Semiconductor Solutions

ThermoFisher
SCIENTIFIC

About Thermo Fisher Scientific

With approximately 70,000 employees, Thermo Fisher is unmatched in its global commercial reach. Our continued innovation is the key to our technology leadership. We are advancing materials characterization and in situ studies. Our technology depth is reflected in our deep applications expertise and our analytical technologies that provide new workflows and innovations.

For semiconductor manufacturers and the electronics industry, we combine our electrical analysis solutions with SEMs, TEMs, DualBeam FIB/SEMs and advanced software suites to deliver root cause analysis with the highest success rate and productivity. Our industry-leading workflows deliver fast, accurate answers for accelerating IC design and production decisions. Our fault isolation and analysis products provide superior images, rich feature sets, cross-sectional metrology and automation to speed process defect identification, enable root-cause analysis, reduce yield loss and accelerate time-to-market for new products. Our expertise, market leadership and continued R&D commitment are paving the way to innovations in 3D gates and memory, transisitor design and advanced material integration.

Thermo Fisher Scientific supplies innovative solutions for electron microscopy and microanalysis to take customers from questions to usable data by combining high-resolution imaging with physical, elemental, chemical and electrical analysis across scales and modes— through the broadest sample types.

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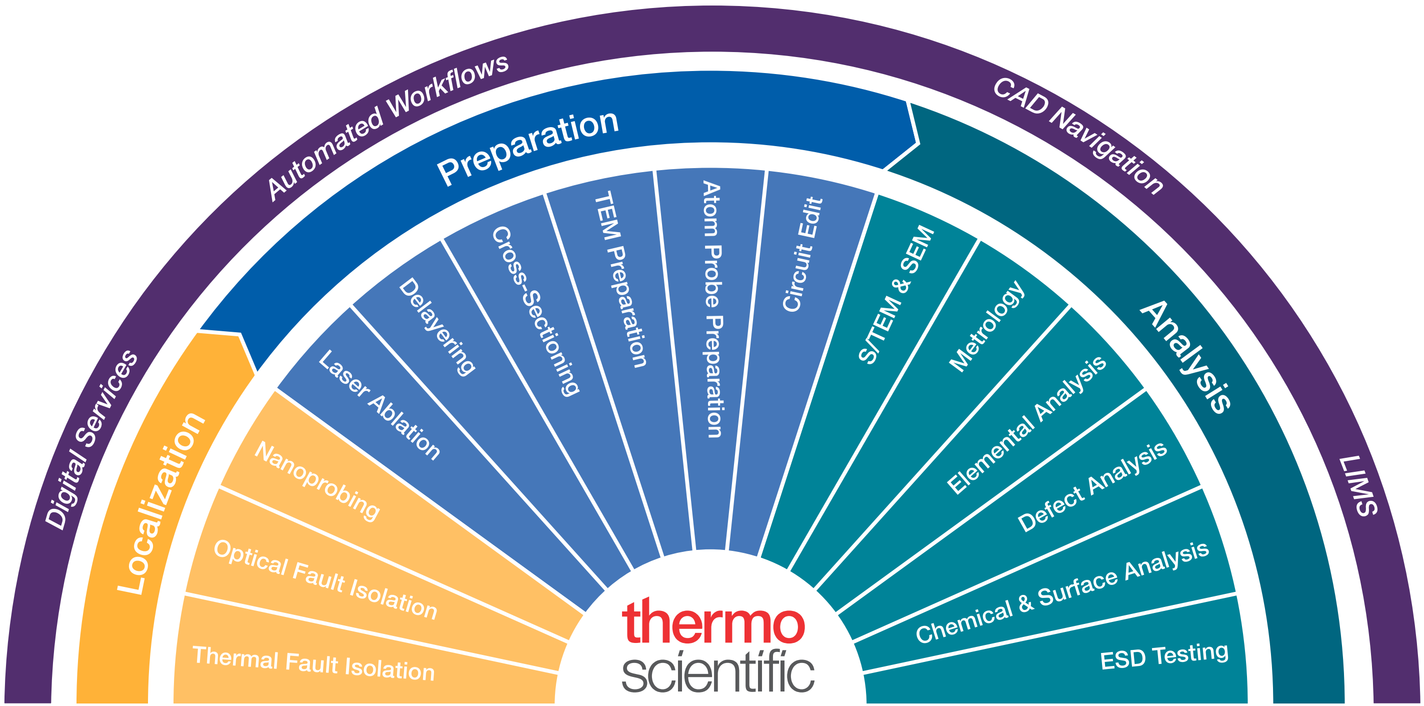


Accelerating research and development • Solving complex analytical challenges • Increasing lab productivity and yield

Localization

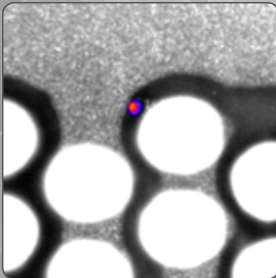
Shrinking technology, new materials, and increasingly complex structures are driving defectivity, especially when the circuit design is sensitive to process variation. These non-visual defects reveal themselves as electrical faults that downgrade device performance, threaten reliability, and destroy yield. Additionally, high-density interconnects, wafer-level stacking, flexible electronics, and integral substrates mean that failure-inducing defects have more places to hide, making characterization more difficult, and more critical, than ever. Our electrical analysis tools clearly identify these subtle electrical issues, significantly augmenting QC and QA oversight.

Localization

Electrical Analysis

Thermo Scientific™ ELITE™ System

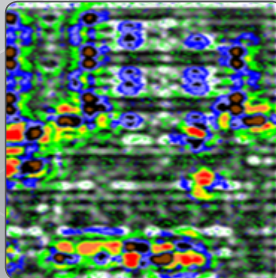
Heat-based, non-destructive electrical fault localization at the die, package or board level



- Fast detection
- Precise localization
- 3D packaging solutions
- Thermal diagnostics

Thermo Scientific™ Meridian™ System

Electrical fault localization and circuit timing analysis at the die or wafer level, based on emission or laser stimulation



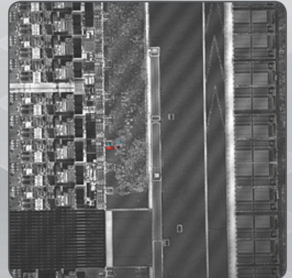
Dynamic analysis and laser voltage imaging/probing

- Sub-cell localization
- Low duty cycle LVP
- Higher SNR
- New applications

NEW!

Thermo Scientific™ Meridian™ S System

Localization of electrical faults in semiconductor devices, identification of electrical shorts, areas of leakage and device activity via non-destructive analysis



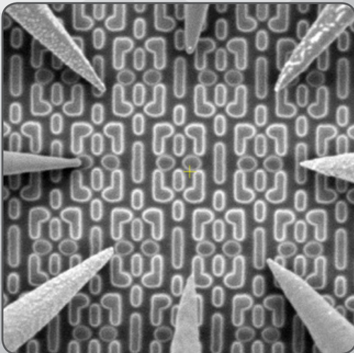
New high-sensitivity OBIRCH detects hard electrical faults

Localization

Electrical Analysis

Thermo Scientific™ nProber™ III and flexProber™ Systems

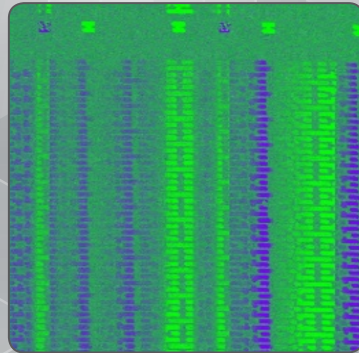
SEM-based nanoprobers for localization and characterization of electrical faults in transistors and interconnects



Low kV SEM and stable probing platform for advanced logic and memory devices

Thermo Scientific™ Hyperion™ II System

AFM-based nanoprober for localization and characterization of electrical faults in transistors and interconnects



- Fast transistor probing
- 7nm capable
- Conductive AFM and topographic AFM

Preparation

Advanced physical and electrical analysis is required, across a broad range of device types and technology nodes, for yield management and process control. Precise, high-quality, efficient sample preparation is a vital part of any analysis workflow and in most cases, the quality of the data depends on the quality of the sample preparation. Thermo Fisher Scientific provides industry standard sample preparation solutions based on its advanced focused ion beam (FIB) and beam chemistry techniques. These solutions are most commonly used for creating SEM cross-sections, TEM analysis, transistor nanoprobing and atom probe tomography preparation.

Preparation

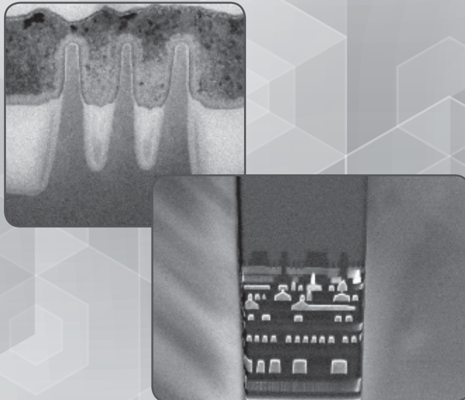
Physical Analysis *(SEM, STEM, FIB Sample Prep)*

Thermo Scientific™ Helios™ 5 FX DualBeam System

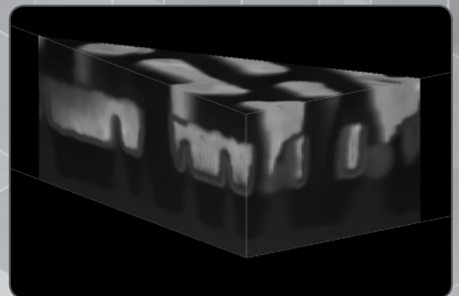
Highest resolution (3A) *in situ* STEM and lowest damage Ga FIB enables root cause analysis within one instrument

Thermo Scientific™ Helios™ 5 UX and HX DualBeam Systems

Combined XHR SEM + Low kV FIB milling supports advanced cross section and TEM sample preparation workflows



Top: High resolution STEM image of a 14nm device cut in across the fins of the device
Bottom: Low kV SEM image of the end of a TEM lamella



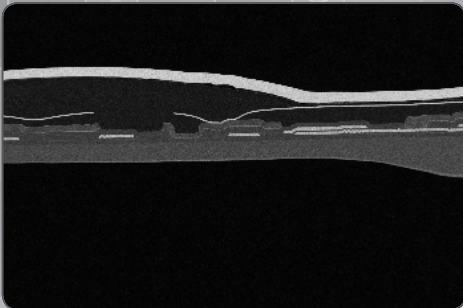
Visualization of a 3D volume of a 22nm Device created using Thermo Scientific Avizo™ Software

Preparation

Physical Analysis *(SEM, STEM, FIB Sample Prep)*

Thermo Scientific™ Scios™ 2 DualBeam

Entry level DualBeam™ system offering high contrast, flexible imaging and analytical capability for failure analysis of larger devices

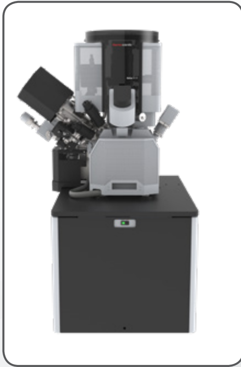


Backscattered electron image of an OLED in cross section

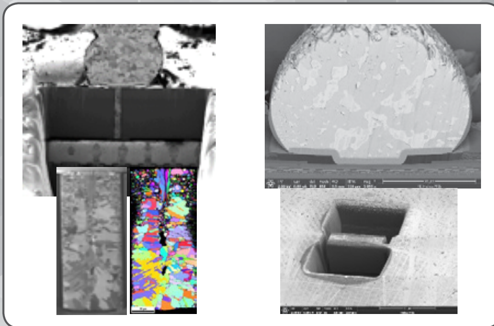
Preparation

Physical Analysis *(Large Area FIB Processing)*

Thermo Scientific™ Helios™ G4 PFIB CXe DualBeam



SEM: Elstar UC+ (0.7nm @1keV resolution)
FIB: PFIB2.0 Xe+ ion, 1pA-2.5uA
110 mm stage
Large Area PFA and Materials Analysis



General purpose, large area sample prep and analysis EDS/EBS imaging of 3D and advanced packaging technologies

Preparation

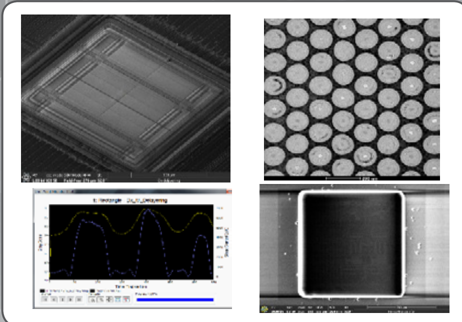
Physical Analysis *(Large Area FIB Processing)*

Thermo Scientific™ Helios™ G4 PFIB HXe DualBeam

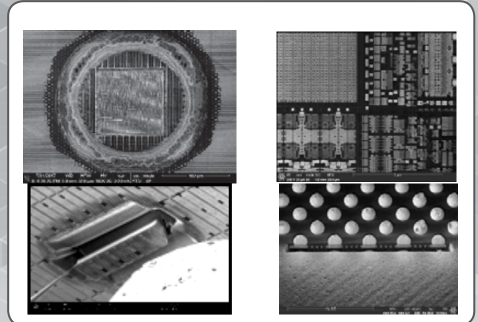
SEM: Elstar UC+ (0.7nm @1keV resolution)
FIB: PFIB2.0 Xe+ ion, 1pA-2.5uA
4” UHR stage
Automated delayering and
large area TEM preparation

Thermo Scientific™ Helios™ G4 PFIB UXe DualBeam

SEM: Elstar UC+ (0.7nm @1keV resolution)
FIB: PFIB2.0 Xe+ plasma, 1pA-2.5uA
6” Piezo stage
Comprehensive delayering and
large area PFA



Advanced Logic and 3D NAND deprocessing and silicon trenching for nanoprobing or electrical failure analysis



Thick Cu deprocessing, delayering, high speed cross section analysis, chunking on advanced node devices and packaging

Preparation

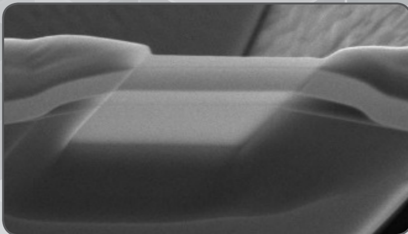
Wafer Yield Control and Metrology

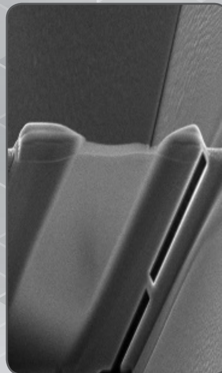
Thermo Scientific™ ExSolve™ 2 Wafer TEM Prep System

Fully automated, high-throughput lamella preparation for advanced logic and 3D NAND metrology

3D NAND

Logic





Left: ROI of 1um x 500nm @ lamella thickness > 15nm with < 5nm cut placement

Right: ROI of 1um x 5um @ 30nm lamella thickness for advanced 3D NAND

Analysis

Analytical solutions are the core of Thermo Fisher Scientific. We serve a broad range of academic, industrial, microelectronics and life science markets with automated, high-productivity, high-performance tools. The semiconductor industry is one of the most demanding of these markets, with a growing need to maximize device performance, device yield, throughput and efficiency. Our analytical tools are the process of record for almost all major manufacturers of logic, memory, display, MEMS, analog and packaged devices. Additionally, they are seen as the reference technology in a wide variety of applications such as:

- Materials analysis
- Device debug
- Yield improvement
- Defect/failure root-cause analysis
- Metrology
- Research and development

Analysis

Physical Analysis *(S/TEM)*

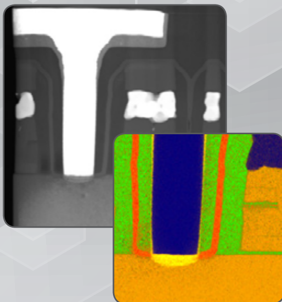
Thermo Scientific™ Talos™ TEM

Ease of use, high-productivity imaging and analysis for general semiconductor FA and production support

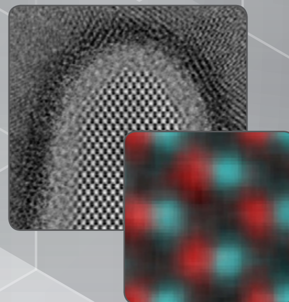
NEW!

Thermo Scientific™ Spectra™ 300 TEM

Ultimate atomic answer for advanced semiconductor analysis and research



Fast imaging and EDS on semiconductor memory devices



Atomic analysis of advanced logic devices

Analysis

Physical Analysis *(S/TEM)*

Thermo Scientific™ Metrios™ DX TEM

TEM for automated and high-throughput metrology

TEM image and EDS metrology

NEW!

Thermo Scientific™ Metrios™ AX TEM

S/TEM for automated and manual work-flows, metrology, and elemental analysis

Automated metrology (top) and automated EDS using Thermo Scientific Dual-X detectors (bottom)

Analysis

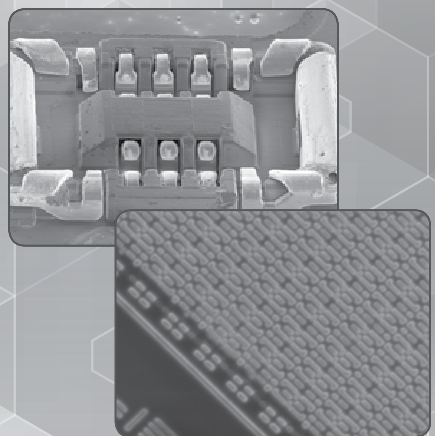
Physical Analysis *(SEM)*

Thermo Scientific™ Verios™ G4 SEM

Extreme high resolution SEM with sub-nanometer performance from 1-30kV

Thermo Scientific™ Apreo™ SEM System

Low voltage images of ceramic battery catalyst and hard drive reader images



Top: Low voltage low magnification images of a component on a PCB

Bottom: 200V image of a deprocessed 14nm device

Analysis

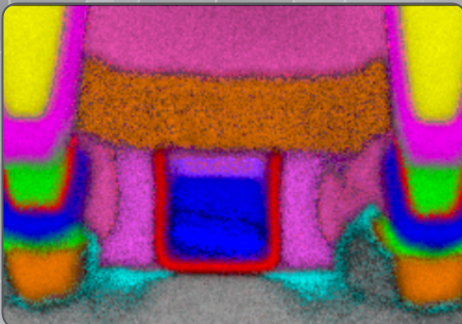
Physical Analysis *(Elemental and Structural Analysis with the Electron Microscope)*

Thermo Scientific™ UltraDry™ EDS X-ray detectors

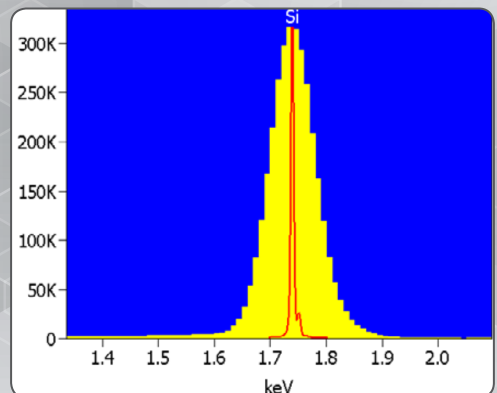
Energy Dispersive X-ray spectrometers for accurate elemental analysis

Thermo Scientific™ Magnaray™ WDS spectrometer

Wavelength Dispersive Spectroscopy (WDS) for the ultimate in energy resolution



EDS elemental analysis of devices using principal component techniques



WDS spectrum of Si overlaid on EDS spectrum of Si.

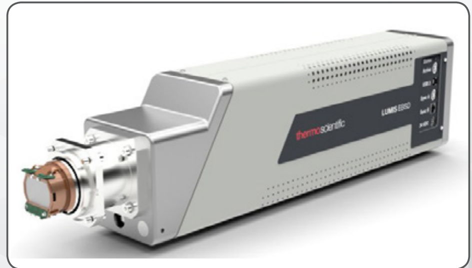
Analysis

Physical Analysis *(Elemental and Structural Analysis with the Electron Microscope)*

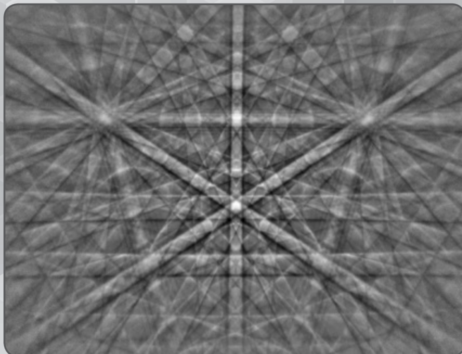
Thermo Scientific™ Quasor™ EBSD Camera

Electron BackScatter Diffraction (EBSD) for microstructural analysis in the SEM

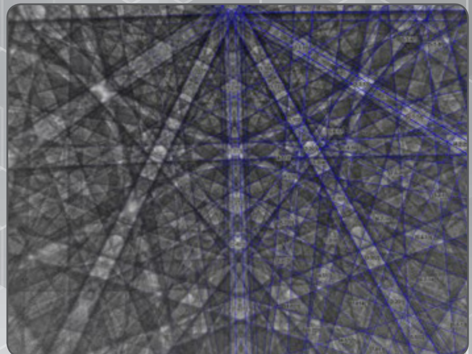
Thermo Scientific™ Lumis™ EBSD Detector



High-sensitivity electron backscatter diffraction (EBSD) for microstructural analysis in the SEM



Diffraction pattern is single crystalline Si



Indexing of GaN electron backscatter pattern

Analysis

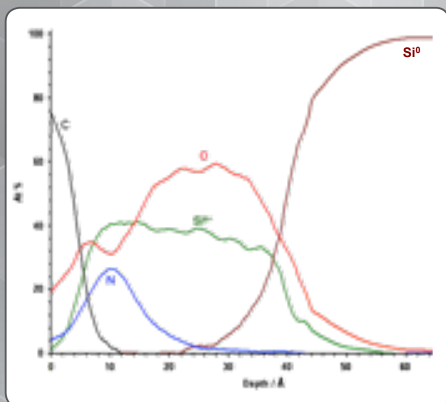
Surface Analysis *(XPS)*

Thermo Scientific™ K-Alpha™ X-ray Photoelectron Spectrometer (XPS) System

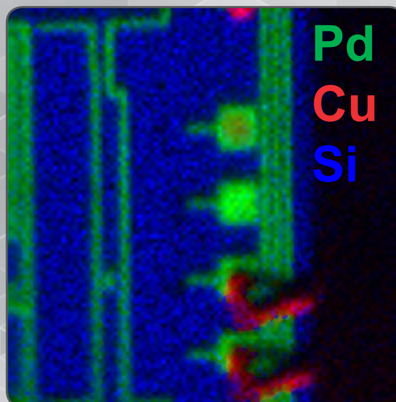
Fully automated XPS system with ion source for depth profiling

Thermo Scientific Nexsa™ X-Ray Photoelectron Spectrometer (XPS) System

Multi-technique surface analysis system with micro-focus X-ray source. Options for cluster ion source, UV-photoelectron spectroscopy (UPS), ISS (LEIS), REELS and Raman



Understanding thin film structure and interface chemistry using the high performance ion source and high sensitivity spectrometer



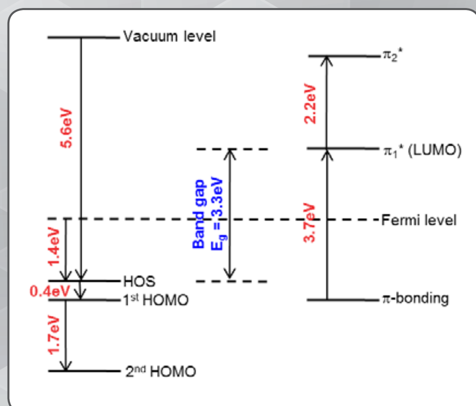
The small spot X-ray source enables identification of pad surface contamination, resist composition, and pad structure through depth profiling

Analysis

Surface Analysis *(XPS)*

Thermo Scientific™ ESCALAB™ Xi+ System

Configurable surface analysis platform with options for UV-PS, Auger spectroscopy, EDS and in vacuum sample preparation



XPS, REELS and UVPS can be used together to understand work function and band gap properties

Analysis

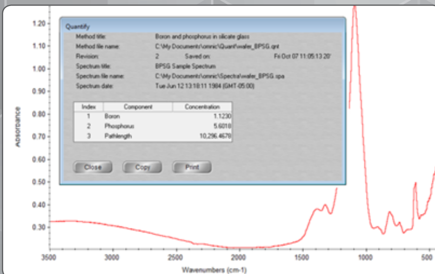
Chemical Analysis *(RAMAN and FTIR)*

Thermo Scientific™ Nicolet™ iS50 FTIR Spectrometer

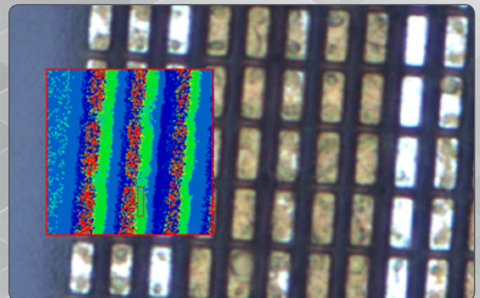
Reliable QC and characterization of Epi, BPSG, C and O in Si wafers
Quantitative analysis of semi-conductor gases

Thermo Scientific™ DXR™ 2xi Raman Imaging Microscope

Rapidly locate and identify organic and inorganic contaminants on circuits, displays, sensors



FTIR spectral analysis of BPSG film



Raman principal component analysis of strained regions in silicon

Analysis

Chemical Analysis *(IC, ICP-MS, GC-MS)*

Thermo Scientific™ Dionex™ ICS 6000+ IC

- QA/QC of UPW and chemicals
- Anions cations contamination analysis

Thermo Scientific™ iCAP™ RQ ICP-MS, iCAP™ TQs ICP-MS

- QA/QC, UPW and semiconductor grade chemicals
- Ultratrace elemental impurities

Thermo Scientific™ ISQ™ GC-MS, Trace 1300 GC

- QA/QC of CR air and gases
- Organic contamination analysis

Thermo Scientific™ Element™ Series High-resolution ICP-MS

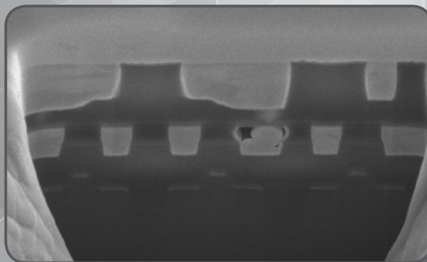
- QA/QC and research
- Interference free ultratrace impurities

Analysis

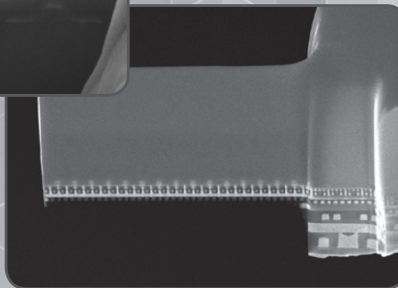
Wafer Yield Control and Metrology

Thermo Scientific™ Helios™ G4 EX/L DualBeam

In-fab, semi-automated defect analysis and metrology tool through Slice and View or advanced TEM lamella preparation



Slice and View



TEM Prep

Navigate to defect via KLARF file from defect review tool:

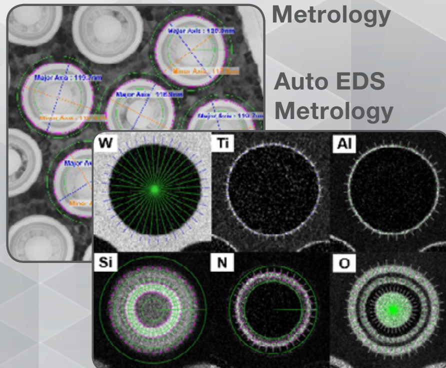
- Slice and View defects for failure analysis
- Automated recipes for TEM sample prep

Analysis

Wafer Yield Control and Metrology

Thermo Scientific™ Metrios™ DX TEM

Fully automated STEM and TEM with automated metrology and analytics

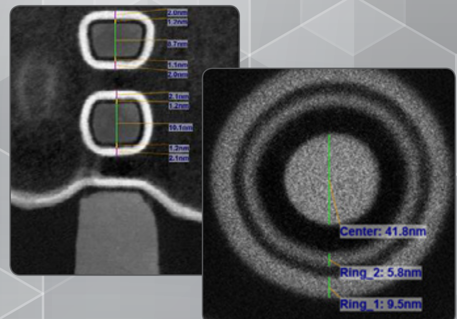


The small spot X-ray source enables identification of pad surface contamination, resist composition, and pad structure through depth profiling

NEW!

Thermo Scientific™ Metrios™ AX TEM

S/TEM for automated and manual work-flows, metrology, and elemental analysis



Automated metrology (top) and automated EDS using Thermo Scientific Dual-X detectors (bottom)

Analysis
ESD Compliance Testing

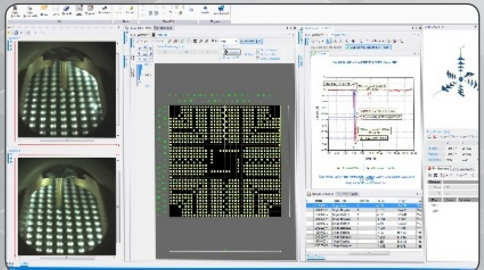
Thermo Scientific™ MK™ Series

Automated ESD testing to industry standards for human body model, machine model and latch-up

Thermo Scientific™ Orion3™ System

Charged device model testing with closed-loop feedback humidity controls for improved accuracy and precision

- Parallel test up to 12 devices
- Reliable relay-based design
- Expandable to 2,304 pins
- Small 0.6 m² footprint



Easy test set-up with Scimitar™ Software and dual high resolution cameras

Analysis

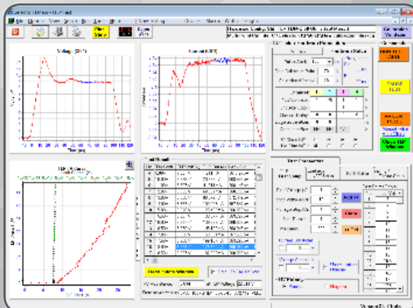
ESD Compliance Testing

Thermo Scientific™ Celestron™ System

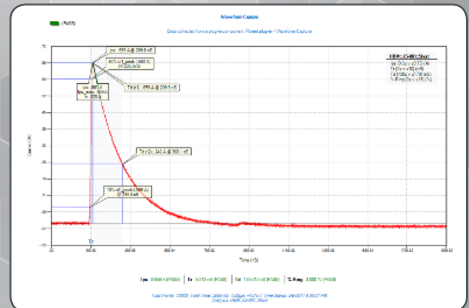
Transmission line pulse to characterize device protection structures and predict failures

Thermo Scientific™ Pegasus™ System

2 Pin ESD and curve tracing for wafers and packaged parts



Intuitive software makes test setup and operation easy with the graphical user interface



Precise 330 ohm waveform delivers results that correlate completely with ESD test standards

Analysis

Temperature Control

(Recirculating Chillers / Heat Exchangers)

Thermo Scientific™ ThermoFlex™ Chillers

- Highly configurable
- -5 to 90° C
- 900 to 24 kW Cooling
- Semi S2 compliant
- Etch
- Deposition

Thermo Scientific™ Merlin™ Chillers

- Flourinert compatible
- -15 to 35° C
- 1.1 to 4.8 kW cooling
- Lithography
- Ion implant

Thermo Scientific™ ThermoChill™ Chillers

- Economical
- -10 to 30° C
- 0.7 to 2 kW cooling
- Lithography
- Ion implant
- Microscopy
- Spectrophotometry

Analysis

Temperature Control

(Recirculating Chillers / Heat Exchangers)

Thermo Scientific™
Heat Exchangers

- Compact
- 5 to 40° C
- 14 to 100 kW cooling
- Microscopy
- Spectrophotometry

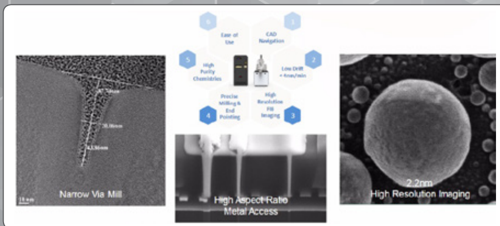
Thermo Scientific™
Custom Designs

- Special requirements
- -90 to 90° C
- Up to 100 kW cooling
- Up to ± 0.001° C stability
- Test

Analysis
Circuit Edit

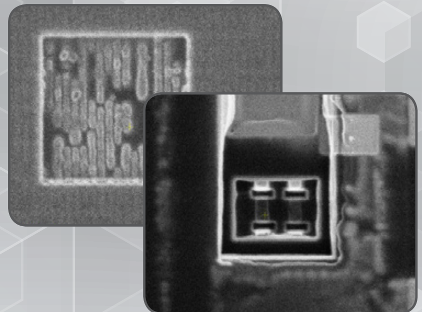
Thermo Scientific™ Taipan™ System

- 7nm Circuit Edit solution
- 2.2nm FIB resolution
- Improved secondary electron detection
- Low drift (<4nm/min)
- High accuracy (laser interferometer) stage



NEW!
Thermo Scientific™ Centrios™ System

- High resolution Tomahawk WDR FIB
- Innovative Dual MultiChem
- Superior contrast with high SNR
- Planar large area delayering
- Circuit Edit solution for 14nm and above design rule devices

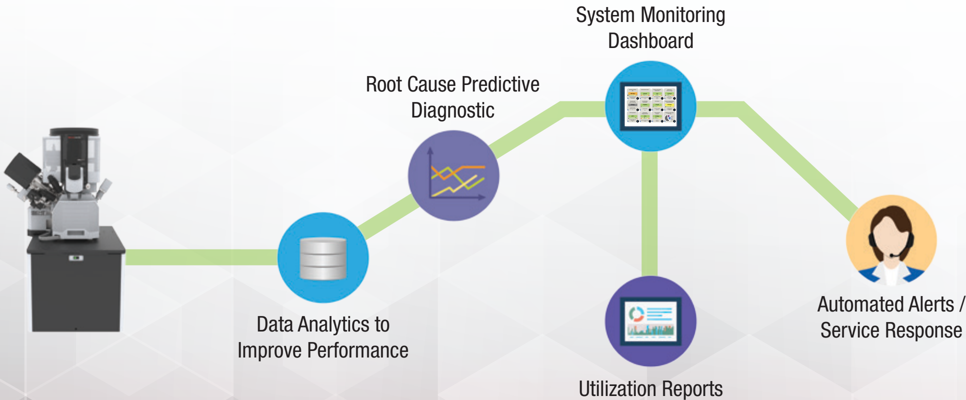


High resolution Tomahawk WDR FIB (top) opens low-level metal layer with precision and control

Dual Multichem design enables (bottom) repeatable, precise and uniform process control

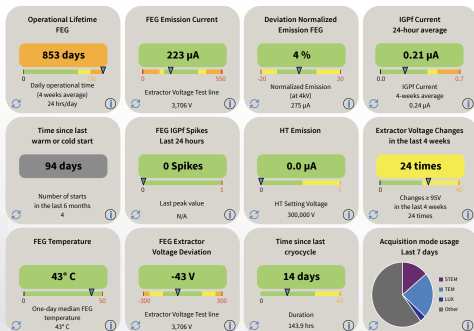
Digital Services

Maximize Productivity and Optimize System Performance



Digital Services

Productivity and System Performance

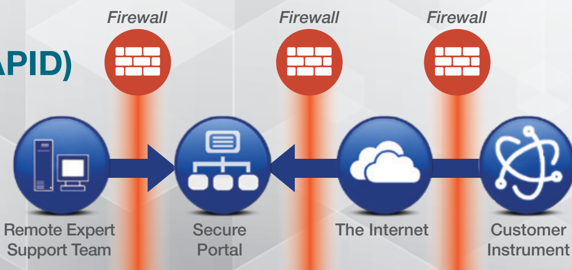


System monitoring

Maximize uptime with our proprietary system-monitoring technology that allows us to observe key system parameters and proactively address service needs.

Remote diagnostics (RAPID)

Increase system performance and utilization by remotely connecting to expert support wherever you are located in the world.



Digital service reporting

Optimize every aspect of your investment by tracking detailed information of your system utilization, service history, operators and other key indicators for your Thermo Scientific fleet.

Digital Services

Advance and Accelerate Key Features

With an **Accelerate** warranty uplift plan, our onsite service response will be twice as fast, and it is backed by an uptime guarantee.

With an **Advance** service plan, we deliver greater visibility, proactive root cause analysis and improved time to resolution, ultimately maximizing productivity.

Our **Uptime Guarantee** gives you the confidence to meet or exceed your system availability demands.

With **Digital Services**, we monitor your system and proactively identify issues to optimize performance.

Maintenance Service issues will be promptly addressed with an remote response capability coupled with an onsite response as needed.

The **Thermo Fisher Scientific Applications Support** team will train your staff on system operation and optimally tune your system to your specific application.

After-Hours Service provides support when you need it, even outside of standard coverage.

Automated Workflows

Near Line Metrology

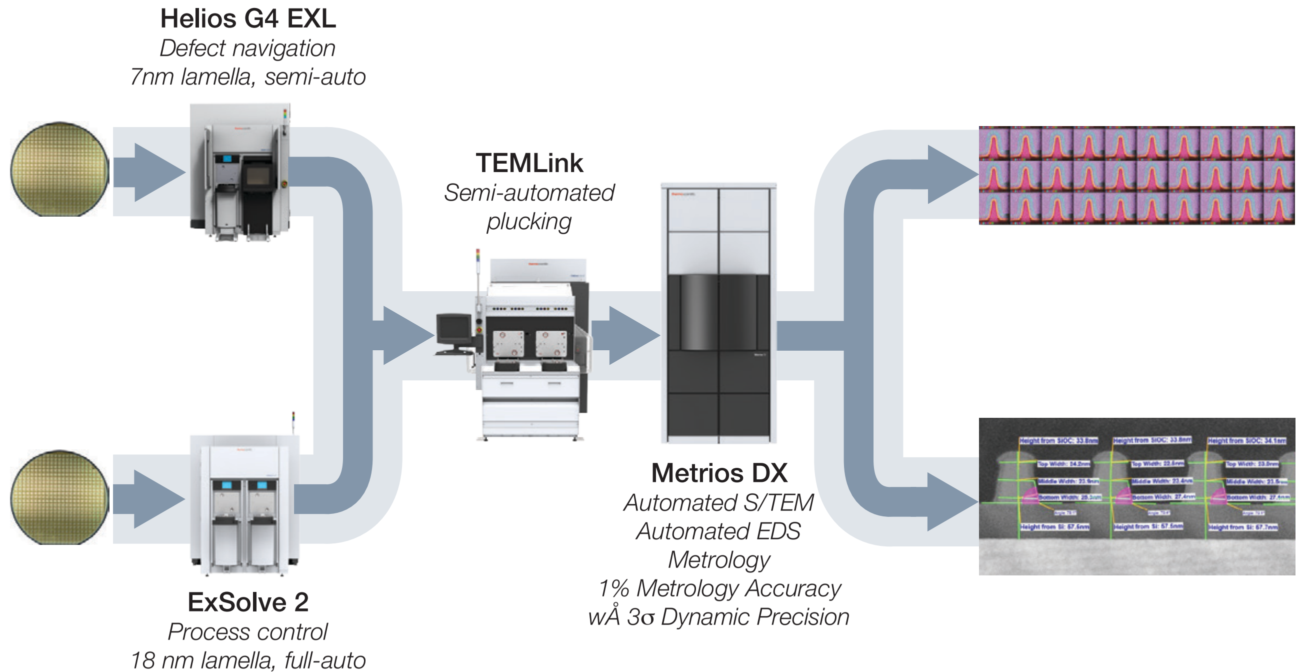
Calibrated and distortion-free imaging is essential for precise and accurate metrology, enabling fabrication engineers to make mission critical process decisions. The ability to produce large amounts of quality automated data is fundamental to understanding how 2D and 3D structures evolve from the front to back end of the line. This data is equally important as reference metrology for optical critical dimension (OCD) models. Automated imaging and metrology enable fast, consistent and precise data at a fraction of the operator overhead. Our enhanced throughput model ((H)ETM) workflows are engineered for industry leading productivity and fastest time-to-data and are the process of record across the semiconductor world.

Root-cause Analysis

The management and elimination of defects during fabrication is becoming more and more challenging as they become smaller and buried in relatively large 3D structures. Thermo Fisher Scientific is the leading provider of workflow solutions to locate, isolate and study defects on a broad range of device types and scale lengths. We have developed high-yield, high-productivity solutions that can work from the millimeter to atomic scale and provide the most comprehensive chemical, structural and physical information, all with the fastest time-to-data available.

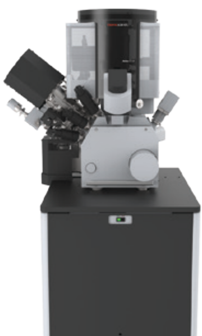
Automated Workflows

Near Line Metrology



Automated Workflows

Root-cause Analysis



Helios Plasma FIB

Precise, damage-free, site-specific device delayering

nProber Nanoprobing

Simple, reliable fault isolation and transistor characterization

Helios FIB/SEM

High productivity, tools for cross-section imaging and analysis,

Metrios/Spectra/Talos TEM

Fastest time to data on TEM platforms that can be configured

CAD Navigation

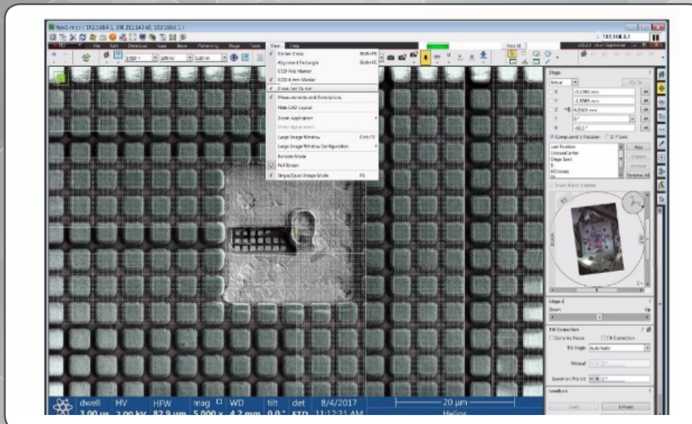
Workflows for physical failure analysis, electrical failure analysis, metrology and defect review all require continual improvements for enhanced productivity. Quickly and repeatably reaching the correct region of interest (ROI) is, therefore, essential. Thermo Scientific™ NEXS™ Software delivers a wide range of CAD-to-stage navigation capabilities for fault isolation, failure analysis, and sample preparation. It features easy-to-use CAD viewing and automatically drives the system stage to a precise ROI as indicated by the CAD model. Note that NEXS Software also reads the mask data from GDS2 and OASIS format files and provides connectivity options with other Thermo Scientific analytical tools.

CAD Navigation

CAD-to-Stage Navigation Capabilities

NEXS CAD Navigation and Overlay

Provides user friendly navigation to CAD coordinates on all Thermo Scientific product platforms (CE, DualBeam Systems, Meridian, etc.)



Simple navigation using CAD overlay on a Thermo Scientific Helios DualBeam image

Further Reading

Papers/presentations

Title	Authors
Electron Channeling Contrast Imaging (ECCI) for beyond Silicon materials characterization	**Mr. Libor Strakos,** Thermo Fisher Scientific, Brno, Czech Republic **Andreas Schulze, PhD,** Imec, Leuven, Belgium **Mr. Ondrej Machek,** Thermo Fisher Scientific, Brno, Czech Republic **Tomas Vystavel, PhD,** Thermo Fisher Scientific, Brno, Czech Republic **Mr. Matty Caymax,** Imec, Leuven, Belgium **Richard J. Young, PhD,** Thermo Fisher Scientific, Hillsboro, OR
Automated Diagonal Slice & View Solution for 3D Device Structure Analysis	**Sang Hoon Lee, PhD,** Thermo Fisher Scientific, Hillsboro, OR **Mr. Jeff Blackwood,** Thermo Fisher Scientific, Hillsboro, OR **Mr. Stacey Stone,** Thermo Fisher Scientific, Hillsboro, OR **Michael Schmidt,** Thermo Fisher Scientific, Hillsboro, OR **Mark Williamson, PhD,** Thermo Fisher Scientific, Hillsboro, OR **Woo Jun Kwon,** Thermo Fisher Scientific Korea, Suwon-si, Gyeonggi-do, Korea, Republic of (South) **Sung Jae Lee,** Thermo Fisher Scientific Korea, Suwon-si, Gyeonggi-do, Korea, Republic of (South)
Improved Phase Data Acquisition for Thermal Emissions Analysis of 2.5D IC	**Ms. Bernice Zee,** Advanced Micro Devices (AMD), Singapore, Singapore **Ms. Wen Qiu,** Advanced Micro Devices, Singapore, Singapore **Brian Lai,** Thermo Fisher Scientific, Fremont, CA **David Tien,** Thermo Fisher Scientific, Fremont, CA **Jim Vickers,** Thermo Fisher Scientific, Fremont, CA
Analysis of induced end-of-life failures in SRAM through nanoprobing	**Mr. Oberon St John Dixon-Luinenburg,** Thermo Fisher Scientific, Santa Barbara, CA **Mr. Jordan Fine, PhD,** Thermo Fisher Scientific, Santa Barbara, CA
Novel Approach of Improving Secondary Electron Detector in FIB System	**Steve Wang, PhD,** Thermo Fisher Scientific, Fremont, CA **Jim McGinn,** Thermo Fisher Scientific, Fremont, CA **Peter Tvarozek,** Thermo Fisher Scientific, Fremont, CA **Mr. Amir Weiss,** Thermo Fisher Scientific, Fremont, CA
High Resolution Image Fusion of Linearly Polarized Subsurface Optical Images	**T. Berkin Cilingiroglu,** Thermo Fisher Scientific **Neel Leslie,** Thermo Fisher Scientific **Seema Somani,** Thermo Fisher Scientific **Prasad Sabbineni,** Thermo Fisher Scientific
Use of analog simulation in failure analysis: Application to Emission microscopy and laser Voltage Probing techniques	**Mr. Etienne Auvray,** ST Microelectronics, Grenoble Cedex, France **Mr. Paul Armagnat,** ST microelectronics, GRENOBLE, France **Dr. Luc Saury,** ST microelectronics, GRENOBLE, France **Dr. Antoine Reverdy,** IMS laboratory, University of Bordeaux, Talence, France **Mr. Tommaso Melis,** ST microelectronics, GRENOBLE, France

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