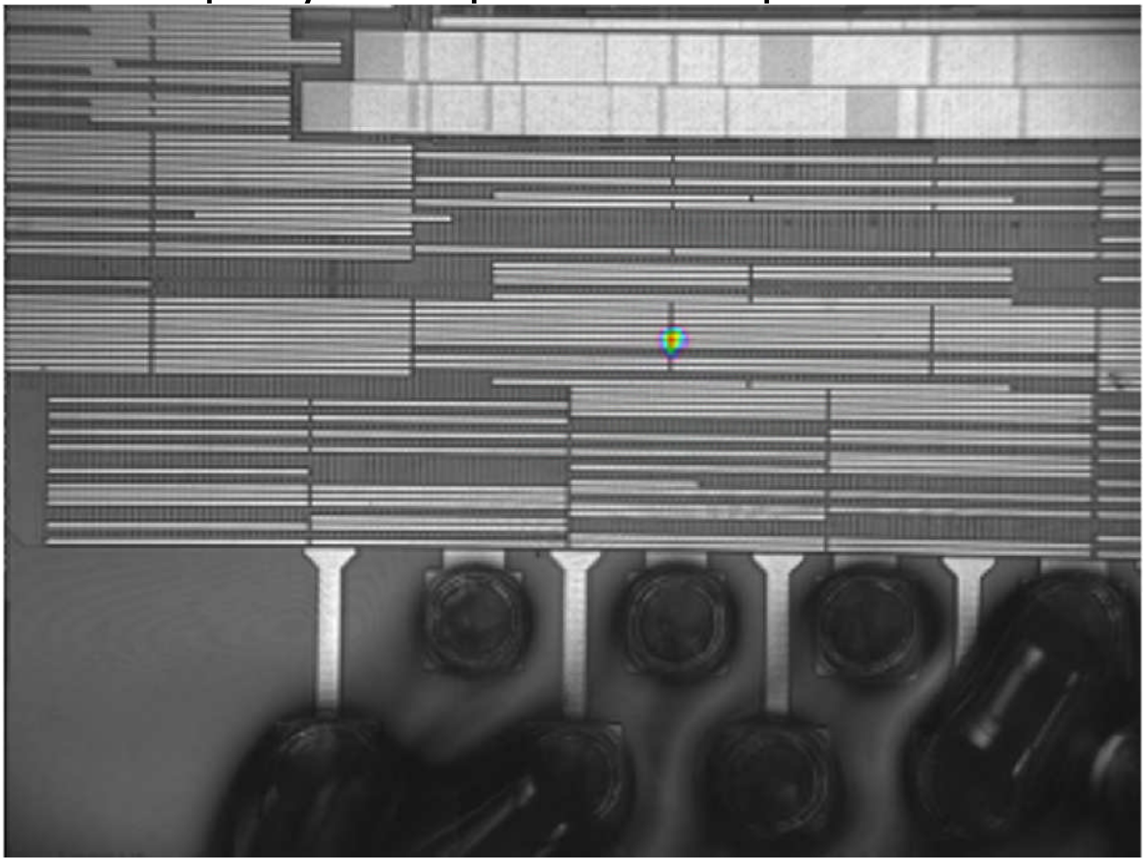
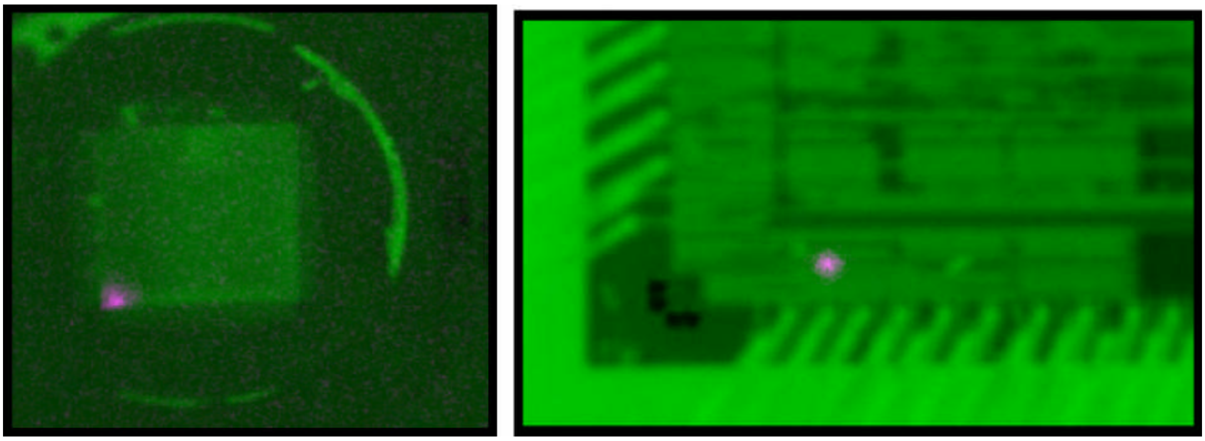


Photo 6. FMI Image at reduced power showing the source of the ohmic short.

Photo 7. Long wave IR thermal image of the die on left and zoom view on right.



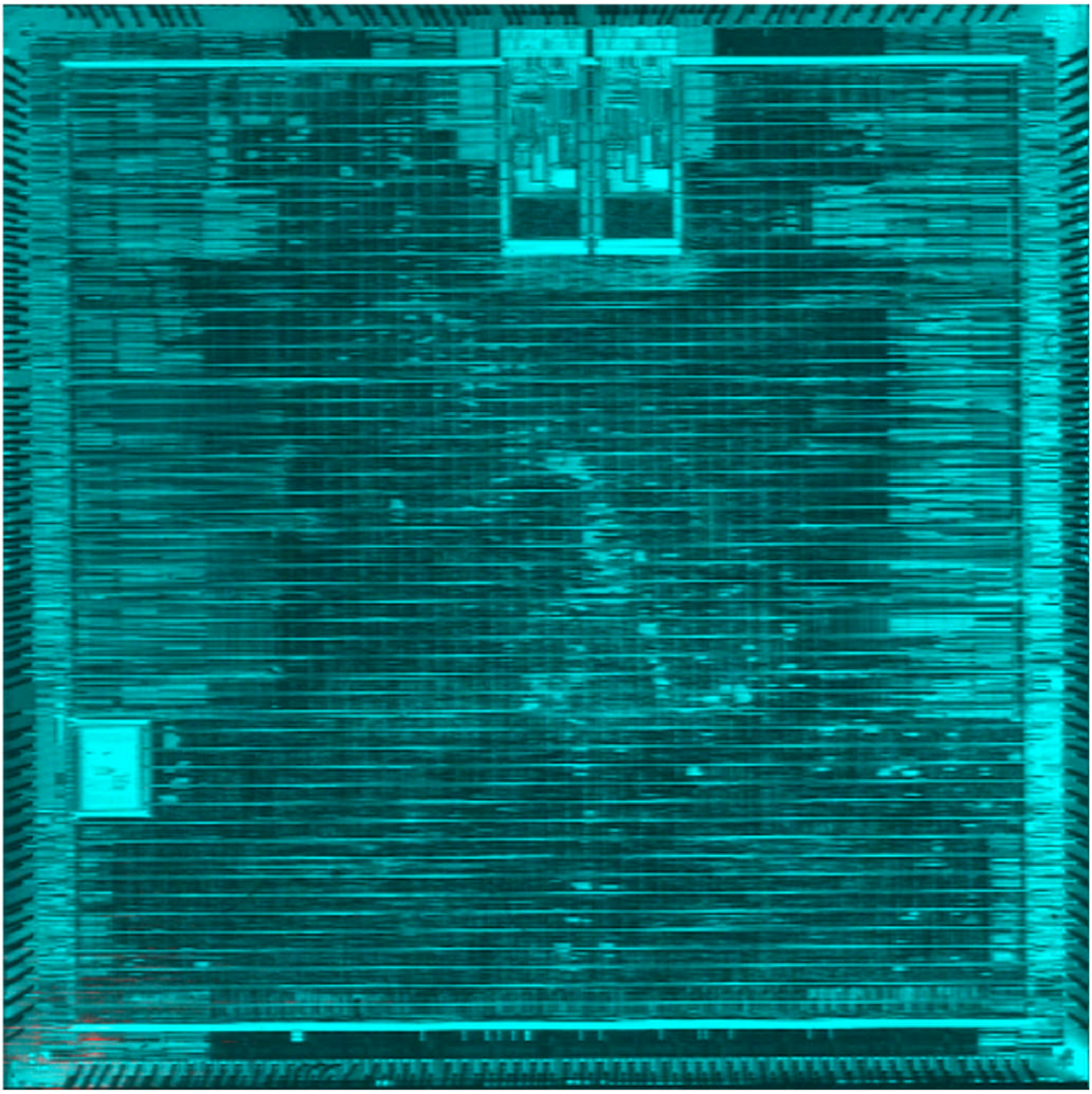


Photo 8. Full die SIFT scan overlay at 1480nm with a 10x NIR objective. Note the signal in red in the lower left.

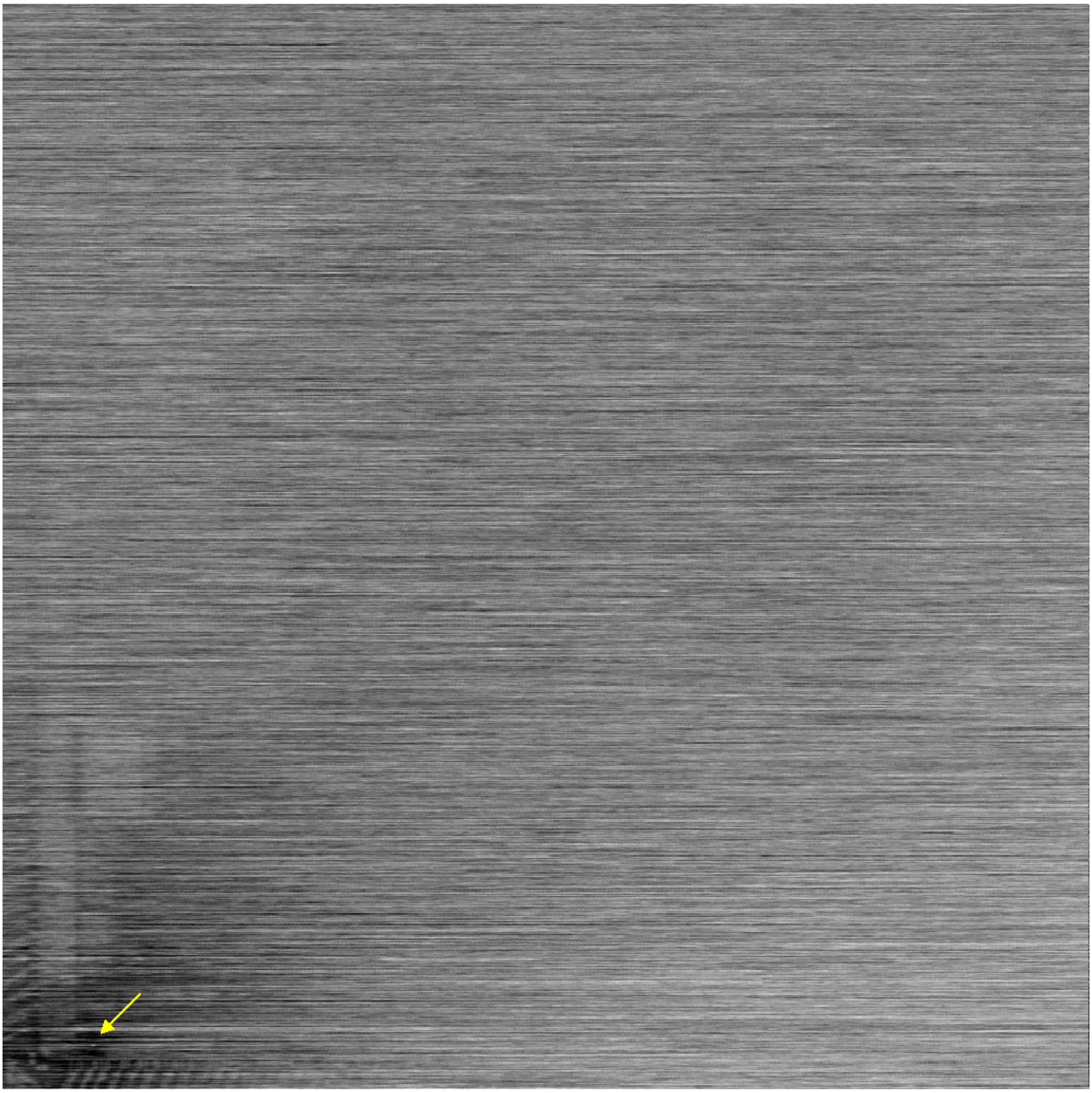


Photo 9. Full die SIFT scan at 1480nm of the signal channel only with the 10x objective. Note the white dot in the signal at lower left.

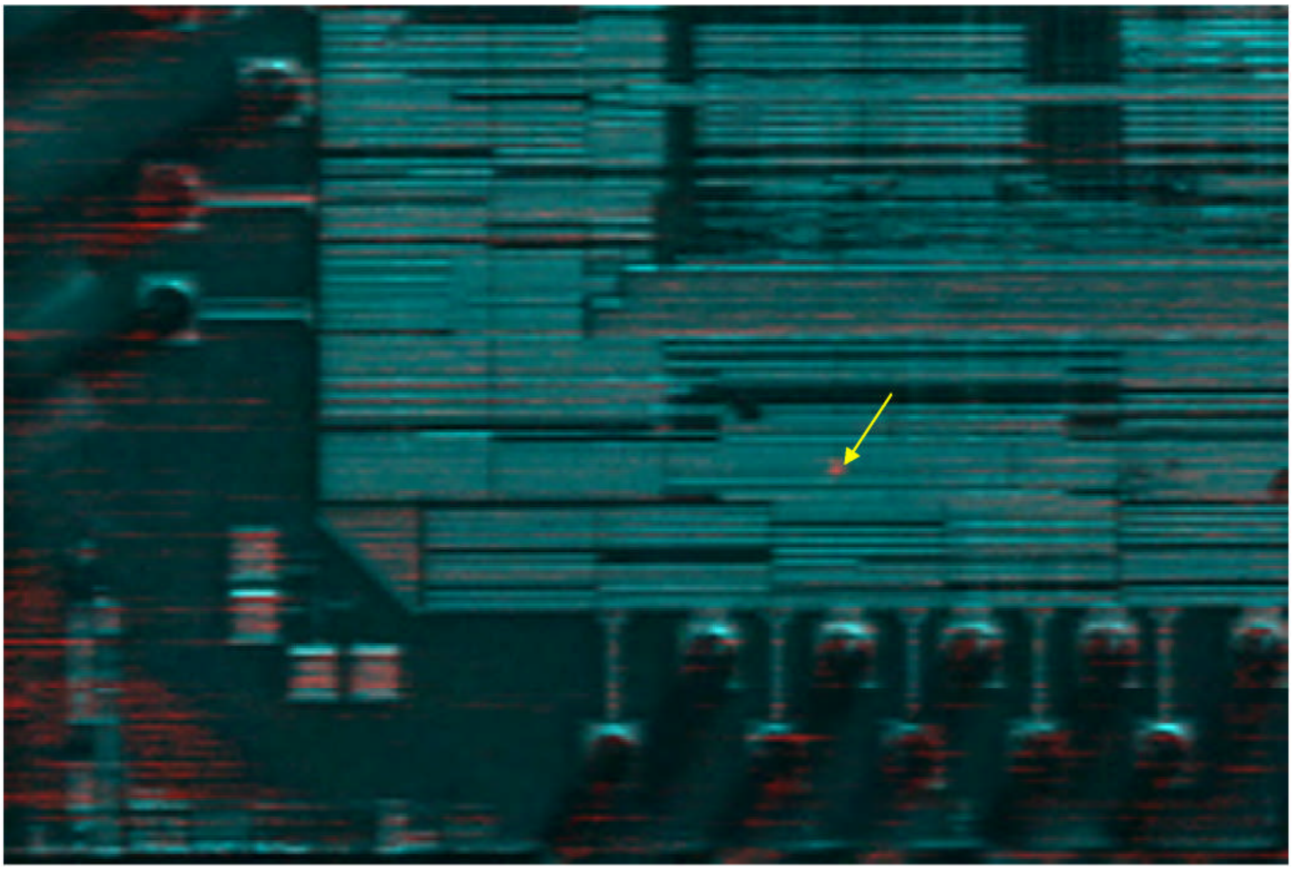


Photo 10. SIFT scan of lower left corner with defect spot identified. 20xNIR objective used.

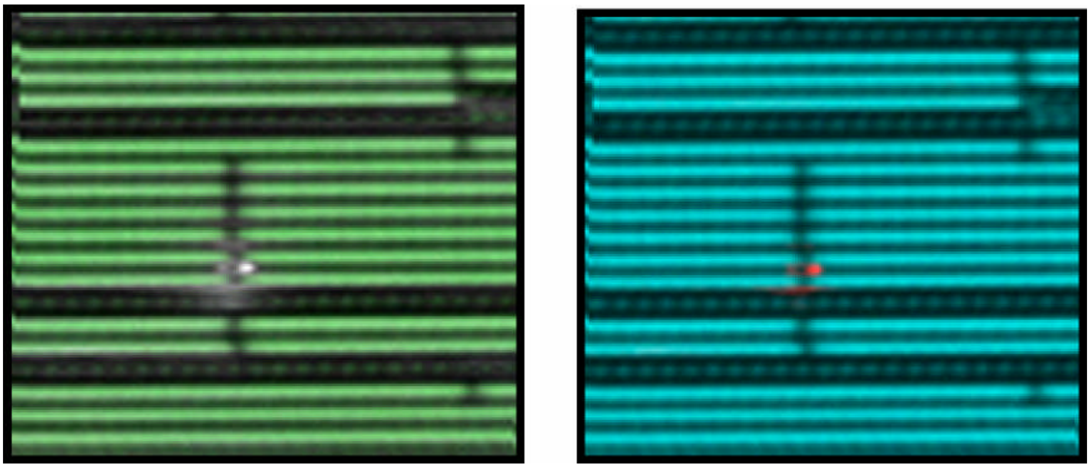


Photo 11. Scan at 1 um with same data shown in 2 different color schemes. 20xNIR objective used.

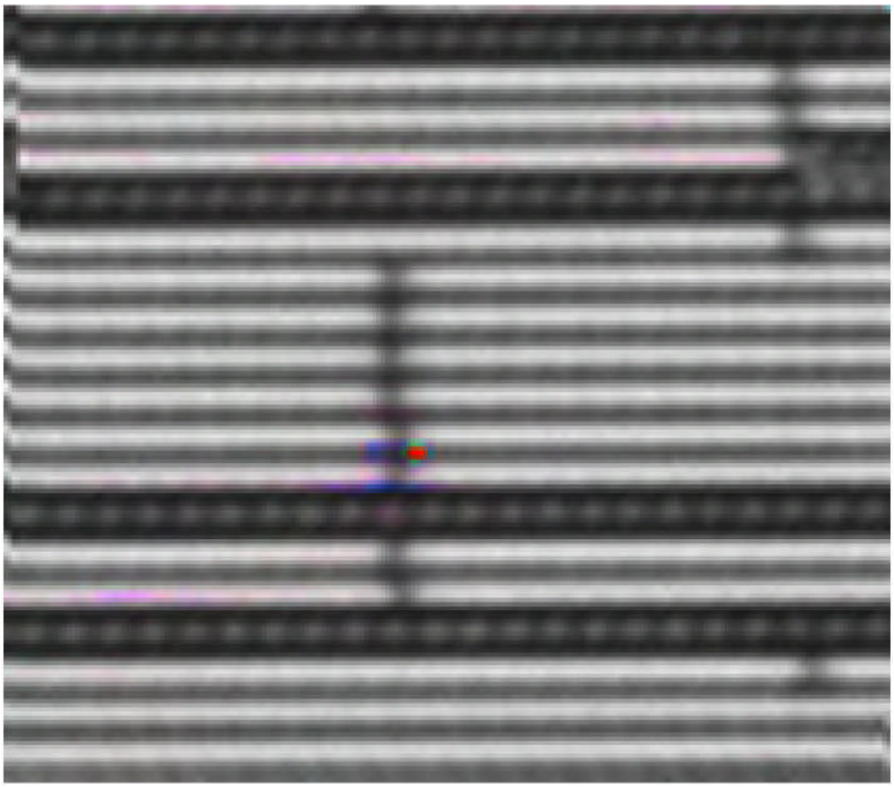


Photo 12. SIFT view shown in HSI color scheme mode. 20xNIR objective used.

We appreciate the opportunity to evaluate your samples on our Crystal Vision® system. Please contact Derek Chau or Jim Colvin at FA Instruments if you have any questions.

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