QDm.1

Quantum Diamond Microscope

QuantumDiamonds QDm.1 is a non destructive, magnetic imaging Failure Analysis system using novel quantum sensing technology.

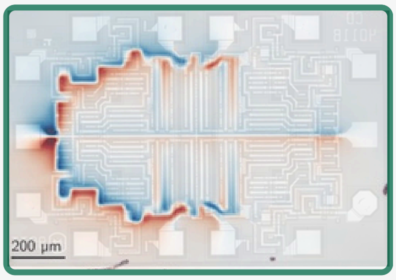
QDm.1 enables accurate fault localization in xy and z for advanced 3DIC packaging, Memory and wide bandgap materials.

The QDm.1

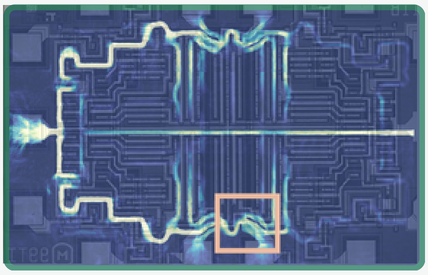
The QDm.1 is a high-resolution magnetic imaging system that visualizes current flow in semiconductor devices by detecting the magnetic fields generated by electrical currents. Using quantum defects in patented diamond sensor technology, QuantumDiamonds tool provides non-destructive imaging of current pathways with exceptional spatial resolution and sensitivity.

Example: Electrical activity image from the backside

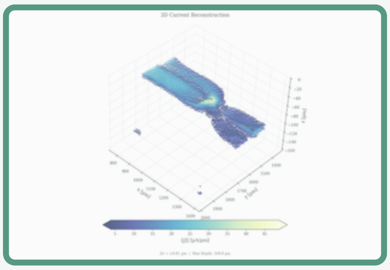
Raw magnetic field data and overlay of the extracted current density on the IR image of a discrete device.



Raw magnetic field



Current flow reconstruction



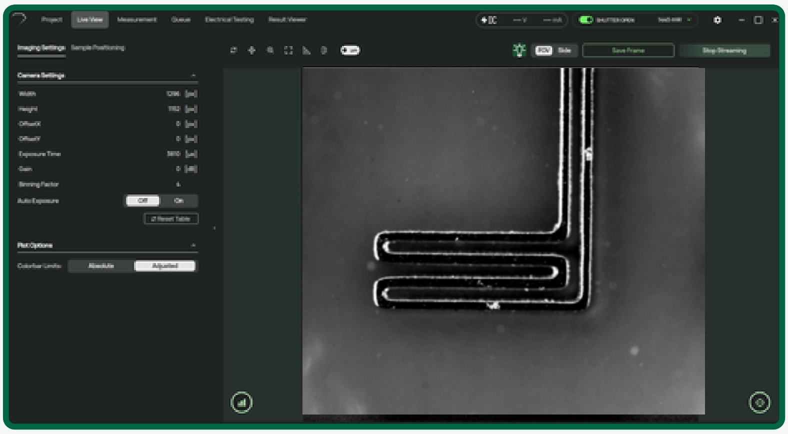
3D current reconstruction

Specifications

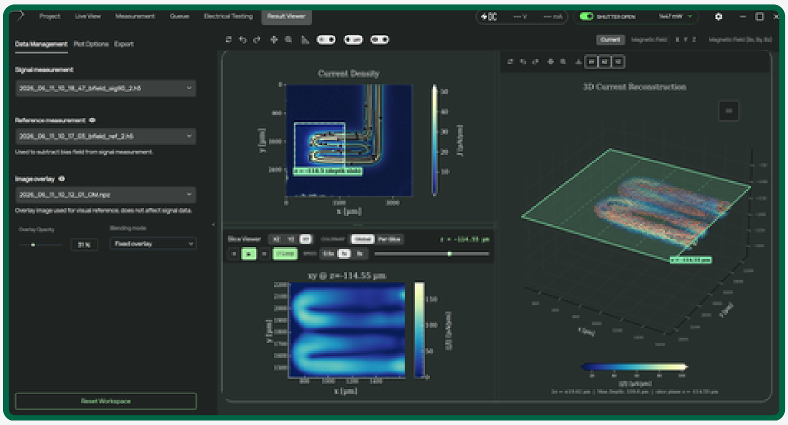
Lateral resolution (xy)	Down to 1.4 μm
Depth accuracy (z)	~5% distance to sensor (± 5 μm E.R. at 100 μm distance)
Wide Field of view	10 mm x 10 mm, automatic stitching up to 5 cm x 5 cm
Noise floor	235 nT
Defect types	Package and die: shorts (including >1 ohms), leakages, opens
Scalar Magnetic Sensitivity	<10 μT/√Hz for <1.4 μm resolution
Typical measurement time	2 minutes (upto 30 mins depending on enhanced settings)
Size and weight	2.3 m x 1.5 m x 2.1 m I 750 kg e-cabinet, 600 kg main device

Requirements

Voltage / Power	230 V (single phase) / 16 A
Mechanical stability	No additional requirements
Operating Temperature	15 - 40 °C
Environment	normal FA lab ambient conditions (no special requirements)

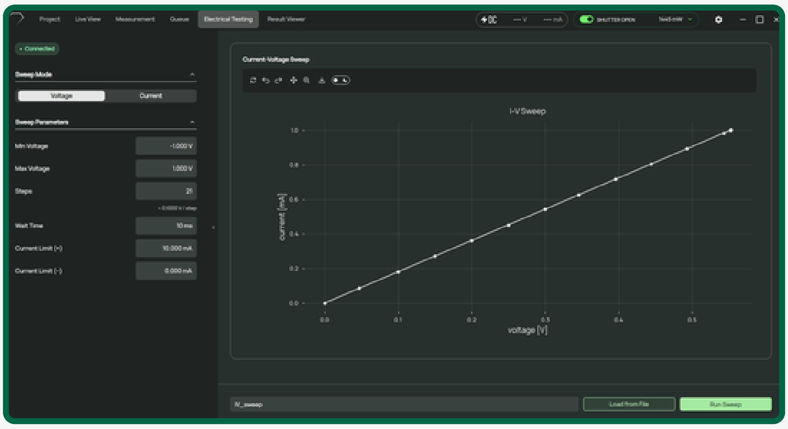


Intuitive UI design



Results viewer of the 3D current reconstruction feature and coordinates

Measurements tab



In-app curve tracer

Intuitive UI/UX Design

The QD software is designed with the failure analysis engineer in mind, offering an intuitive interface that makes data acquisition and interpretation straightforward. Clear visualization tools and guided workflows simplify complex tasks, while advanced features remain available for expert users who require deeper customization and analysis flexibility. This balance ensures both ease of use for routine investigations and powerful capabilities for demanding analysis challenges.

Software Main Features

- Magnetic field analysis, 2D current reconstruction with streamlines, 3D current reconstruction with depth analysis, and exact coordinates
- Interactive magnetic field and current data
- 3D model slice viewer for current
- HTML exports of 3D current reconstruction
- Automated stitching of large areas
- Multiple post-processing options
- Diverse data export options to cross-correlate with other techniques
- Overlay functionality and super-imposed images (e.g. optical, infrared, design file)
- Additional super-user features

Automatic calibration

The software includes an auto configuration option that optimizes the measurement system for your specific sample. The process automatically determines the optimal measurement parameters to be used during QDM testing.

In-app curve tracer

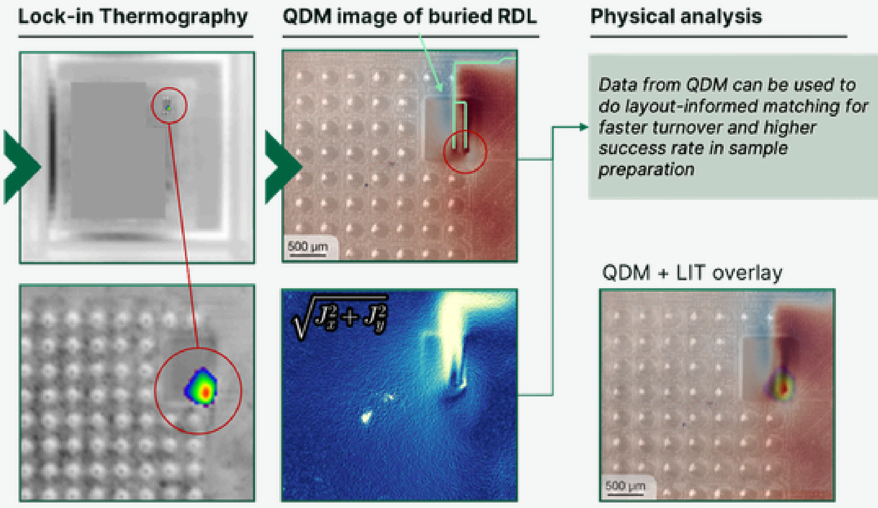
The software is equipped with an in-app curve tracer to aid in electrical verification and characterization directly within the QDM system.

Example use-cases

Visualize underlying electrical activity for shorted defects

Once an IV test reveals anomaly at a pin, generic imaging techniques such as LIT can be used to obtain hotspots. The QD tool complements these techniques by revealing electrical activity around the area and give layer information by analyzing the signal or matching the layout.

This worfklow is especially valuable for package-level non-destructive analysis before proceeding to sample preparation for root cause.



LIT hotspot suggestive of a short beneath IPD

QDM images of buried RDL in Magnetic Field and Current

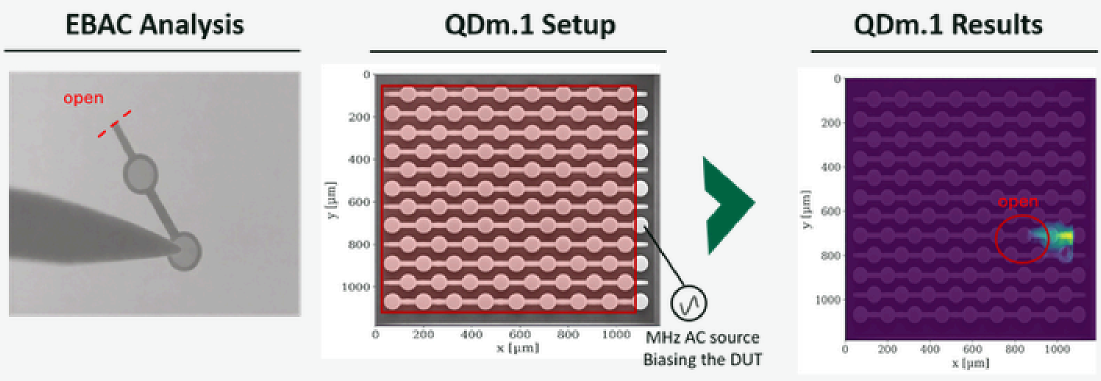
QDM + LIT overlay showing suspect metal line for target cut

Localize opens

QDM allows localization of open failures through AC quantum sensing.

In this mode, a MHz/GHz frequency AC signal is applied to the device. At an open site, discontinuity effectively acts as an antenna, which pinpoints the defect location in an intuitive image, either as a gap or an “end-point”. QDM can pin-point opens both through two-point and one-point contact.

The EBAC successfully identified the open defect, however, it requires a tedious workflow and physical analysis. In contrast, QDM can be performed under ambient conditions and generally does not require extensive and destructive sample preparation. This nondestructive capability preserves the DUT integrity, reducing overall analysis complexity and accelerating cycle time.



SEM-based EBAC was performed on TSV chain structure

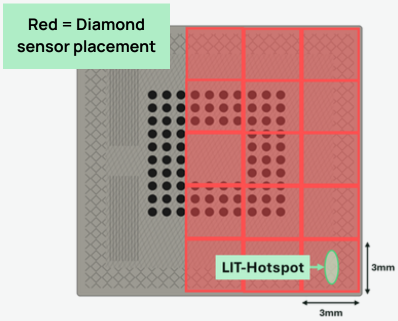
Diamond was placed over the TSV layer.

QDm.1 fluorescence map overlaid with TSV chain optical image.

Determine where in the stack a fault is

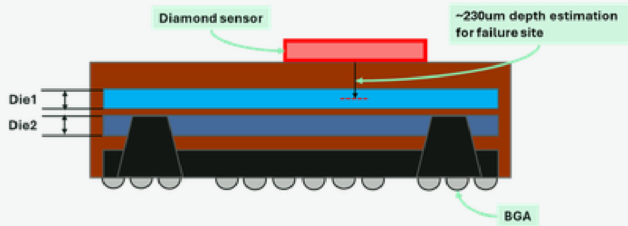
QDM localized a low-ohmic short in full 3D on a fully intact, packaged BGA device — no decapsulation or backside prep required. LIT first flagged a thermal hotspot but could only resolve its X-Y position, leaving the depth within the stacked-die assembly unknown. QDM imaging (3×3 mm field of view, 15 spots stitched to 9×15 mm) confirmed the same lateral position independently via magnetic field mapping. Critically, 3D current reconstruction from that same field data then pinpointed the fault depth at ~230 μm below the surface, corresponding to Die 1 in the stack — delivering the full X, Y, Z localization that surface-biased techniques alone cannot provide.

QDM set-up



Diamond placement during QDM test covering most of the sample package including the LIT hotspot location

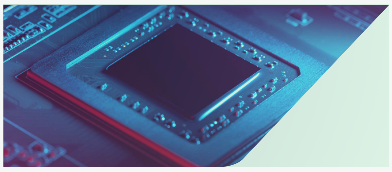
QDM results



The package cross-section showing that the QDM's estimated failure depth of 230um corresponds to the position of Die 1

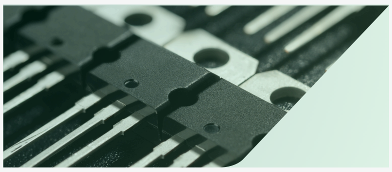
Applications

The QDm.1 can address a variety of technologies such as: conventional packaging, advanced packaging, wide bandgap materials, and HBMs. It can perform advanced imaging and diagnostics for ohmic and low-ohmic shorts, leakage pathways, open circuits, bond wire failures, and interconnect reliability issues.



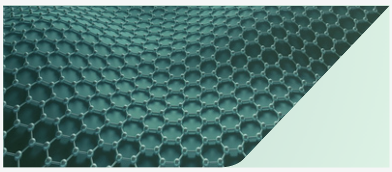
Advanced Packaging & HBM

Advanced packaging solutions such as 2.5/3D integration and chiplets, are becoming essential. However, they complicate access and introduce new failure modes including interconnect verticals. There is a need for novel and robust testing platforms.



Wide Band-Gap Materials (GaN, SiC)

Wide band-gap materials are being adopted more and more for high-power and frequency applications. These materials, as well as their potential combination with Silicon, introduces new and complex failures that require novel analysis methods.



Material Science

Characterisation of promising new materials for the semiconductor industry, such as graphene or transition metal dichalcogenides, require a new approach. Quantum materials require quantum solutions.

Interested in learning more?

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