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Complementary methodologies for thin film characterization in one tool – a novel instrument for 450 mm wafers

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The scaling down of critical dimensions for the manufacturing of nanoelectronics requires the continuous introduction of new materials. The results of the analysis of thin high-*k* films made from Al_2O_3 as reference samples were used at multiple laboratories to show the power and strength of complementary metrology, *e.g.* using various techniques, such as synchrotron radiation X-ray spectrometry, 'table top' grazing incidence X-ray spectrometry and X-ray reflectometry, and spectroscopic ellipsometry. The layer thicknesses and material parameters validated by several analytical techniques demonstrate the successes of the use of complementary metrology. The requirement for validation, assurance, and support using differing analytical methods is driving the integration of multiple methods into one tool. This paper proposes an integrated metrology approach for reliable characterization of structure and composition. For the analysis of surfaces and materials, light sources in different spectral ranges, *e.g.* X-rays or infrared light, are used for diffraction, scattering, or excitation of fluorescence. The use of appropriate detectors in the scattering or fluorescence geometry is indispensable. Highly precise metrology requires accurate positioning of the sample with respect to the sources and the detectors. The handling unit for samples and automation are the main contributors to the cost of the semiconductor metrology equipment. For this reason, the approach of integrating multiple analytical techniques has advantages with respect to cost aspects and handling steps. A design study of the 450 mm analytical platform was performed. This design study integrates seven complementary analytical methods into one metrology chamber. Five methods rely on X-ray characterization methods, such as Total Reflection X-Ray Fluorescence Analysis (TXRF), Grazing Incidence X-Ray Fluorescence Analysis (GIXRF/XRF), X-Ray Reflectometry (XRR), X-Ray Diffractometry (XRD), and Grazing Incidence Small Angle X-Ray Scattering (GISAXS). Furthermore, the two methods of spectroscopic ellipsometry and vacuum UV reflectometry using the spectral range of ultra-violet to infrared were supplemented. A novel 5-axis positioning system was designed and patented, enabling the integration of all analytical methods into one chamber under vacuum or atmospheric conditions.

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1 Introduction

In 1965, Moore published an article forecasting the technology cycles of ultra-large-scale integrated circuit manufacturing.[1] Moore's Law predicted that the number of transistors on a chip would be doubled every 18 to 24 months, making obvious the speed of innovation in the semiconductor industry. Consequently, structures would be reduced by each new technology cycle, and the number of transistors per chip would increase continuously. Approximately 50 years later, Moore's Law is still reflected in the International Technology Roadmap of Semiconductors (ITRS).[2] The ITRS additionally shows the increasing substrate diameters driven by the reduction in manufacturing costs. Currently, the manufacturers are preparing for the introduction of silicon wafers with a diameter of 450 mm.

For the transition to wafers with a diameter of 450 mm, a cost reduction of 30% is expected.[3] Huge investments are required for the transition, which cause hesitation on the part of manufacturers.

The benefits of such technological transitions are the introduction of the latest R&D results to new generation manufacturing, inspection, and metrology equipment. The transfer of leading edge manufacturing to wafers with a diameter of 450 mm will push analytical methods to their limits,

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generating new developments and innovations also to be used in industries other than semiconductor manufacturing. Furthermore, history has shown that leading edge technology is used in 'More than Moore' industries, *e.g.* power electronics approximately one decade later, as demonstrated most recently by Infineon Villach.[4] For this reason, the European Commission has supported the feasibility studies of the work described in this paper within the framework of the European project, European 450 mm Equipment and Materials Initiative (EEMI 450).[5] This paper shows the results of the design study for the feasibility of an advanced metrology chamber for wafers with a diameter of 450 mm. The current instrumentation at the PTB beamline at BESSY II was the first step for showing the feasibility of the integration of various metrologies.[6] The design study performed an extensive scaling for large samples and for the integration of additional analytical techniques, enhancing the capabilities of the metrology platform for wafers with a diameter of 450 mm.

2 Characterization of the thin high-*k* layers using various methods and laboratories

In the following, the capabilities of using several analytical techniques for characterization are demonstrated. For this purpose, samples, previously designed as reference samples, were employed.[7] The substrates were silicon wafers with diameters of 100 mm. Plasma Assisted Atomic Layer Deposition (PA-ALD) was used to create Al_2O_3 layers on silicon. Formation of a SiO_2 layer between the Si substrate and the high-*k* layer is expected. The root cause is most likely the cleaning and transfer process prior to deposition. In addition, the formation of a very thin hydrocarbon surface layer is to be expected. The root cause for this layer is most likely surface contamination from the environment.[8] An overview of the samples is given in Table 1.

In the following, results from the characterization of a high-*k* sample using multiple analytical techniques are shown.

Two research institutes and a national metrology institute performed the characterization of the samples using Spectroscopic Ellipsometry (SE), X-Ray Reflectometry (XRR), and Grazing Incidence X-Ray Fluorescence Spectroscopy (GIXRF). The goal of this approach was to achieve reliable and reproducible results using various excitation energies and analytical techniques. This is a challenge when taking into account the fact that the selection of material parameters at different excitation energies has a considerable impact on the evaluated results. Databases from NIST,[9,10] PTB,[11,12] Panalytical, Atomica, Sopra, and Woollam were used. For thin-layer characterization, probably the most challenging issue is figuring out the mass deposition, which is the product of thickness and density, also representing electron densities for scattering. As there are several solutions providing similar results, the identification of the appropriate material parameters at a specific energy and the corresponding thickness require the use of an approach using more than one analytical technique.

Table 1 Overview of samples, the number of ALD cycles, and the targeted thickness.

Sample	Number of ALD cycles	Targeted Al_2O_3 thickness in nm
Sample 1	10	1
Sample 2	30	3
Sample 3	100	10
Sample 4	500	50

The GIXRF measurements at Fraunhofer IISB were performed using an Atomika 8300 W with WL-β excitation. For GIXRF measurements, the sample was tilted with respect to the incident beam. The spectra were evaluated automatically by the built-in software, whereas the intensity distribution of specific elements was calculated using a transfer matrix method varying the density and thickness of the layers. Only simple layer models and NIST fundamental parameters were used. The calculated thickness results show an offset of the thickness as a function of the ALD cycles. The samples were found to be at least thicker than expected. This positive offset could be explained either by the formation of an interface with the mixture of layer and substrate or a hydrocarbon surface layer.[13]

The XRR measurements were performed with an X'Pert PRO MRD from Panalytical using the Cu-Kα line. The evaluation was performed using the X'Pert software and material parameters. Complex layer models were required, which take into account the formation of interfaces and the mixing of elements between layers during the deposition process to achieve an accordance between calculated and measured XRR curves.

The ellipsometry measurements were performed using a Woollam M-2000DI rotating compensator spectroscopic ellipsometer at the Research Institute for Technical Physics and Materials Science of the Hungarian Academy of Science.

The GIXRF measurements at PTB were carried out in the laboratory at BESSY, where a plane-grating monochromator beamline provides high spectral purity and high photon flux in the photon energy range of 78 eV to 1.86 keV.[14] The samples were excited using 1.622 keV photons at an incident angle between 6° and 10°. For the quantitative analysis of the samples, a completely reference-free, fundamental parameter-based approach[15] was employed (Fig. 1).

The measurements show accordance between the thicknesses determined by the analytical techniques and at different laboratories. But one should keep in mind that open issues remain, such as the description of the surface contamination by water and an appropriate model for the interfaces. Currently, the achieved results are in accordance but the use of additional analytical techniques, *e.g.* chemical analysis of the surface and the interface, is expected to explain the observations. This has not been performed yet.

3 Methods implemented in the advanced 450 mm chamber

For quality control, the wafer surface is studied with respect to dimensions, structures, contamination, and elemental composition during and after each processing step. To check uniformity, 100% mapping of the surface of the wafer is mandatory. Chip yield in the front end of the line and the chip reliability are

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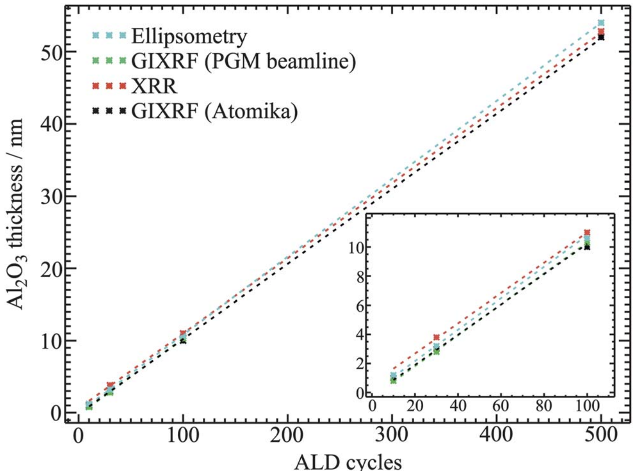

Fig. 1 Complementary analysis of Al_2O_3 layers on silicon with varying thicknesses. The determined thicknesses of X-ray reflectivity, as well as grazing incidence X-ray fluorescence, and ellipsometry are in accordance with each other.

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impacted by defects or contamination.[16] Therefore, the contamination and defect-free handling of wafers is a prerequisite for metrology and inspection equipment. Currently, new materials are being introduced for the manufacturing of new technologies in nanoelectronics for reduction of leakage currents and have become more important as the device dimensions shrink continuously.[17] Intensive research is already devoted to advanced materials requiring new and different analytical techniques. The paragraph above impressively demonstrates the benefits and capabilities of complementary metrology.

Total-Reflection X-Ray Fluorescence Analysis (TXRF) qualifies and quantifies the elemental contamination of surfaces.[18] Using X-Ray Diffraction (XRD), important crystallographic quality characteristics (*e.g.* crystal structure, grain size, internal stress, and texture) are determined.[19] Dimensional and physical properties of thin films, such as layer thickness, density, and roughness are analyzed with X-ray reflectometry.[20] The layer thickness, as well as the dependence of optical constants and energy/wavelength, is measured with high precision by spectroscopic ellipsometry that is well established in the semiconductor industry. To complement spectroscopic ellipsometry, VUV (Vacuum Ultra-Violet) reflectometry is an ideal method of enabling the analysis of ultra-thin films. Grazing incidence small-angle X-ray scattering (GISAXS)[21] and grazing incidence X-ray fluorescence analysis[22] enable deep insights into the dimension, composition, and configuration of boundary layers and interfaces. These techniques are summarized in Table 2.

The analytical methods mentioned above were integrated into an advanced and innovative metrology platform as a design study. The design study was used to demonstrate the possibility of the integration of various analytical methods and techniques into compact and small footprint metrology equipment. Furthermore, the designed platform is an enabler for meeting the requirements for mapping and contamination-free handling of large substrates. The key component of the platform is the stage aligning the large samples with the detectors and various light sources. The approach presented enables a broad scope of analytical techniques.

The stress applied to the wafer is comparable to the manufacturing environment. Reliable analysis is possible due to the contaminant-free environmental condition of the metrology chamber.

The goal of the design study was to highlight all aspects, *e.g.* economic and scientific, of the design and realization of a metrology platform for wafers with a diameter of 450 mm. The criteria studied are the

- analytical performance of the methods, which includes the determination of structural and compositional information, including material parameters of surfaces on wafers with a diameter of 450 mm,

- complementarity of the analytical techniques, which means the usage of different analytical techniques to assess the surface to improve the reliability and traceability of the results,

- tool performance (*e.g.* spatial resolution, measurement speed, mechanical components), and

- costs.

The results of this study are presented in two tables. The typical properties measured using the various analytical techniques described above are presented in Table 3. The table

Table 2 Overview of the analytical methods, measurement setups, required components, and applications.

Method	Incidence angle θ/°	Detection angle/°	Detection systems	Application
TXRF	0–0.9	90, 2θ	SDD, diode	Elemental (B-U) surface contamination
GIXRF/XRF	0–30	$90-\theta$, 2θ	SDD, diode	Depth profiling, nanolayer analysis
XRR	0–30	2θ	Diode	Layer thickness
XRD	0–30	2θ	Diode	Crystal structure
GISAXS	0–2	2θ	CCD	Nanoparticles and nanostructures on surfaces
Ellipsometry	15[a] (standard setting) 0–25 (extended setting)	2θ	Analyzer + photomultiplier, CCD system	Layer thickness, optical constants
Vacuum UV reflectometry	Normal incidence	—	UV and VIS spectrometer	Layer thickness

[a] All incidence angles are valid for beam incidence with regard to the target surface. Also the ellipsometry angle is given in terms of the target surface (15°) and not in terms of the surface normal (75°) by convention.

Table 3 Typical characteristics and properties of the analytical and metrology techniques to be integrated into the modular metrology platform.

	TXRF[15,27,28]	GIXRF[27]	XRF[24,28]	XRR[24]
Applications	Surfaces	Nanolayers, element depth profiles, implantation profiles	Bulk materials	Nanolayers
Properties to be measured	Mass density in the range of the elements B to U	Mass density, concentration, depth profile in the range of the elements B to U (modeling with roughness and density)	Mass density in the range of the elements B to U	Layer thickness, roughness, density
Detection limit	Approx. 10^{10} atoms per cm^2	Approx. 10^{12} atoms per cm^2	Approx. 10^{13} atoms per cm^2	2–5 nm
Range	10^{10} to 10^{15} atoms per cm^2	10^{12} to 10^{17} atoms per cm^2	ppb – %	5–500 nm
Accuracy (and reproducibility) (*reference-free)	0.15*/0.05 (0.02)	0.2*/0.05 (0.03)	0.2*/0.05 (0.03)	0.02 (0.01)
Spatial resolution	1 mm^2 to 1 cm^2	0.5 mm^2 to 0.5 cm^2	to 1 mm^2	to 1 mm^2
Measurement speed	50–1000 s per pt	2000 s to 5 h	100–1000 s	1000 s to 5 h
Costs	100–300 T€	100–300 T€	100–300 T€	100–300 T€
Strengths	Highest sensitivity	Depth sensitivity	Good quantification	Nanolayer determination
Weaknesses	Quantification	Calibration	Atomic fundamental parameter	Opt. constants, increase of uncertainty < 2 nm

	XRD[29]	**GISAXS[21]**	**VUV Reflectometry[24]**	**Ellipsometry[30]**
Applications	Thin layers	Nano structured surfaces, thin films	Surfaces, thin layers	Surfaces, thin layers, bulk materials
Properties to be measured	Layer thickness, orientation	Particle size	Layer thickness, roughness, material concentration	Layer thickness, optical properties, composition, roughness, interface, quality, crystallinity, band gap, homogeneity
Detection limit	3 wt%, 2 nm	2 nm	0.1–1 nm	0.1 to 1 nm
Range	0.1–10 nm	2 nm to 1 μm	1–100 nm (for 120–800 nm wavelength)	1 nm to 10 μm (for 300 nm to 800 nm, or extended: 200 nm to 1700 nm)
Accuracy (and reproducibility) (*reference-free)	0.05 (0.02)	0.15 (0.02)	Minimum 0.02 nm (0.002 to 0.003 nm required for 2 nm 10 nm oxide films on Si)	Minimum 0.02 nm (0.002 to 0.003 nm required for 2 nm 10 nm oxide films on Si)
Spatial resolution	0.5 mm^2 to 0.5 cm^2	0.5 mm^2 to 0.5 cm^2	35 μm × 35 μm	3 mm to 50 μm
Measurement speed	1000 s to 5 h	10 min per frame	3–10 s per pt	0.1 s to approx. 1 min per pt for CCD system; depending on requested S/N
Costs	100–300 T€	200–600 T€	500 T€	50 T€ to 200 T€, depending on type and wavelength
Strengths	Nanolayer determination, lattice constant, stoichiometry	Particle size distribution determination	Fast, non-destructive, measurement of small spot sizes at vertical incidence	Sensitivity sub-monolayer in thickness, 0.0005 (short term repeatability) in refractive index, fast, non-destructive, measurement of small spot sizes, reference-free, complex refractive index from one measurement
Weaknesses	Beam divergence, sample alignment, roughness	Measuring range 10 nm to 100 nm	Only reflectance spectrum, indirect analysis by modeling; determination of opt. constants < 2 nm	Indirect analysis by modeling; spot size not smaller than 50 micron determination of opt. constants < 2 nm

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describes method-specific parameters, *e.g.* the measurable properties, the limit of detection, range, accuracy, reproducibility, and the spatial resolution. The given specifications were obtained from the laboratory documentation available within the quality management systems of the ISO 17025 accredited testing laboratories of two research institutes and a national metrology institute.[23] Some of these results were estimated from synchrotron radiation based metrology.[15,21,23,24,33–37] Table 3 shows the capabilities and performance of the metrology platform in terms of *e.g.* the spatial resolution, accuracy, and detection limit concluded from the experience of the laboratories.

The expected duration of a measurement is important for the determination of the throughput of a tool. The throughput, the cost of the components, and the strengths and weaknesses are important aspects for the calculation of the cost of ownership. Furthermore, this supports engineers and the management for the decision on the pros and cons of different designs of a metrology platform. Therefore, the table presented is an important tool for the final realization of a metrology platform, taking into account the scientific and economic aspects. Both are crucial for the efficiency and unique selling propositions of a metrology platform.

From the scientific point of view, the complementarity of the methods is presented in Table 4. This is a matrix showing the various analytical techniques indicating validation, support, and additional properties and information supplied by the techniques. This table shows how the methods benefit from each other, enabling the highest reliability of the results. For example, GIXRF and XRR support each other by using the same parameters for layer thicknesses and properties, such as density and roughness.[25] The improvement of results can be shown for other analytical techniques, too.[26]

4 Metrology chamber setup

An advanced positioning system, presented in Fig. 2, was designed, enabling the analytical technique for accessing each position on the wafer surface under various incident beam angles and considering the crystal orientation of the Si crystal of the wafer.[31] To clamp the wafer onto the positioning system, an electrostatic chuck, which can also be adapted to a vacuum environment, is used.[32] The design of the metrology chamber integrates all characterization methods mentioned above. An X-ray source assembly will be used for all X-ray based characterization methods.

For integration of the X-ray method, the following approach for components was applied. A Silicon Drift Detector (SDD) is mounted perpendicular to the X-ray source for the detection of X-ray fluorescence. For the GISAXS method, a CCD camera is positioned on the site opposite to the X-ray source. The CCD chip should have a minimal height of 18 mm to cover all reflected beams for a 2° incident angle difference. To trap the reflected beam in all measurements, different diodes are mounted on the 2-theta arm. The transfer of the wafer from the load lock to the metrology chamber is realized by a handling robot through a gate valve.

To integrate optical ellipsometry into the UHV environment, there are different options available on the market. Ellipsometry is a highly precise, complex optical measurement technique, typically performed in stand-alone measurement tools. The key to achieve precise measurements is the precise calibration of all optical components and the whole ellipsometer setup. In SEMI 141, a guide for specifications of ellipsometer equipment for use in integrated metrology is provided, covering commonly used ellipsometer systems, their components, notations in the measurement, and measures for ellipsometer calibration.[33] A variety of solutions for integration of ellipsometry have been demonstrated in the past. Integration of ellipsometry into vacuum environments may now rely on available commercial components and tested implementation procedures.[34,35] Typically, in ellipsometry and reflectometry, xenon bulbs, Quartz Tungsten Halogen (QTH) lamps and deuterium lamps are used to cover the wavelength ranges from the DUV/VUV to visible and near-infrared regions. The lamps should be mounted outside the vacuum chamber due to their heat production. In the CAD model, a VUV reflectometer is mounted on the top of the chamber. The light source is a deuterium and halogen lamp. The beam is guided through a beam splitter system at normal incidence on the wafer surface and continues to a VUV&UV/VIS (ultra-violet visible) spectrometer. Typical angles of incidence for the ellipsometer measurement are 15° to 25° to the surface normal of the wafer transfer plane, and the light beam must be coupled into the chamber over a viewport at these geometric specifications. Here, it needs to be considered that the viewport may cause birefringence and hence depolarization of the light beam. This can be avoided by application of special viewports in combination with calibration procedures to compensate for the errors introduced by the optical components. Commercial adapters are available which minimize stress during mechanical mounting and enable operation at UHV.[36] These UHV adapters can be mounted outside the chamber on both the beam incoupling and beam outcoupling sides. A special window is placed inside the UHV adapter. This window offers several advantages over normal viewports. The strain during mechanical mounting in the window itself is reduced; the stress-induced birefringence stays within a negligible range.[37] The second option is the use of a plane window for beam incoupling and outcoupling.

A typical measurement of spot size of spectroscopic ellipsometers which may be realized without using focusing optics is in the range of a few millimeters (parallel beam configuration). Alignment operations of the sample *versus* the plane of incidence of the light beam, as well as focusing of the sample surface *versus* the beam path through the aperture of the polarizer and analyzer, can be performed by the stage movement.

Unique to this setup is that the incident angle is dictated by the positioning system, and the beam sources are mounted onto the chamber at an appropriate angle. The detection angle is changed by means of a second goniometer, which acts independently of the positioning system. In comparison, there are combined metrology chambers available on the market that

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Table 4 Support and validation matrix of the analytical techniques to be integrated into the modular metrology platform.[a]

Methods	TXRF	GIXRF	XRF	XRR	XRD	GISAXS	VUV reflectometry/ellipsometry
TXRF		Surface contamination	Additional information on surface contamination	Additional information on surface contamination	Additional information on surface contamination	Nanoparticle composition	Additional information on surface contamination
GIXRF	Absolute angle calibration		Validation measurands	Element depth profiles near the surface	Element depth profiles near the surface	Nanoparticle composition	Element depth profiles near the surface
XRF	Validation measurands	Validation measurands		Information on material composition	Information on material composition	Nanoparticle composition	Information on material composition
XRR	Layer thickness and roughness as input parameters for modeling	Layer thickness and roughness as input parameters for modeling	Contamination/spectral diffraction artefact		Layer thickness, roughness, density	Substrate surface layer	Layer thickness, roughness, layer structure as input parameter for modeling
XRD	Information on material morphology, identification of diffraction artefacts	Information on material morphology, identification of diffraction artefacts	Information on material morphology, identification of diffraction artefacts	Information on material morphology		Information on material morphology	Information on material morphology
GISAXS	Particle size distribution	Particle size distribution	—	Particle size distribution	Particle size distribution		Particle size distribution
VUV reflectometry/ellipsometry	Precise layer thickness as input for the quantification or simulation of models	Precise layer thickness as input for the quantification or simulation of models	Precise layer thickness as input for the quantification or simulation of models	Precise layer thickness as input for the quantification or simulation of models	Precise layer thickness as input for the quantification or simulation models	Information on structures and dimensions for scatterometry measurement	

[a] How can a method (rows) help another method (columns) to improve or complement the results.

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Fig. 2 CAD model of the analytical platform for a 450 mm wafer (design study).

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usually rotate the radiation source while the positioning system is stationary.

5 Positioning system

To integrate all analytical methods into one metrology chamber, the positioning system is subject to many requirements. Therefore, a new approach for the design of the positioning system was considered[38] – a positioning system for positioning the wafer according to the preferred orientation. The positioning system presented here is a 5-axis positioning system. It enables 2D mapping of the whole wafer surface, as well as height and incident angle adjustment.

To realize a 2D mapping of the whole sample surface, three types of axes combination can be employed. One option for realizing a 2D mapping of the wafer is a so-called Rφ-system,[39] which is very well suited for round shaped samples such as wafers. In an Rφ-system, a translational and a rotatory movement are combined. Therefore, a path length equal to the radius of the sample is sufficient for a linear stage, which is placed on a 1-circle goniometer with 360° of rotation. Its rotation axis is in the center of the sample. In the presented version, the spatial requirement is drastically reduced compared to a common *xy*-stage.[40] The main element of the setup is a tilt goniometer, which allows a variation of the tilting angle of the wafer between +15° and −15° from the horizontal position.

For various applications, it is necessary to consider the crystal orientation[41] of the wafer. A patent with a solution to this issue has recently been submitted.[15]

In comparison with common positioning systems, which use an *xy*-linear stage to maintain the preferred orientation of the crystal structure of the wafer at all points of interest, the advantage of the manipulator described above is that a lot of space is saved due to the Rφ-geometry, while the preferred orientation can be considered at every point of interest.

If the individual components of the analytical methods cannot be mounted radially over the chamber wall, *e.g.* for reasons of space, they could be positioned side by side. For this application, the positioning system can be completed with a further linear stage which is mounted at the ground level under the 1-circle segment. The whole positioning system with the wafer can then be placed into the radiation plane using an additional linear stage.

6 Conclusion

The research results of a joint European Integrated Infrastructure Initiative showed the strength of complementary metrology for the characterization of thin films. In this paper, the achieved thickness results of Al_2O_3 high-*k* films were demonstrated to be reliable. Nevertheless, there are still unresolved issues, such as surface contamination through hydrocarbons or vertical uniformity of the deposited films. Interfaces also remain an issue. With respect to these open issues, it is recommended that different analytical methods are used for the study of thin layers and surfaces to benefit from their complementarities, improved reliability, and accuracy of the measurement results. Additionally, reference values for comparison can be obtained.

For enabling the characterization of wafers using different analytical techniques in one spot, it is essential to integrate various analytical methods into one small footprint metrology chamber. It has been shown in this design study that the

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transfer of long-approved UHV instrumentation for X-ray spectrometry at PTB can be adapted and extended to the 450 mm platform without constraints. The platform enables a local and contamination-free characterization of a wafer with a diameter of 450 mm, as well as reliable mapping of the whole wafer surface with different analytical techniques.

The new patented positioning system is the enabler for the implementation of various analytical techniques under the rather strict constraints of cluster tool dimensions. The new compact positioning system is essential for a 450 mm wafer because a large spatial requirement already results from the wafer size. The positioning system realizes the alignment of the height and the tilting of a sample in three axes in relation to a characterizing beam of a measuring device, as well as alignment of the preferred orientation. Depending on the handling robot, a 450 mm wafer and a 300 mm wafer can be surveyed in the metrology chamber presented.

The availability of crucial components is essential for the realization of the equipment. UHV components can be adapted to the 450 mm metrology station without constraints. A possible solution is a technology that fixes the wafer in the positioning system by using electrostatic forces. Such systems meet the requirement specification for flatness compatible with UHV environment.

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