Flexible EUV and XUV Spectrophotometer for reflection, transmission and absorption metrology.

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Introduction

Various tasks in developing and maintaining EUVL processes require accurate information on spectral properties of involved components. Besides very specialized tools tailored to ultimate accuracies for specialized tasks (e.g. geometries etc.) like e.g. our mask reflectometer EUV-MBR, R&D, application labs and fab metrology require highly flexible metrology tools to solve broad spectrum of tasks – some of them unknown, yet, only potentially arising in the future. We have realized an EUV Spectrophotometer adapted for the analysis of samples in the EUV, XUV and VUV spectral range.

Bruker's Compact EUV Spectrophotometer (CEUVS) is designed for measurements:

- Normal to grazing incidence reflection measurements
- Transmission measurements
- Small and wide angle scatter
- Near Edge X-ray Absorption Spectroscopy (NEXAFS)
- EUV/ XUV Ellipsometry

The tool concept has been developed such that adaption to various spectral ranges is possible. With the spectrograph based on EUV grating the wavelength range from 5 to 20 nm is covered such that measurements at 6.5 nm require adaptation of laser pulse energy. With such source adaptation and simple exchange of the grating the tool may be tuned to the soft-x-rays (1-6 nm e.g. water-window range) or VUV range (10-40 nm).

Potential Applications

Our techniques can cover wide range of potential industrial and scientific applications, e.g.:

- semiconductor industry,
- organic technology,
- biological analysis,
- oil tribology and environmental studies.

Benefits

Our laboratory stand-alone solutions exhibit specific advantages:

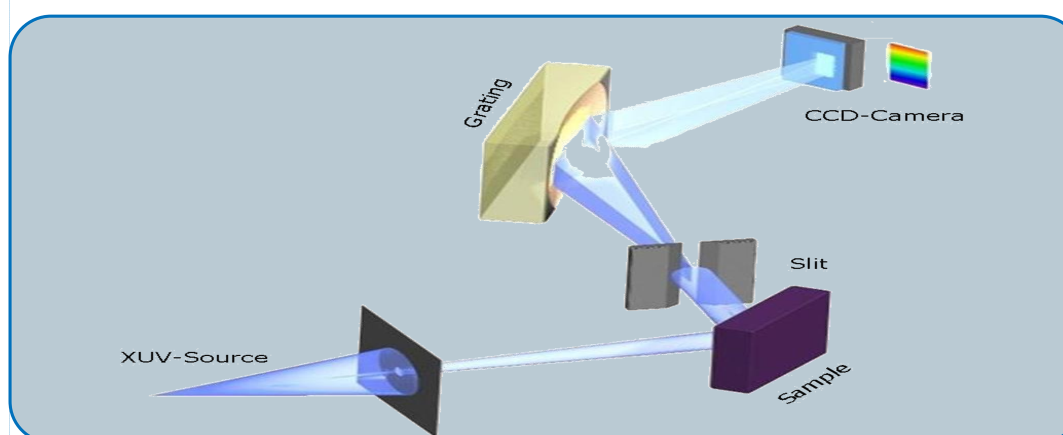
- availability at your home lab
- compactness
- low measurement time (few seconds)
- in-line/ in-situ with production systems
- Full spectrum with > 1000 channels of < 10 pm measured in less than 60 (opt. 20) seconds

Compact XUV Spectrophotometer by Bruker ASC

Techniques

Polychromatic Concept

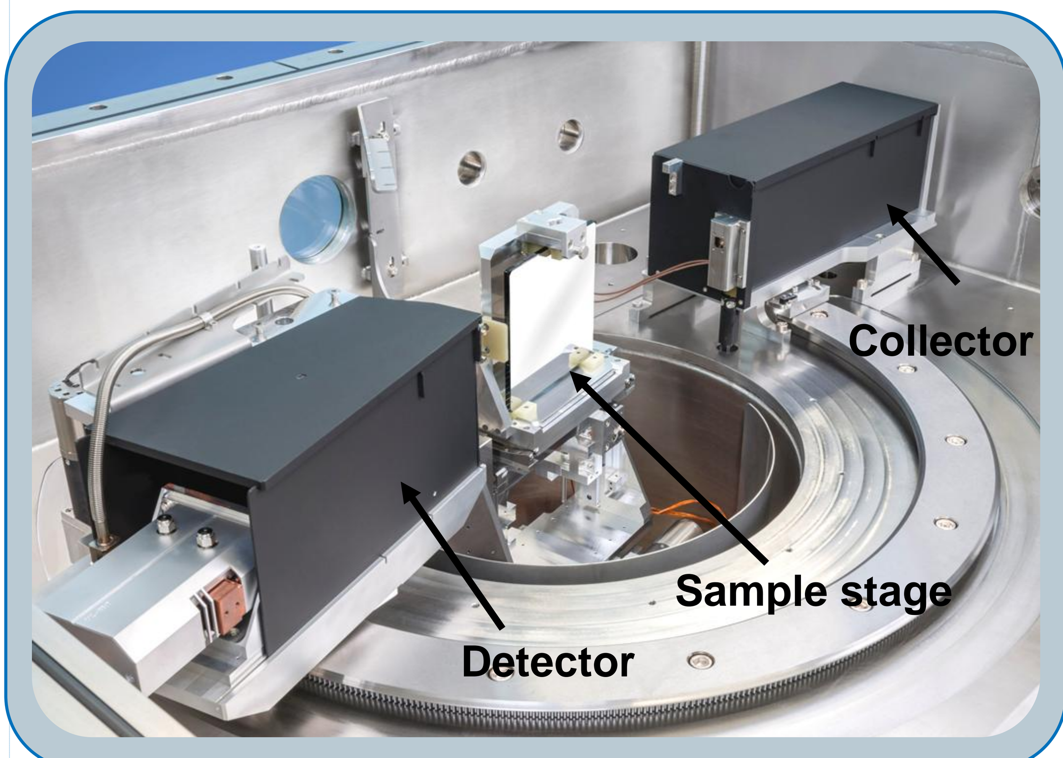
Our stand alone reflectometry and spectroscopy techniques are based on our proprietary polychromatic approach. In this approach the whole part of the spectrum emitted from the source falls onto the sample. The reflected light is spectrally dispersed and detected with a CCD detector. This concept, in particular, allows short measurement time (seconds or below) and fast data acquisition which is specially adapted to our plasma emitting thermal radiation sources.



Schematic of the polychromatic reflectometry concept

In-beam dose monitoring and calibration

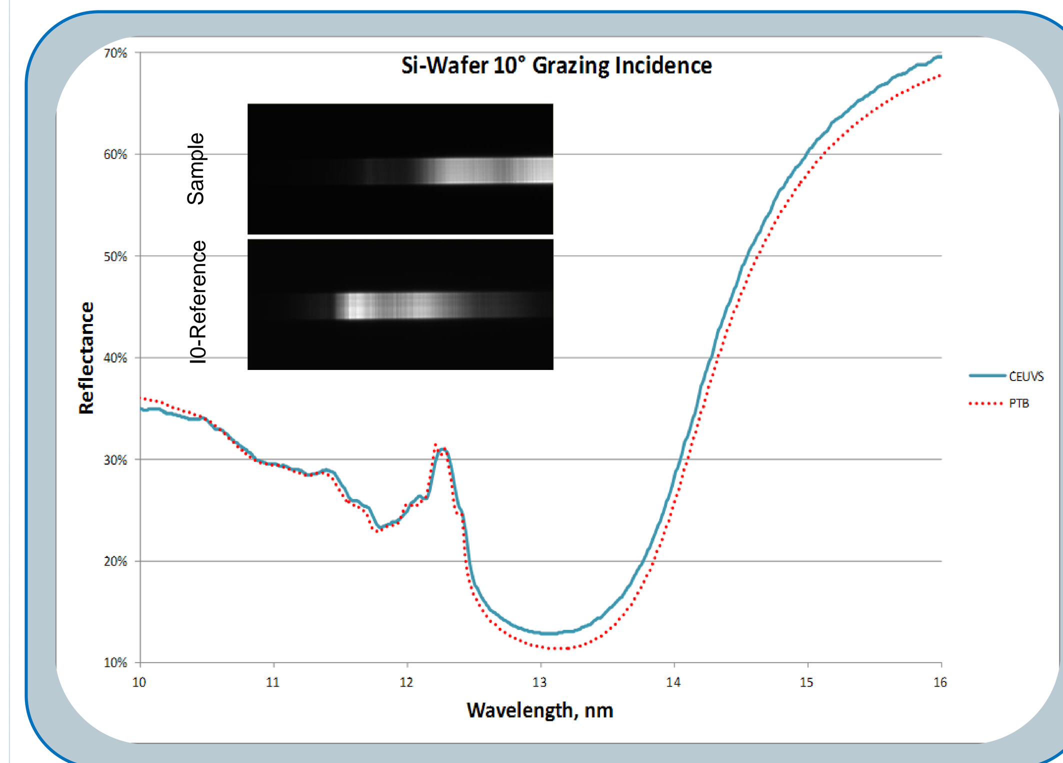
The CXUVS is equipped with a dose monitoring UNIT. This is designed to measure the integrated signal of the incident source beam which is used for the measurement. This device consists of filter and diode tools. For the evaluation procedure of the spectrum, the ratio of this value relative to the calibration value has to be used as correction factor for obtaining the right spectrum.
With measuring transmission of the vacuum, the tool is routinely recalibrated easily before and after each measurement series.
Wavelength calibration is imminent in each measure-ment with detecting gold emission lines. As no NIST data exist, we have calibrated those lines by cross-comparison with Krypton resonance absorption lines.



Main in-vacuum optical units of CXVUS collector module, sample stage unit and detector unit.

Samples

Samples may be nearly arbitrary sized plane or curved (R< 500 mm) ranging from full sized masks or mask blanks over few millimeter diameter transmission windows mounted on flexible sample holders or gases injected into the integrated gas cell.



Silicon wafer reflection measured with CEUVS, compared with the measurement on the same sample at PTB

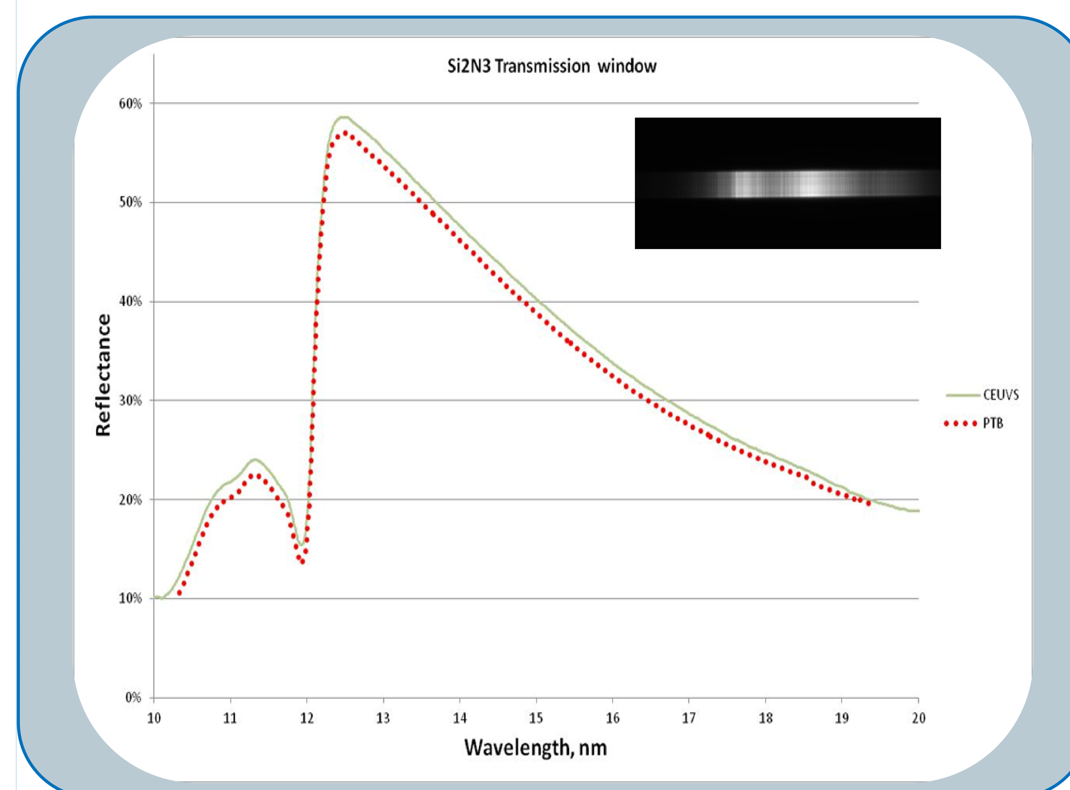
Measurement

Results

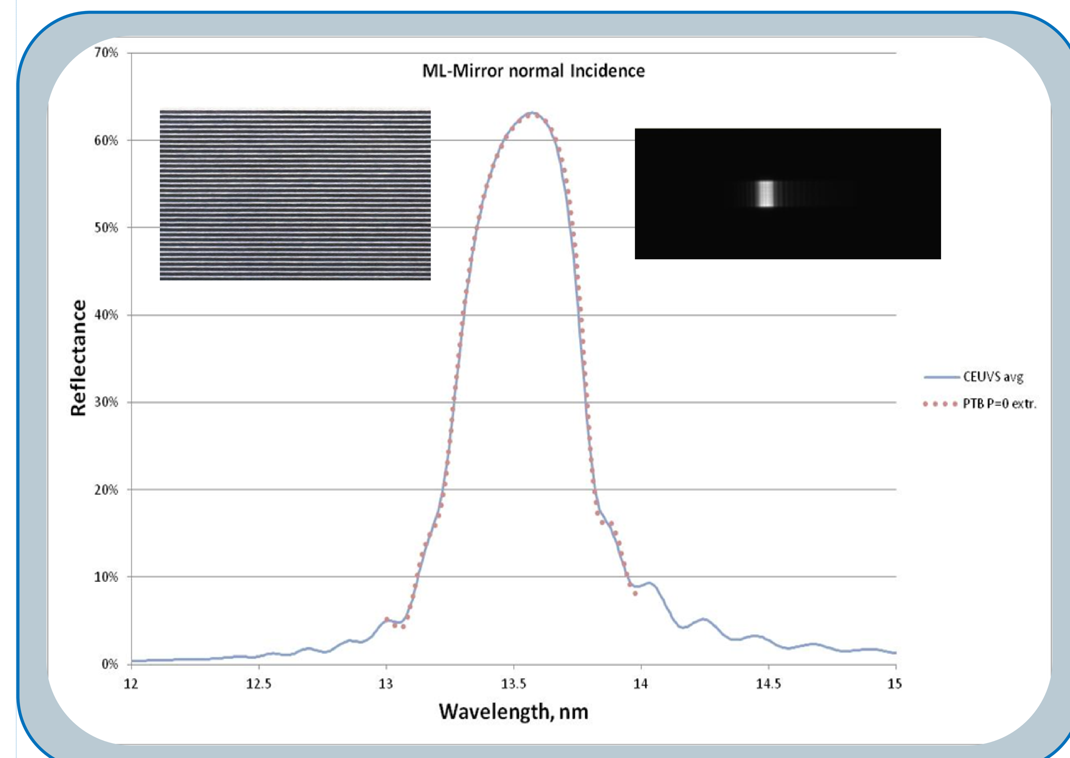
Measurements have been performed on mask blanks, 1 inch EUV-multilayer mirrors, and Silicon nitride windows, Silicon wafer grazing incidence reflection and noble gas transmission.

For some of the samples direct comparison with PTB calibration have been performed.

From this comparison, we learned – together with PTB – that considering polarization is crucial when comparing lab sources (< 5 % polarized) with beamline measurements (usually > 90 % s polarized),



The transmission measurement for Si-nitride windows, compared with the measurement on the same sample at PTB



Near normal incidence reflection of multilayer samples, CEUVS compared with resolution the same sample at PTB

Conclusions

- We demonstrate full functionality of our laboratory stand alone EUV and VUV spectrophotometer CEUVS for variety of measurements in transmission, reflection and window and gas absorption.
- Spot size used was < 100*100 µm²
- Exposure times for one single spot giving > 1000 channels of < 10 pm (EUV) resolution is < 60 (20) s.
- Accuracies in the range of ±1 % absolute and ± 10 pm in wavelengths (CWL_50, FWHM) have been routinely demonstrated.
- Reproducibilities and repeatabilites are in the range of 0.5 % absolute and 5 pm.
- Extended concept for enhanced accuracies exist.

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Compact EUV and XUV Spectrophotometer

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