BRUKER

Bruker AXS

D8 FABLINE

- X-Ray Metrology Solutions

think forward

XRD & µXRF

D8 FABLINE – Metrology for Semiconductor Manufacturing

The functional units of semiconductor and compound semiconductor devices shrink in size and thickness from generation to generation. In addition, the device structures become increasingly complex – and the process more and more expensive. Thus, the demand for reliable analytics for process development and at-line or in-line quality control increases permanently.

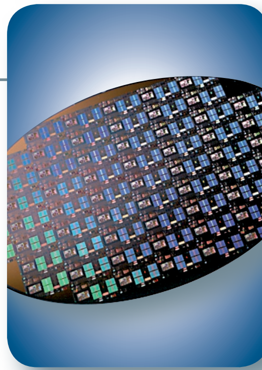
X-ray metrology offers a non-contact and non-destructive method of probing the nanometric scale, which provides various essential parameters without the need to use a reference. Secondly, the method is known and accepted for many years within scientific, research and development communities for its accuracy and reliability. In many cases just one quick measurement is required to determine sample parameters with a spatial resolution better than 50 µm in diameter.

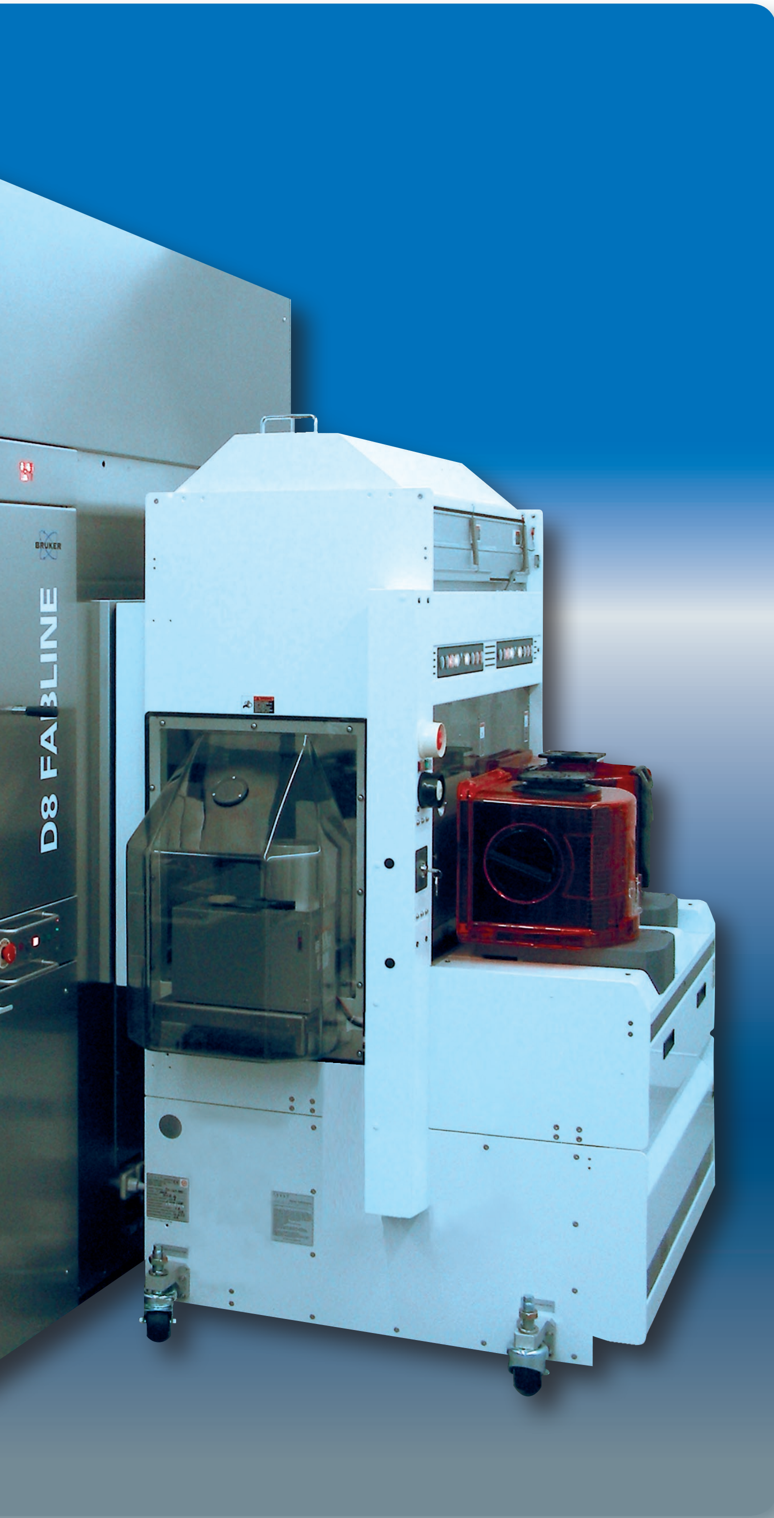
The D8 FABLINE is the Bruker AXS' product line dedicated to semiconductor industries. The instrument consists of two modules. The analytical tool consists of the X-ray metrology unit combined with the EFEM (Equipment Front End Module) for easy FAB automation integration; the Spartan dual load port from Asyst technology allows automated sample change.

The X-ray metrology unit is based on the D8 DISCOVER, the world's leading diffraction instrument for R&D in semiconductor industry.

The D8 FABLINE is the only X-ray metrology instrument with four combined applications:

- High-Resolution X-Ray Diffraction (HRXRD)
  - Single-crystal / epitaxial layer structure, e. g. SiGe
  - Composition, thickness, relaxation
  - Spot down to 50 µm in diameter
- X-ray Reflectivity (XRR)
  - Polycrystalline, amorphous, single-crystal film structure, e. g. HfO_2 on blanket
  - Thickness, density
- Micro X-ray Fluorescence (µXRF)
  - Polycrystalline thin film, e. g. HfO_2 on product wafers
  - Composition and film thickness
  - Spot down to 50 µm in diameter
- Grazing Incidence Diffraction (GID)
  - Polycrystalline thin film
  - Identification of crystalline phases, crystallite size





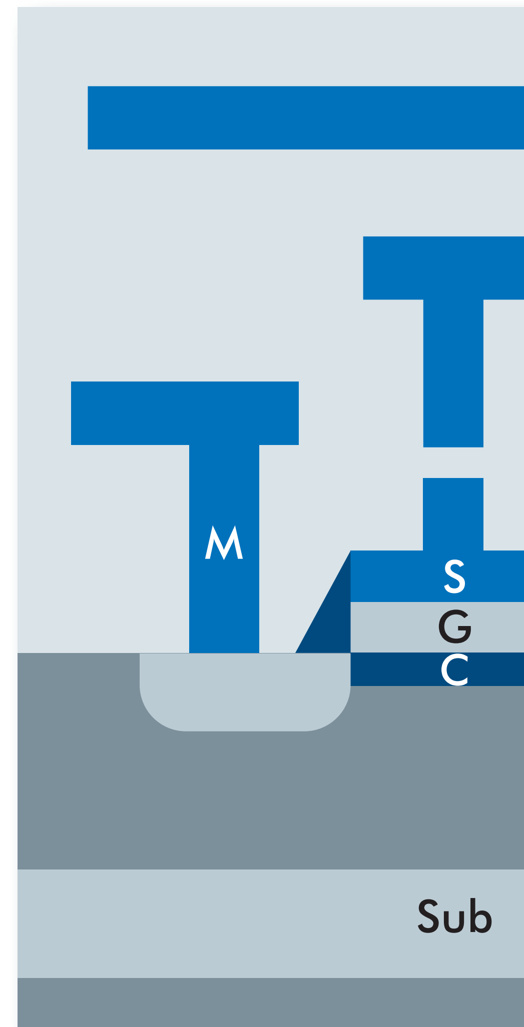
- Non-destructive, non-contact metrology using X-ray technology
- Thickness, composition, crystalline phase and strain determination for multilayer structure
- Absolute measurements with accuracy and resolution down to atomic level – no calibration required
- Measuring film structures on both blanket monitor wafers and patterned product wafers
- Fully automated, cleanroom-compatible system for both R&D and in-line process control

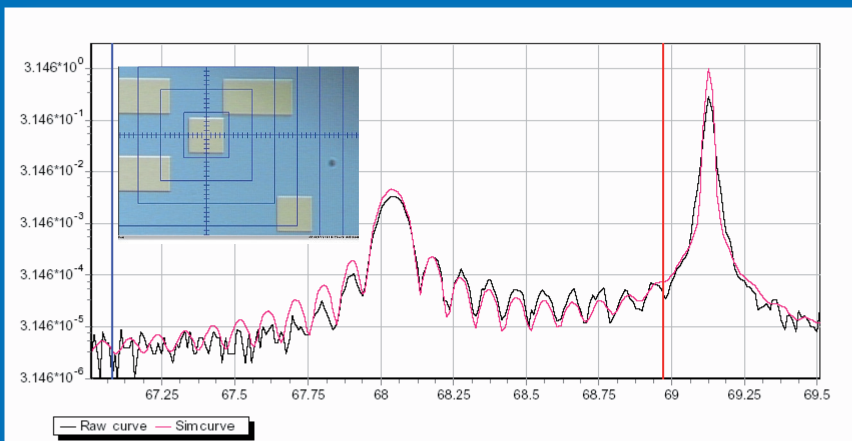
D8 FABLINE –
Advanced Process Control

Smaller, faster and more efficient – are the most important factors in semiconductor developments. However, these demands are becoming more and more difficult as it comes to 32 nm technology and beyond. Since the dimensions of the components are so close to the physical limit, new processes and new materials must be applied to IC manufacturing. The extra complexities involved with these new developments bring new variables into the production processes. Consequently, new metrology tools are required to monitor more closely and in more detail in order to prevent severe yield loss. The D8 FABLINE X-ray metrology solution is your best partner for process control. With its powerful system design, the D8 FABLINE gives you important structure parameters such as:

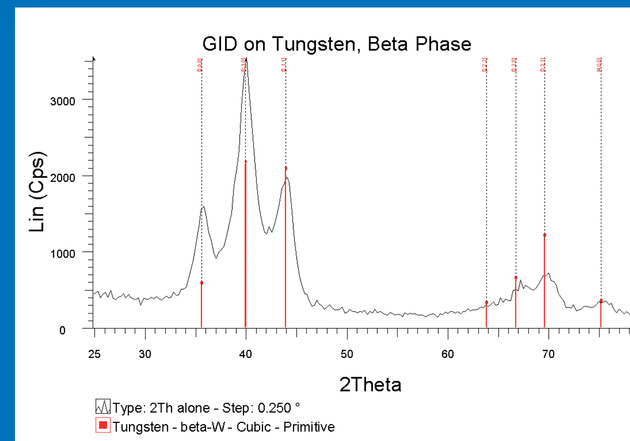
- layer thickness
- chemical composition
- surface / interface roughness
- layer density
- porosity
- lattice spacing
- crystallinity
- gradients
- mismatches
- degree of relaxation
- texture
- stress and strain

And even better: this works for multilayer samples as well as for ultra thin films (e.g. ALD films).

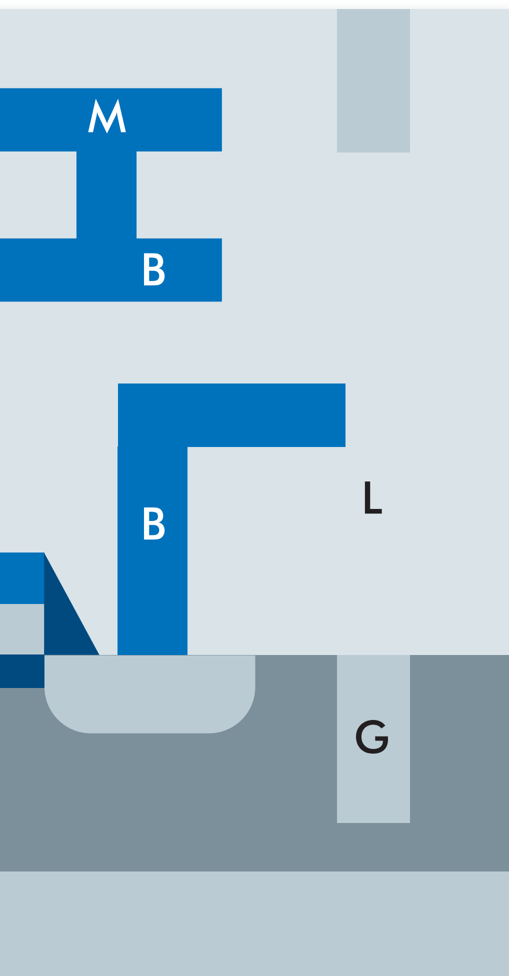




SiGe/Si microdiffraction on SIMS pads

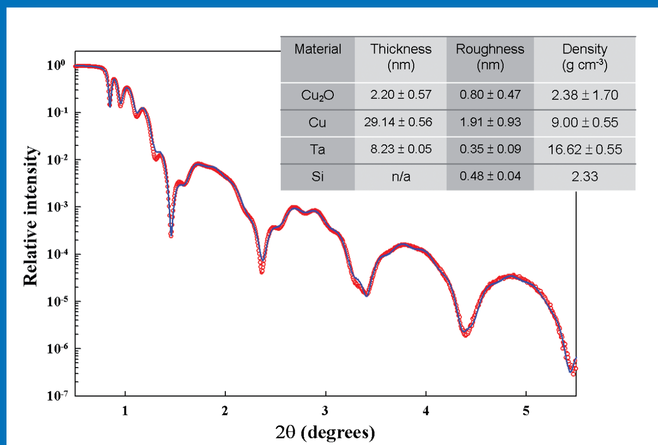


Crystalline phase analysis on Tungsten barrier layer

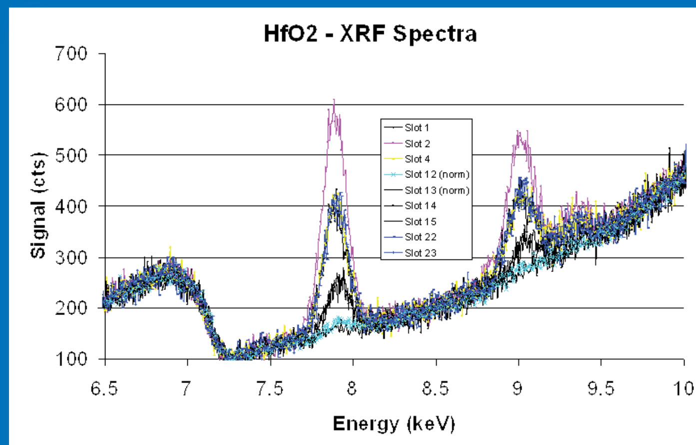


Back-end applications	
Metal layers: Cu, Al-Cu, W	Thickness, crystalline phase orientation, stress
Barrier layers: Ta/TaN, Ti/TiN, W/WN	Thickness, density, crystalline phase
Low-k layers: Black Diamond, SiLK	Thickness, porosity

Front-end applications	
Silicide and polycide: WSi, TiSi, CoSi, NiSi	Thickness, crystalline phase
Gate oxide and memory capacitor (high-k): SiO_2, SiNO, Ta_2O_5, HfO_2	Thickness, phase, crystallinity
Channel: epi-SiGe, strained-Si	Thickness, composition, relaxation
Substrate: SOI, sSOI	Oxide thickness/depth, Ge profile, miscut angle



X-ray reflectivity on metal barrier layers (Cu process)



Micro XRF spectra on thin HfO_2 films

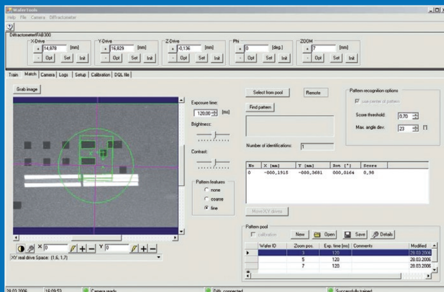
D8 FABLINE – Automated Analytical Power

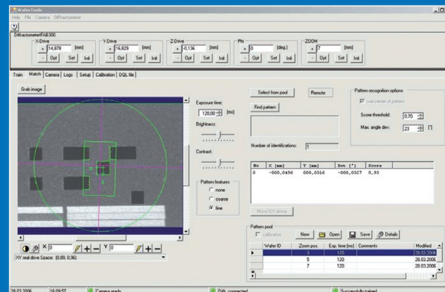
X-ray instrument as implemented in the D8 FABLINE

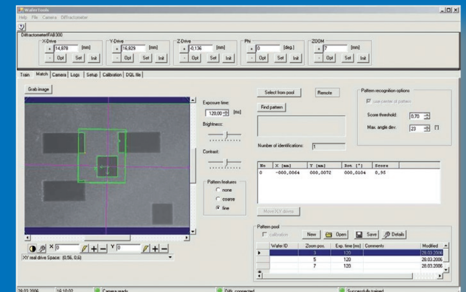
For today's semiconductor production line, X-ray metrology equipment must fit into the FAB environment. To achieve this, the D8 FABLINE combines many unique design features.

- Compact system with internal sample handling keeping the wafer horizontally to minimize mechanical movements for optimized system stability
- Direct measurement on patterned wafers with pad size better than 50 µm in diameter
- Variable zoom video system. Multiple zoom factor pattern recognition procedure to optimize the position accuracy
- Peer Tool Orchestrator (PTO) for handling all of the SEMI automation standards for 300 mm automation and connectivity
- Spartan dual load port Equipment Front End Module for easy and rapid FAB integration
- ISO Class 2
- SEMI S2, S8 compliance

D8 FABLINE – the ultimate X-ray metrology solution for today's semiconductor FAB



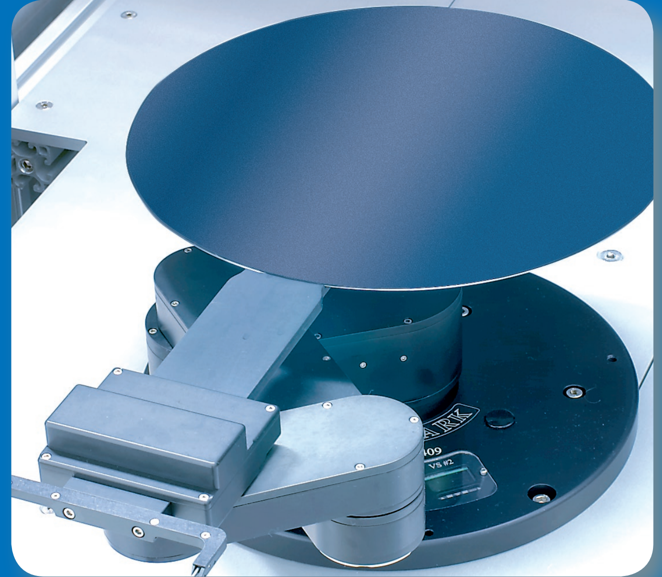




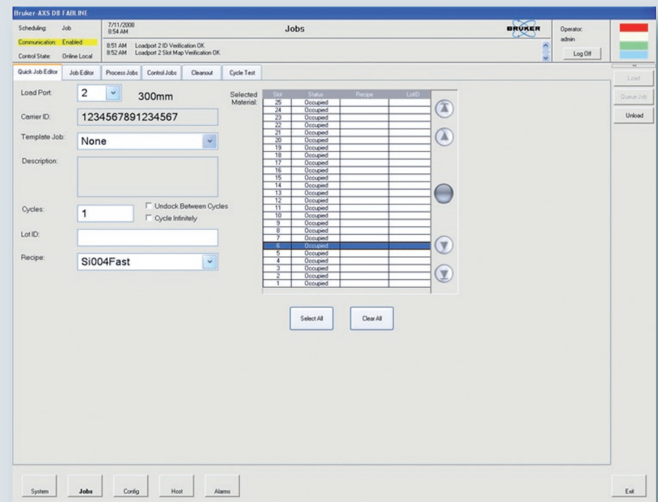
The UMC 300 (Universal Motion Concept) is a dedicated stage for investigating wafers up to 300 mm with full mapping capability. It is mounted to a vertical D8 goniometer. Since the X-ray source and the detector are moving, the wafers always stay horizontally. This horizontal position allows measurements with minimal influence on the wafer when it mounts on a three point Wafer Chuck. Thanks to the optimized sequence of the wafer movements, full 300 mm mapping is achieved within the smallest required space. In combination with high flux UBC optics, fast and reliable X-ray Reflectometry (XRR), High Resolution X-ray Diffraction (HRXRD), Phase ID and stress measurements are executed with maximum flexibility.

- Micro XRF capabilities included to determine composition and thickness of metal layers and metal stacking with a spot size down to 50 µm in diameter
- XRF evaluation software for qualitative and quantitative analysis based on fundamental parameters

The variable zoom video system and pattern recognition process: multiple zoom factors are used to determine the measurement location accurately.



The D8 FABLINE can be configured with single or dual FOUP / SMIF loadport. Open-cassette or bridge-tool (200 / 300 mm capability in one single system) is also available.



Easy control software for semiconductor FAB operation.

Technical Data	
General	
Footprint	2 m x 2 m
Wafer size	Up to 300 mm full wafer mapping
Cleanroom class	ISO Class 2
X-ray source options	
Sealed tube	Co-, Cu-radiation, up to 2.2 kW
IµS	Cu-radiation, 30 W, air-cooled
Micro XRF option	
Microfocus X-ray source	Mo-, Rh-, Cu-radiation, 30 W, air-cooled, 50 µm spot size
Energy dispersive detector	XFLASH™ SDD Detector, 30 mm^2 active area
Sample stage (UMC 300)	
Sample setting	Horizontal loading and measuring
Omega/2Theta reproducibility	±0.0001°
X-translation	±150 mm travel, 0.01 mm step size
Y-translation	±150 mm travel, 0.01 mm step size
Z-translation	±2 mm travel, 0.005 mm step size
Phi	Unlimited travel, 0.001° step size
Chi	±7.5° travel, 0.01° step size
Alignment	
Cognex pattern recognition	
Laser/Video system	
Software	
Automation control	Peer Tool Orchestrator from Peer Group
Diagnostic	D8 Tools
Evaluation software	LEPTOS for HRXRD, XRR and stress TOPAS BBQ for analysis of polycrystalline layers TASI for µXRF
Automation	
Equipment Front End Module	Spartan from Asyst/Crossing Automations Inc.
Compliance	
SEMI S2, S8	
Full CE compliance	Machinery Directive, 2006/42/EC Electrical Equipment, 2006/95/EC Electromagnetic Compatibility, 2004/108/EC

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