

XUV-Lab-Systems: Achieving precision and accuracies approaching PTB with XUV-Spectrophotometers

Rainer Lebert, Thomas Missalla, Azadeh Farahzadi, Christoph Phiesel, Urs Wiesemann, Wolfgang Diets

Bruker Advanced Supercon GmbH, Waltherstrasse 49-51, D-51069 Cologne, Germany

Bruker ASC is developing and producing tools for metrology in the spectral range of 2 -60 nm (XUV) for both synchrotron beamline and laboratory use. Our approach in our tool developments is meeting user demands in EUV, XUV and soft x-ray metrology efficiently. Using our portfolio of sub-unit options, experience and design concepts we select and integrate the components, XUV-source, optical scheme, grating and detection as to supply the most suitable and simultaneously most economic solution for fulfilling the top-level specifications best.

With our laboratory stand-alone XUV-sources such systems are fully autarkic and can be set-up for different ranges of XUV radiation, e.g. soft x-ray (2-5 nm: 250-600 eV), EUV (10-20 nm: 60 – 125 eV) and VUV (20-50 nm: 25-60 eV). For spectrophotometric measurements, we have demonstrated that our polychromatic concept is such an efficient solution with lab sources. We have used this concept e.g. for high quality characterization of EUV-mask blanks or EUV components and explore its specific advantageous for many analytical techniques. Dedicated variants for specific tasks are easily tailored and may be extremely compact and economic. Such solutions feature the potential to be integrated as in-line/ in-situ metrology with production systems.

One of the demands of the customers is to best approach the precision and accuracy of the champion national labs like PTB. While precision is largely an issue of source monitoring and mechanical stability, accuracy is highly demanding. With the plasma based sources, which we are using, we have demonstrated to achieve brilliant wavelength precision and accuracy of up to $\lambda/\Delta\lambda > 10,000$, which is sub-pm for EUV at 13.5 nm exploiting tool internal calibration with plasma emission lines. On the other side there are multiple aspects to be solved to proof the amplitude accuracy of polychromatic lab measurements benchmarked with spectral scanning measurements at beam lines. Amongst others, the most obvious one are the different polarization properties of the sources, which –at least - need explanations to the customers.

The aspects and solutions are discussed on our latest product the XUV Spectrophotometer (XUV-SPM) which is designed to offer full flexibility. The XUV-SPM can cope with a large variety of sample types e.g. reflective mirrors under variable angles of incidence from 5 degree near normal to grazing incidence, transmission foils or windows and even gaseous media.

The XUV-SPM measures a full spectrum of > 2000 spectral channels with typical resolution of $\lambda/\Delta\lambda \approx E/\Delta E \geq 1000$ per channel from a sample spot of about 50 μm diameter in less than 30 seconds. Benchmarked with results from PTB at BESSY accuracies for amplitudes of reflectivity or transmission (e. g. peak reflectivity) of better 1% absolute and wavelengths (e.g. peak position) of better than $\lambda/\Delta\lambda = 500$ (e.g. 25 pm for 13.5 nm) have been demonstrated. Precision is about a factor two better.

With the achieved precision, accuracy and flexibility the XUV-SPM system is an alternative for the individual research lab for many tasks which are routinely being accomplished at beamlines. The specific advantages of the lab-system are costs, availability, compactness and fast measurements. Such, the XUV-SPM can be used for many tasks of qualification of nano layered samples, but also for analytical techniques in materials research, thin films such as GI-XUV-reflectometry, transmission spectroscopy and near edge absorption fine structure studies (NEXAFS). For example, sensitivities in the range of 0.1 nm on thickness variations of SiO₂ on Silicon or distinction of amorphous and crystalline AlO₂ have been found.

For more information, contact Bruker ASC, Waltherstr. 49-51, 51069 Cologne, Germany, XUV@bruker.com, Phone + 49 221 2925 1000