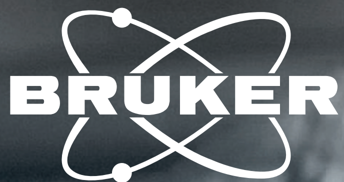


BRUKER NANO SURFACES AND METROLOGY

Semiconductor Solutions

Assess and Improve Semiconductor Manufacturing Processes

Process Equipment and Metrology Systems

Bruker's comprehensive suite of specialized technologies addresses the broadest range of metrology and process monitoring needs, from R&D to high-volume manufacturing process improvement. 75% of the world's top 25 semiconductor manufacturers rely on Bruker instrumentation for their front-end and back-end applications. Our commitment to innovation also drives the advances that enable continual development of next-generation semiconductor devices.

Our dedicated semiconductor solutions include:

- **Ellipsometry and Reflectometry**—Thin film metrology systems for wafer and CD metrology to meet requirements not measurable with conventional equipment
- **Automated X-ray Metrology**—Systems for high-quality process monitoring, detailed R&D analysis of epi-layer films, identification of substrate defects, front-end-of-line control of epi films and high-k dielectrics, and analysis of metal films and wafer-level packaging bumps
- **Automated Atomic Force Microscopy**—Systems to reliably measure surface roughness, chemical mechanical planarization (CMP), and etch-depth features
- **Photomask Repair**—Systems to address the critical production issue of controlling pattern defects on high-end photomasks
- **Cryo Dry Cleaning**—Cryogenic CO_2 process equipment to remove contaminants and residues from wafers and electronic devices
- **Surface Metrology**—Topographic measurement and mechanical testing solutions for efficient process monitoring and control across the full range of applications

Inline AFM, XRD, µXRF, and XRDI Solutions
with over 1000 semiconductor metrology tools installed worldwide

Service and Application Support to Optimize Tool Utilization

The decision to invest in high-performance metrology is based on more than instrument performance and price. Bruker is committed to keeping your tool running at the peak of up-time and productivity. We have a highly educated worldwide team of service and support personnel that takes great pride in first-time solution of issues. Our variety of service coverage programs can be customized to match your specific requirements, including optimization of tool performance, recipe writing, and in-person technical support visits.

Bruker tailors services to your needs:

- Priority technical support
- Advance replacement parts and assemblies stored in regional warehouses for rapid response times
- Application and training services

Non-Contact In-Line Metrology for Film Analysis

Featuring exclusive and patented technology for spectroscopic ellipsometry and reflectometry, multiple-angle reflectometry, and reflection-transmission spectrophotometry, Bruker's extensive FilmTek™ product line enables more precise and repeatable measurements on wider film types and thicknesses.

Broad Capabilities and Efficient Operation

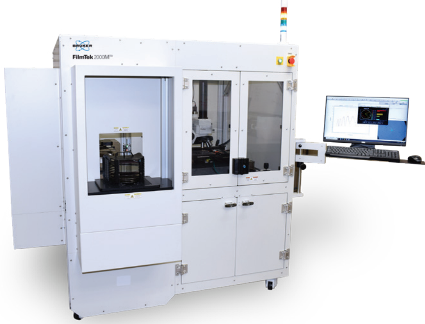
FilmTek ellipsometry and reflectometry systems have best-in-class accuracy and refractive index resolution for many thick, thin, and multilayer films. This performance enables applications that are not feasible with other metrology systems. FilmTek tools are available from fab to lab with a variety of automation options to suit individual customer requirements.

Metrology: film thickness, refractive index, total thickness variation (TTV), composition and crystallinity, critical dimensions (CD), and roughness

Layer thickness: from bare substrate (<1 Å) to very thick (2 mm)

Sample types: dielectrics, semiconductors, III-V films, thin metals, metal oxides

Ellipsometry and Reflectometry
Semiconductor Solutions



Applications

- In-line control for multi-layer film thickness and refractive index on micron-sized device features
- In-line composition control (e.g., %Ge in $SiGe_x$) for thin films
- In-line process control of thin metal oxide thickness to prevent non-wet open failures
- In-line monitoring of high-aspect-ratio TSV depth and CD
- Accurate, high-throughput trench depth measurement
- High-resolution measurement of film thickness and refractive index for silicon photonics (e.g., SiON, Si_3N_4)

Designed for Individualized Needs

FilmTek 2000M TSV: Fully automated metrology platform for film thickness, high-aspect-ratio TSV depth, critical dimension, and trench depth

FilmTek 2000 PAR-SE: Advanced multi-angle and multi-modal technology for production measurement of thin films and multi-layers

FilmTek 6000 PAR-SE: Advanced multi-angle and multi-modal technology for monitoring thickness and refractive index of IC device film layers at the 1x design node and beyond

FilmTek 4000 NIR: High-resolution measurement of film thickness and refractive index for silicon photonics and planar waveguide applications

Non-Destructive X-ray Technology for Films and Wafers

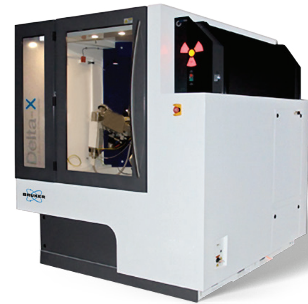
Silicon Semiconductor

Bruker provides the world's most advanced and non-destructive X-ray technology solutions for thin-film metrology for high-volume manufacturing fabs, covering the full range of processing in both logic and memory. We offer specialized systems for identifying substrate defects and performing front-end-of-line process control of epi films and high-k dielectrics, as well as dedicated products for analyzing metal films and wafer-level packaging bumps.

Compound Semiconductor

X-ray metrology tools for the compound semiconductor industry range from QC monitoring of epi-layer films to detailed R&D analysis of a wide range of semiconductor films and wafers. Bruker offers systems designed specifically for the challenging demands of the production environment, as well as multi-application research tools for development supporting current and future metrology needs.

Automated X-ray Metrology
Semiconductor Solutions



Applications

- Nanosheet thickness and composition metrology
- Thin film crystalline measurements
- Bump metallization process monitoring
- Advanced memory high-aspect ratio 3D metrology
- Power devices FEOL process monitoring
- BEOL metallization process monitoring

Silicon Semiconductor

SIRIUS-XCD: X-ray-based high-aspect ratio 3D profiling for advanced memory

SIRIUS-XRD: Next-generation X-ray diffraction metrology for gate-all-around and advanced memory devices

SIRIUS-RF: Fully automated µXRF and XRR metrology platform for advanced front-end-of-line logic, memory, and power devices

SIRIUS-FW: Fully automated µXRF metrology platform to monitor bump composition and under bump metallization

7300LSI: X-ray metrology for in-fab R&D and in-line production process monitoring

Compound Semiconductor

DELTA-X: Latest generation of X-ray metrology system for semiconductor thin film analysis

QCVELOX-E: Latest generation, high-throughput HRXRD for epi-layer monitoring

QC3: Dedicated HRXRD metrology system for epi-layer monitoring

Advanced In-Line X-ray Imaging

Bruker defect detection systems use X-ray diffraction imaging (XRDI) to detect crystalline defects on single-crystal substrates, such as slip, cracks, dislocations, and micropipes. Operating without the use of etching acids, our non-contact XRDI inspection systems are broadly employed to detect cracks in Si wafers that cause wafer breakage and to improve yield and quality of other high-value substrates such as CdTe and SiC.

In addition, Bruker offers advanced X-ray imaging (XRI) for 100% inspection and real-time feedback on the die-attach process, revealing even marginal defects that can pass electrical testing. XRI can be used to improve process control systems for a wide range of applications, from system-in-package (SiP) to 2.5D/3D integrated circuit (IC) integration.

X-ray Defect Inspection
Semiconductor Solutions

Applications

- Advanced packaging defect inspection
- Thin film crystalline defect monitoring
- Warpage and tilt mapping for advanced processors
- Wetting behavior analysis for automotive controllers
- Automatic non-wet detection for wireless chips

X-ray Defect Inspection

SENSUS-600F: High-throughput non-visual defect inspection for fully automated 300 mm fabs

SENSUS-CS: High-resolution XRDI system specifically designed for production monitoring of SiC

QC-TT: Production-dedicated, non-visual defect detection and classification in high-value substrates including Si, GaAs, GaN, and InP

QC-RT: Production-dedicated, non-visual defect detection and classification in CdTe, HgCdTe, and other high-density substrates

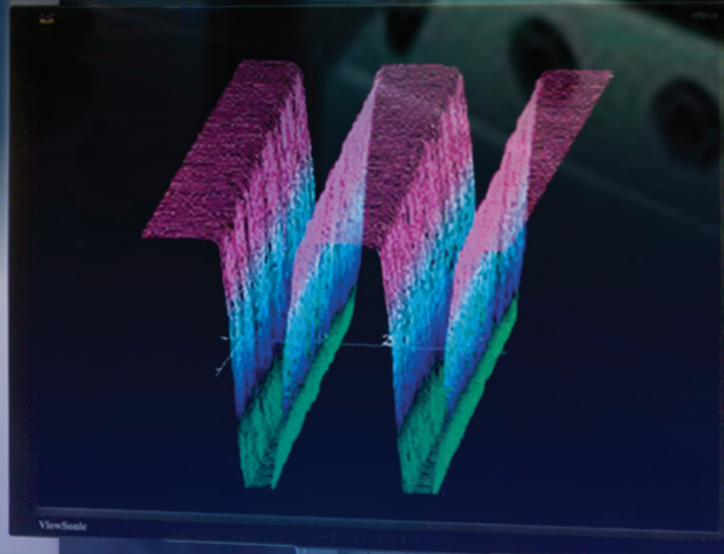
X200: Precise, real-time metrology and defect feedback for improving process control systems

High-Accuracy Probe-Based Metrology

Automated AFM metrology solutions reliably measure surface roughness, chemical mechanical planarization (CMP), and etch-depth features on the most current technology nodes and wafers. Bruker has a long-standing reputation for providing the highest-available speed and performance for industrial metrology applications. Designed specifically for high-volume production environments, our systems offer the utmost ease of use and the lowest cost per measurement for quality control, quality assurance, and failure analysis.

Bruker's InSight® family of fully automated AFM systems are integrated into production lines, allowing data collection to take place without operator intervention for advanced in-line process control. With highly repeatable and accurate roughness, height, and depth measurements—from sub-nanometer steps to high-aspect-ratio trenches—nanoscale defects can be located and characterized on a variety of wafers, substrates, and sliders. Some common applications are in semiconductor, data storage, polymers and thin films, high-brightness LED and solar materials, and display manufacturing.

In the category of probe-based solutions beyond automated AFMs, Bruker's SmartProber P1 enables high-field, high-accuracy current-in-plane tunneling (CIPT) measurements to characterize magnetic tunnel junctions (MTJs), with both in-plane and perpendicular field options available.



Automated AFM and CIPT
Semiconductor Solutions

Applications

- CMP process control and development
- Etch process control and development
- Lithography EUV process control and development
- Sidewall metrology and CD reference
- Surface roughness metrology for FEOL/BEOL
- CIS and CFA analysis
- QA/QC for etch depth

Automated Atomic Force Microscopy

InSight AFP: World's only metrology tool designed to measure both CMP and etch-depth, offering unmatched capabilities and precision

InSight CAP HP: World's most intuitive, easiest-to-use, cost-effective AFP providing the highest value, performance, and lowest cost-of-ownership

InSight CAP: A low-cost automated AFM that is focused on CMP, depth, and roughness applications

Current-In-Plane Tunneling

SmartProber-P1: Advanced CIPT system for semiconductor R&D and failure analysis, mapping 300 mm wafers with a high perpendicular-to-plane magnetic field

Production-Enhancing Technology

Precise, Accurate Photomask Repair

Bruker's suite of mask repair equipment offers solutions for materials that provide significant challenges for the current industry standard repair techniques; specifically, quartz bumps on alternating phase shift masks, trimming of carbon patches, multi-level materials, foreign materials, persistent unknown particles and precision repairs within tight lines and spaces.

Dry Cryogenic CO_2 Cleaning

Extremely fast and environmentally friendly, Bruker's dry cryogenic CO_2 cleaning technology offers unique advantages over conventional cleaning techniques: it is cost-effective, non-destructive, waste- and residue-free, and eliminates corrosion and staining. With over 100 tools installed, Bruker provides cryogenic CO_2 process equipment for a broad range of applications across most semiconductor market segments.

Mask Repair and Wafer Cleaning

Semiconductor Solutions

Applications

- High-end, complex photomask repair
- Precision repairs within tight lines and spaces
- Removal of corrosion and staining

Mask Repair

fp-III: 3rd-generation femto-pulse laser repair system

nm-IV: 6th-generation AFM guided nanomachine

Rhazer III: 3rd-generation haze removal system

Mask and Wafer Cleaning

EL-C: 2nd-generation photomask dry cleaning system

Wafer Clean 2200: Non-aqueous CO_2 cryogenic dry cleaning

Lab-to-Fab Surface Characterization

From process development to quality assurance, understanding surfaces is an essential part of semiconductor device manufacturing. Bruker offers reliable, accurate surface characterization solutions with broad versatility that are still designed to maximize productivity.

Stylus Profilometry and White Light Interferometry

Profilometry is used to qualify and quantify the topography of surfaces, enabling analysis of film thickness, stress, surface roughness, form, and more. Stylus profilometry uses a sharp tip to capture height information from every point along a surface trace. Bruker has driven stylus profiling innovation with the Dektak® systems, constantly improving resolution, stability, speed, and versatility over the last 5 decades. These systems have a long history of streamlining precise thickness metrology, even on fragile, transparent thin films for multi-layer stacks.

White light interferometry (WLI) is a non-contact profilometry technique that captures surface data areally using interferometric objectives. WLI has magnification-insensitive resolution, high throughput, and the ability to measure trench sidewalls. Incorporating 30+ years of proprietary advances, Bruker's WLI metrology systems provide rapid time-to-results, exceptional versatility, and unmatched repeatability for applications ranging from CMP optimization and layer stacking to wafer bonding and advanced packaging.

Nanomechanical Testing and Tribology

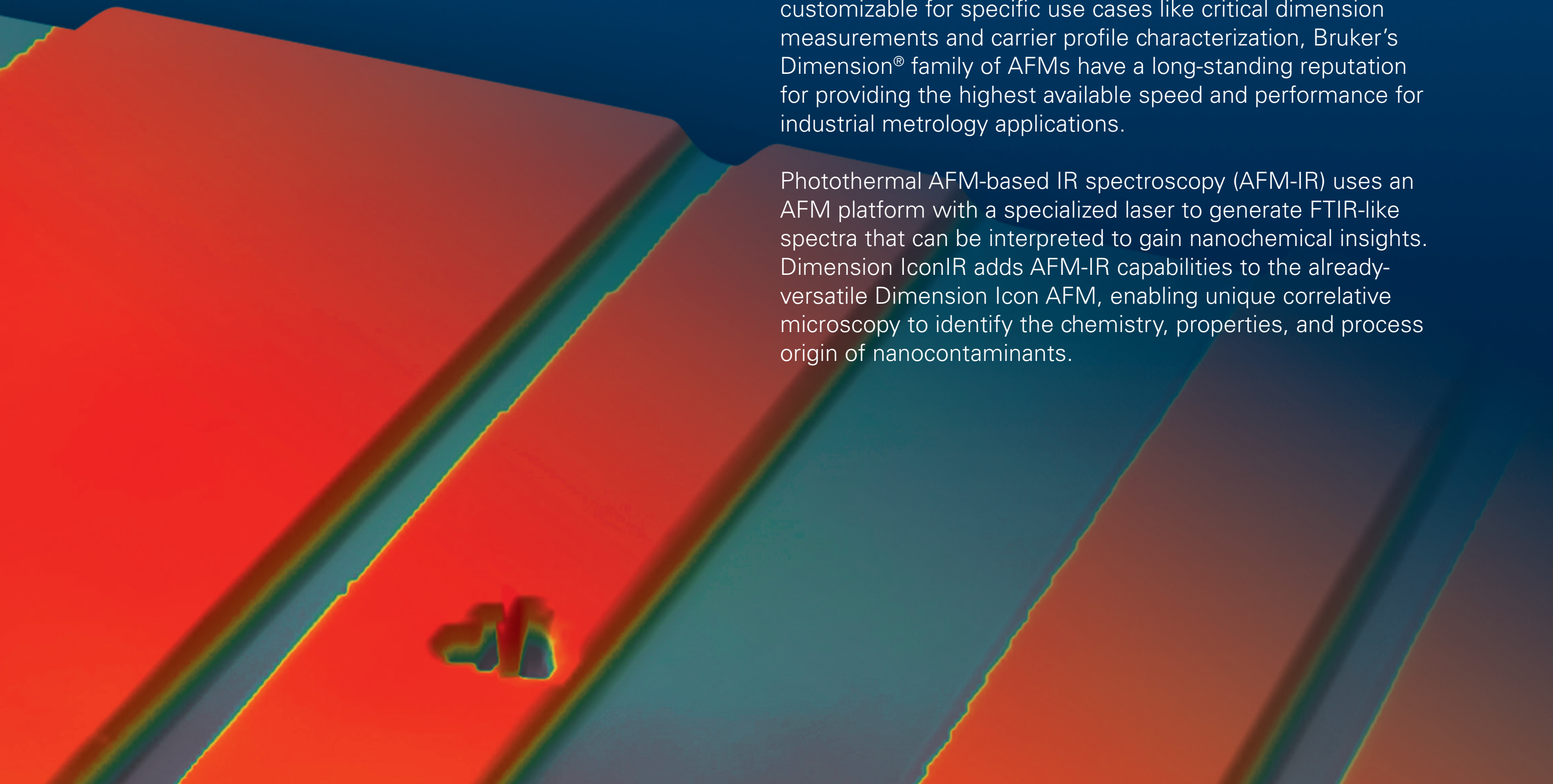
Characterizing properties, interactions, and functionality of surfaces is a prerequisite for fully understanding how a part or device will perform during use. Bruker's Hysitron® nanomechanical metrology tools provide automated metrology solutions that deliver high-speed, high-resolution, highest-sensitivity thin film mechanical property and/or interfacial adhesion measurements, streamlining nanomechanical property sampling and empowering persistent product and process improvement.

TriboLab® tribometers and mechanical testers provide comprehensive and versatile means to investigate tribology, including friction, wear, load, hardness, and lubrication. In particular, this can be highly effective for the qualification, inspection, and ongoing functionality testing required for CMP consumables and process development.

Nanoscale Property and Chemical Characterization

Atomic force microscopy (AFM) is a multiparametric scanning probe microscopy-based imaging technique that is used to characterize the nanoscale topographical, mechanical, electrical, magnetic, thermal, and coupled properties of advanced materials. Offering ultimate versatility and customizable for specific use cases like critical dimension measurements and carrier profile characterization, Bruker's Dimension® family of AFMs have a long-standing reputation for providing the highest available speed and performance for industrial metrology applications.

Photothermal AFM-based IR spectroscopy (AFM-IR) uses an AFM platform with a specialized laser to generate FTIR-like spectra that can be interpreted to gain nanochemical insights. Dimension IconIR adds AFM-IR capabilities to the already-versatile Dimension Icon AFM, enabling unique correlative microscopy to identify the chemistry, properties, and process origin of nanocontaminants.



Surface Metrology
Semiconductor Solutions

Applications

- Die flatness and CMP metrology for advanced packaging
- TSV and interconnect measurements
- Hot-spot and defect detection on full reticle die
- Automated thin film mechanical and interfacial adhesion metrology
- In-line and near-line process monitoring
- Complete characterization of CMP processes and consumables
- Surface roughness characterization, step height measurements, and film stress analyses

White Light Interferometry and Stylus Profilometry

InSight WLI: Fully automated optical surface measurement capabilities with wafer-handler integration, designed for R&D, quality assurance, and process quality control

ContourSP: Large-panel metrology system for high-volume, high-precision PCB production control

Dektak XTL: Gage-capable QA/QC profiler for optimal 300 mm performance

Nanomechanical Testing and Tribometry

Hysitron ATI 8800: Automated thin film mechanical and interfacial adhesion metrology

Hysitron TI 980 TriboIndenter: The world's most powerful nanomechanical and nanotribological test system

Hysitron PI 89 Auto: Automated co-localized imaging and analysis for high-throughput in-situ nanoindentation

TriboLab CMP: R&D-scale process and material characterization system for wafer polishing processes

Nanoscale Property and Chemical Characterization

Dimension Icon: Proven highest performance and versatility in an easily tunable AFM platform

Dimension IconIR300: Variation of the high-performance IconIR platform with 300 mm of sample access, ideal for semiconductor R&D, failure analysis, and nanocontaminant identification

Dimension FastScan Pro: Automated nanometrology for industrial R&D

Bruker Semiconductor Solutions

Process, Metrology, or Inspection Step	Technique	Instrument(s)
Wafer and photomask cleaning	Cryo dry cleaning	Wafer Clean 2200
		EL-C
Substrate defect inspection	X-ray diffraction imaging (XRDI)	QC-TT
		QC-RT
		Sensus-600F
Epitaxial characterization	High-resolution X-ray diffraction (HRXRD)	Sirius-XRD
		7300LSI
		QCVelox-E
		QC3
		Delta-X
Crystalline thin film analysis	X-ray diffraction (XRD)	Sirius-XRD
		7300LSI
		Delta-X
Thin film thickness and composition	X-ray reflectometry (XRR)	Sirius-RF, 6300-XRR
		Sirius-XRD
	Micro X-ray fluorescence (µXRF)	Sirius-RF, 6300-RF
	Ellipsometry / reflectometry	FilmTek line
3D metrology	Automated atomic force microscopy (AAFM)	InSight AFP
		InSight CAP
	Critical dimension small-angle X-ray scattering (CD-SAXS)	Sirius-XCD
Photomask repair	Femto-pulse laser repair	fp-III
	Atomic force microscope-guided nanomachining	nm-IV
	Haze removal	Rhazer III
TSV and bump quality analysis	Micro X-ray fluorescence (µXRF)	Sirius-FW
	X-ray imaging (XRI)	X200
Additional surface characterization	White light interferometry and stylus profilometry; Nanomechanical testing and tribology; Nanoscale property and chemical characterization	See previous page for details

©2023 Bruker Corporation. Dektak, Dimension, Dimension FastScan, Dimension IconIR, FilmTek, fp-III, Hysitron, InSight, PicoIndenter, Rhazer III, TriboLab, and Wafer Clean are trademarks of Bruker. All other trademarks are the property of their respective companies. All rights reserved. B5000, Rev. A1.

Bruker Nano Surfaces and Metrology
San Jose, CA • USA
Phone +1.805.967.1400 / 800.873.9750
productinfo@bruker.com

www.bruker.com/SEMI