

Take your package-level failure analysis to the next level: quantum diamond microscopy

In package-level failure analysis (FA), a common first step is to perform lock-in thermography on both sides of the package to identify hotspots. However, the increasing complexity of modern packages makes the interpretation of results far less straightforward. Today's devices integrate multiple redistribution layers, dense solder ball arrays, and complex interconnect structures, where a thermal or optical hotspot does not necessarily correspond to a single failure site or even a single layer. Crosstalk between stacked dies, buried defects, and indirect failure signatures often obscure the true root cause. As a result, conventional backside and frontside imaging must now be complemented by novel techniques to navigate the multi-layered landscape of package backside analysis. Quantum diamond microscopy (QDM) is an emerging technique that can address this type of FA application.

Case Study: InFO_PoP backside imaging

In this application note, we showcase QDM measurements of the backsides of two commercial Integrated Fan Out Package-on-Package (InFO-PoP) samples taken from iPhones. InFO-PoP is TSMC's leading advanced packaging platform for high-performance and light applications such as System-on-Chip (SoC) packages, combining logic and memory in a compact footprint, frequently utilized in smartphones such as the iPhone.

This work is a collaboration between QuantumDiamonds and Integrated Service Technology (iST), where iST prepared the samples for the FA scenario and conducted preliminary electrical testing, Lock-in Thermography (LIT), and CT X-Ray scan (find all details in our recent publication). QuantumDiamonds has conducted all the QDM measurements and comparative data analysis. The measurements were done on the prototype of QuantumDiamonds' flagship product, the QDm.1.

Experimental setup: A12 iPhone packages

Three A12 InFO-PoP devices were prepared for a realistic FA scenario on re-wiring circuit boards.

Samples were named as #1, #2, and #3, and the third device was front-side decapsulated to expose the DRAM. The IV curves have revealed an anomaly for device #1 (see Image 1). This note focuses on the analysis of devices #1 and #2.

Furthermore, LIT on device #1 has revealed a hotspot, with a smaller spotsize at the backside, suggestive of the failure being closer to the backside near an integrated passive device (IPD), (see Image 2).

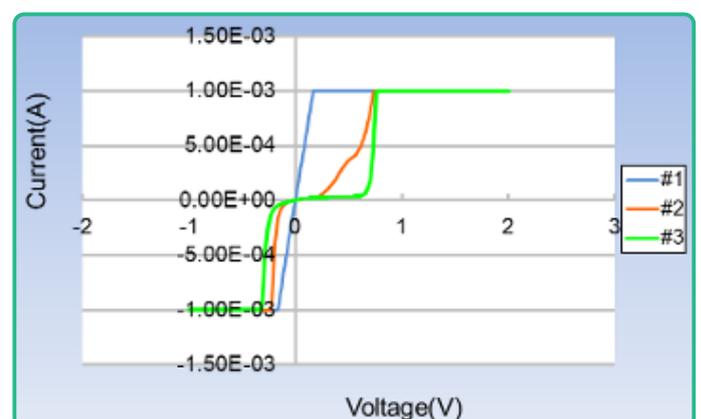
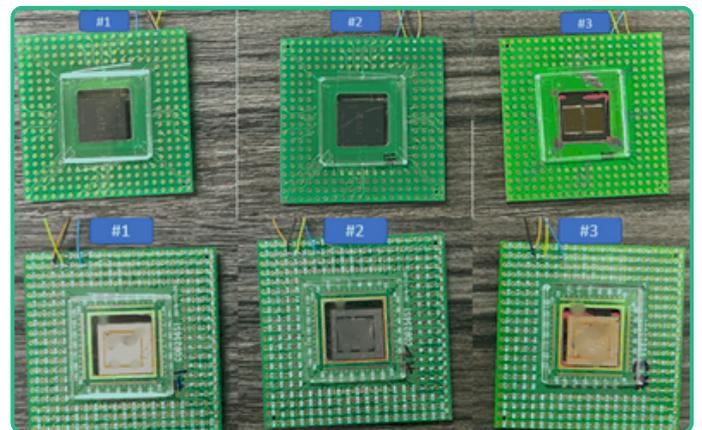


Image 1: Top) Macro image of prepared samples for the FA test. **Bottom)** IV curves from 3 samples. Linear IV anomaly observed for #1, suggestive of a short-failure. Both images courtesy of iST.

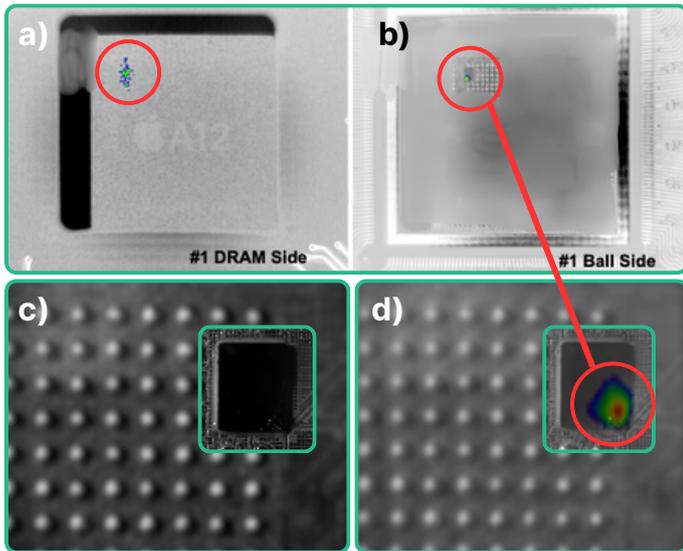


Image 2: a, b) LIT data of device #1, front and backside, courtesy of iST. c) FoV image from QDM. d) LIT backside data overlaid on QDM FoV taken through the diamond sensor.

Both devices were measured with the QDM for 10 minutes. For comparable results, the field of views (FoVs) were taken to be the same for both devices. A second set of measurements was done, introducing a 200 μm artificial distance by placing a thin glass slide between the sensor and the backside to demonstrate performance at a distance. Image 3 shows the diamond sensor placement on the region of interest for each sample with the glass slide.



Image 3: Samples with +200 μm loaded into the QDM with the diamond sensor (red) and microwave antenna visible. Glass slider visible below the diamond. **Left)** Device #1, **Right)** Device #2. Both devices have been biased in the same configuration (same pin, same current value), and the 3D magnetic field within the FoV has been measured.

Results

One magnetic field component (B_z) from QDM can be seen in Image 4. Here, the color white corresponds to the wire that carries current and leads up to the hotspot,

whereas red and blue correspond to the positive and negative magnetic field values around the wire due to the current flow.

Good (#2)

Failed (#1)

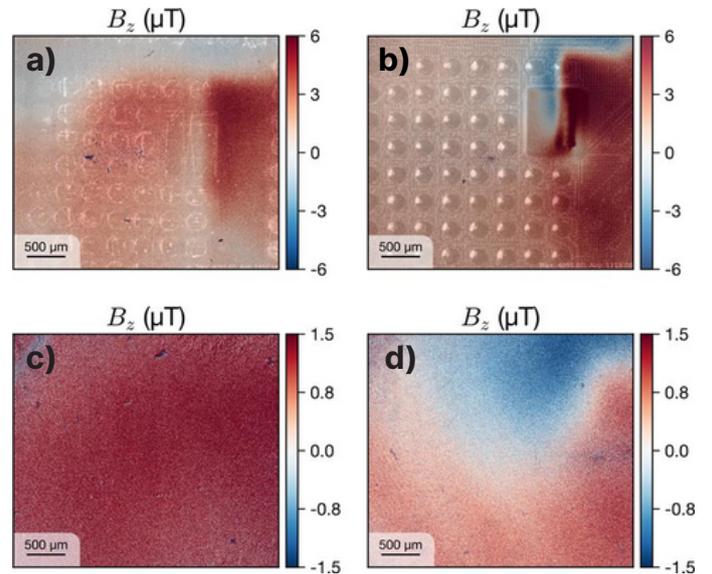


Image 4: a, b) One of the 3 magnetic field components, B_z , for device #2 and #1 respectively. b) overlaid with the LIT hotspot. c, d) Same measurement spots at a 200 μm additional distance (no overlay). Data still clearly shows the fingerprint for the failed device.

The magnetic field leading to the hotspot location suggests a short-type failure that is at the end of the metal trace (seen from the disappearance of the 2nd trace visible in (a), due to a lower resistance path). Visualizing current-carrying wires, not only for the backside use-cases but many more, is a valuable addition to the FA engineer's tool-kit, accelerating time-to-results and boosting success rate.

Conclusion

As demonstrated in this Application Note, QuantumDiamonds' QDm.1 is a strong tool for non-destructive failure analysis workflows. Utilizing the QDm.1, together with other generic technologies, allows users to take layout-informed decisions for their analysis, accelerating time-to-results and boosting success rate. Want to learn more about this use case? Visit our website and check out our latest publication which includes the physical analysis.

Interested in learning more?

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