Federal Bureau of Investigation

Electronic Analysis Report

Cryptologic and Electronic Analysis Unit

Case ID:	NTSB/WPRHMA454avi006	**Item:**	Q1
Mfr/Model:	SanDisk 2GB SD	**S/N:**	
		Date:	12/20/2011

1. INVENTORY OF DEVICES RECEIVED

One SD card. Item Q1 is labeled WPRHMA454avi006 and marked as 2GB in capacity.

2. PHYSICAL CONDITION OF DEVICE

Q1 was non-functional. Q1 shows some physical wear on the outside packaging and mounts as a 30MB device containing all 00’s when plugged into a PC.

3. EXAMINATION EXTENT

The interface to the physical NAND die internal to the SD card was directly accessed in an attempt to recover data since the card was not responsive through the normal SD card interface.

4. TECHNICAL BACKGROUND

Communication between an SD card and PC is carried out by an SD card reader. The health/status of an SD card is often obscured by this channel. By communicating directly with the SD card with a custom SD card reader, information on the card’s controller health, NAND health, and lock status can be read.

Internal to the plastic SD card casing, Q1 is comprised of two stacked die; a controller die and a NAND flash memory die. The 9 large pins visible on the surface of the card communicate with the controller die which in turn communicates with the NAND memory. Also included on the card’s surface is an array of test pads for interfacing directly with the NAND memory. In cases where the controller die or connections to it are damaged, it is sometimes possible to recover data from the NAND memories with these hidden pads.

A tool called a curve tracer is used to diagnose failures on electronic components. A curve tracer ramps voltage on individual pins while observing and safely limiting current. Performing a curve trace assists in determining the health of a device and assessing the potential for remedies.

The final step for evaluating unresponsive NAND flash is performing acid decapsulation to expose the die surface. Once decapsulated, any mechanical damage seen is an immediate indication that the die is unrecoverable. Damage from electrostatic discharge (ESD) or electrical overstress (EOS) may also become apparent under high magnification. If the ESD or EOS resulted in fused metallization, it might be possible to repair the NAND flash by lasing away the short-circuit defect.

5. ANALYSIS RESULTS

Q1 was connected to a custom SD card reader. The SD controller responded and the card reported that was not locked. However, when reading sector data, the card returns all zeros.

The next step in analyzing the card was to connect directly to the NAND flash. The NAND test pads were monitored with a logic analyzer while inserting the card into an SD card reader. The SD controller was observed issuing a reset command to the NAND, to which the NAND flash did not respond. After the reset command, no further communication occurs between the SD controller and NAND (even when the controller is providing sectors with all zeros to the PC).

Following the logic analyzer, a curve tracer was used to evaluate pin characteristics. The curve trace showed no opens or shorts that could be the main failure mode, however, a low resistance between power and ground indicates there is likely a defect.

Q1 was X-Rayed in order to map internal components, and locate damage in the packaging. No obvious damage in the packaging was found.

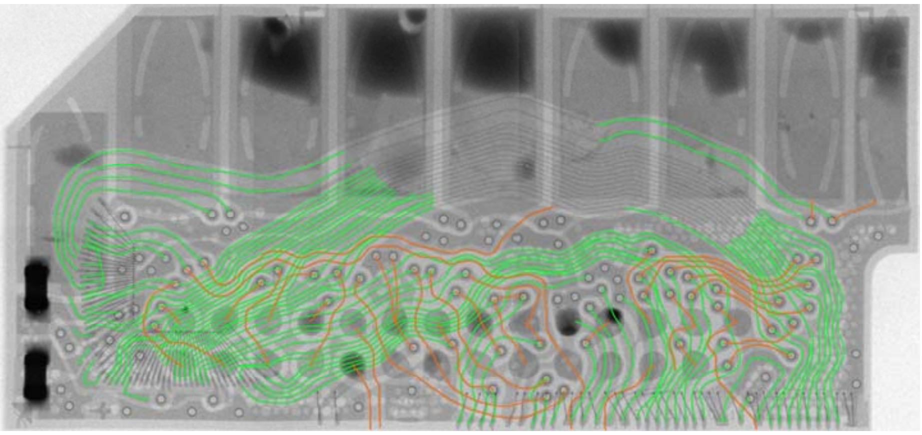

Figure 1: X-Ray Traced Signals

In order to isolate the NAND flash die from the controller the wire bond connections between the two were intentionally severed. A laser decapsulator was used to uncover the connections to the

SD controller, followed by precision cuts with a fine tip probe. A follow-up curve trace indicated that all test pad connections to the NAND flash were intact. A custom memory reader was then used to query the NAND flash for an ID. As before, the NAND flash was unresponsive.

Typically the last step in evaluating a NAND flash is to perform acid decapsulation to expose and evaluate the die surface for repair. For this particular NAND, wirebonds to the NAND were oriented such that an intermediate step could be taken to polish the package down to the die backside and wirebonds. Then, wirebonding to existing wirebonds and curve tracing could completely rule out package-level damage as the source of failure. However, severe cracks in the silicon backside of the flash memory NAND were found during polishing, making recovery of data unfeasible.

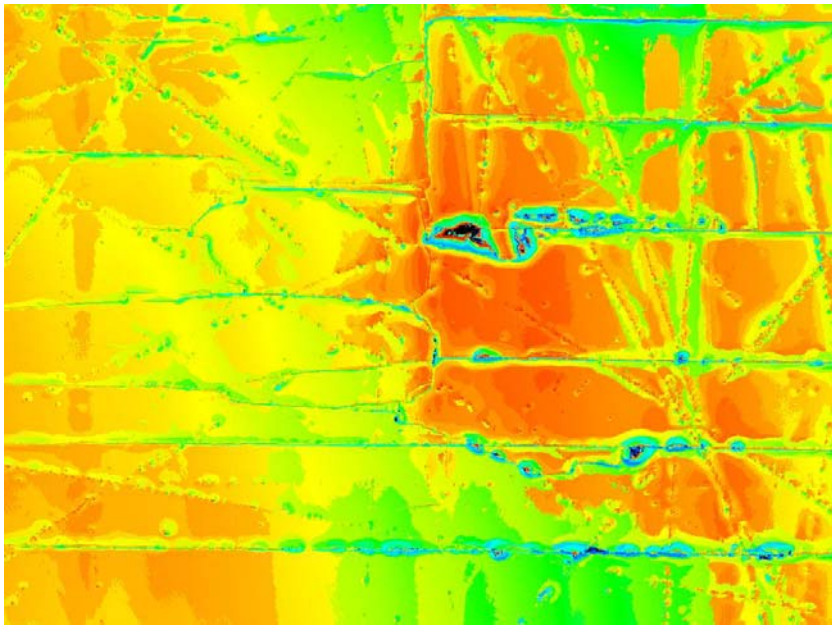

Figure 2: Height Map of the Die Backside Cracks

6. CONCLUSIONS

Cracks were found on the NAND flash die. These cracks make recovery of data unfeasible.