MEADOW 2013 – Poster list

G. Brenner - DESY

Photon beam diagnostics at FLASH1 and FLASH2

Photon beam diagnostics play an essential role for tuning free-electron lasers (FEL) and delivering the requested beam properties to the users. An overview of the FLASH1 and FLASH2 photon diagnostic devices will be presented with emphasis on the new pulse resolving intensity monitor covering an extended energy range.

C. Ozkan - XFEL

Semi-transparent bunch-resolved beam position monitors for the European XFEL: Qualification of a single crystal CVD Diamond Detector at Synchrotron and FEL sourcesSemi-transparent bunch-resolved beam position monitors for the European XFEL

Single crystal CVD diamond is commonly used as beam position monitors at synchrotron sources. It is radiation hard, possesses high charge carrier drift velocity and is semi-transparent at X-ray energies above few keV. This makes it a promising candidate for shot-to-shot beam position monitors for the hard x-ray beamlines at the European XFEL, considering the high intensity and repetition rate. However, the XFEL beam intensity is high enough to cause single shot damage to metal contacts. To avoid this issue, a different electrode geometry was utilized and qualified at two sources. Presented in this paper are the results from the qualifications carried out at the Micro-fluorescence beamline at ELETTRA (Trieste, Italy) and at the XPP beamline, LCLS (SLAC, USA).

I. Freijo Martin, M. Vannoni, H. Sinn - XFEL

Vibrations and interferometric measurements for the mirror chamber at European XFEL

The European XFEL will deliver SASE pulses with the peak power of up to 20GW. The facility will generate extremely short and intense X-ray laser pulses of high coherence and nearly diffraction limited divergence. Guiding these X-rays beams over a distance of more than 1 km to the experiments requires an extreme precision in the angular stability of optical components like mirrors and gratings. Since the photon energy will be tunable, readjustment of the incident angles at the offset mirrors will be needed in order to steer the beam to the right position and avoid beam displacements.

For this reason, the positions and vibrations in the offset mirrors need to be monitored with high precision, in the order of 10nm in position and 20nrad in angles. The first prototype of the mirror chamber, designed to hold one of the European XFEL mirrors, arrived at the end of July and the characterization measurements were started.

A test set-up based on two linear interferometers was built to monitor the angle position of a “dummy” mirror placed inside. The accuracy of the interferometer is about 1nm under optimal conditions but the set-up itself is highly influenced by environmental factors like temperature, humidity, air pressure and ground vibrations.

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The angular vibration level achieved until now is about 25nrad rms over 10 seconds. The observed long term drift is 500nrad over 24 hours without any optimized temperature controlled system.
To improve these results, we will optimize the floor mount and we will implement a temperature and air pressure control system.

M. Roper – STFC Daresbury
Prospects for Femtosecond Pulse Length Measurement on the FEL Test Facility 'CLARA'
CLARA is the Compact Linear Accelerator for Research and Applications, a proposed photo-injector driven linear accelerator for developing and testing novel schemes for producing ultra-short light pulses. It will be a test-bed for techniques such as laser seeding, laser-electron bunch manipulation and femtosecond synchronisation.
A necessary part of the project is the ability to make a full spectral-phase measurement of the light pulses generated. Since the light pulses could be as short as ~1 fs in a train with pulse separation of 167 fs, this is technically very demanding. A single-shot cross-correlation scheme with frequency resolved optical gating (XFROG) is proposed. The challenges and reasons for choosing this approach are explored in this poster.

P. Zuppella – LUXOR Padova
Solar particles damage effects on UV and EUV optical coatings
Multilayers coatings for space and solar applications are usually exposed to harsh environments. Thermal stress, ion bombardments and natural aging process can affect their performances over time. We have investigated the α–particles stability of UV and EUV optical coatings suitable for high–performance solar instrumentation. Experimental procedures, analysis and preliminary results are discussed.

S. Lin – NSRRC Taiwan
Metrology and performance of active gratings at NSRRC
A third order polynomial active grating was developed for soft x-ray spectroscopy at NSRRC. We used 2 bendable gratings at inelastic scattering beamline. The active gratings effectively eliminate the defocus and coma aberration to achieve the high resolution. Recently, we reached a high stably operation with resolving power of 10,000 at 870 eV. The active grating was composed of two main parts: one was a bender controlled by two PZT actuators, and the other was a plane grating with 0.3 ìrad rms slope error glued to the bender. Before the installation of gratings in the beamline, the surface profiles were measured by the long trace profiler (LTP). LTP had the stability around 0.1ìrad rms and repeatability around 0.06 ìrad rms. The different parameter settings of 2 PZT actuators for the high order coefficient C2, C3 in the different energy were also prepared by the LTP. After the gratings were installed in the beamline, the parameters setting of PZT from LTP were used as a reference, more fine adjusting of PZT actuator optimized energy resolution from the CCD spectrum.

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E. Ziegler – ESRF

Dielectric constant profile and roughness characterization of single metal layer x-ray optical coatings using x-ray reflectometry and scattering techniques

Single metal layer coatings for x-ray optical mirror applications were investigated both in the lateral direction, described by roughness parameters, and over depth through the dielectric constant depth profile. A dedicated UHV station installed at the ESRF BM5 beamline[1] allows depositing various coatings and studying their morphology through X-ray total reflectivity and diffusing scattering measurements at various grazing angles of the probe beam. The reconstruction of the depth distribution of the dielectric constant is described in ref. 2 and the method of determination of the PSD functions describing the roughness in ref. 3. However, as the determination of roughness and of the dielectric constant depth profile are affected by each other, a computational iterative procedure is used to consider the effect of roughness during reconstruction of the dielectric constant profile and, vice versa, the depth-distribution of the dielectric constant during determination of the Power Spectral Density functions describing the film roughness.[4] The particular case of silicon mirrors coated with tungsten films illustrate the approach.

1. L. Peverini, Ph.D. thesis, Univ. Joseph Fourier, Grenoble 1, Grenoble, France (2005).
2. I.V. Kozhevnikov, Nucl. Instrum. Methods A, 508, 3, 519-41 (2003)
3. L. Peverini, E. Ziegler, and I. Kozhevnikov, Appl. Phys. Lett. 91, 053121 (2007)
4. I.V. Kozhevnikov, L. Peverini, E. Ziegler, Phys. Rev. B 85, 125439 (2012)

Y. Yuan, J.-M. André, K. Le Guen, P. Jonnard – LCPMR-UPMC Paris

Analysis of nanoscale Co/Mo2C multilayer combing x-ray reflectivity and standing wave measurements

We present the optical properties of Co/Mo_2C multilayer by the x-ray reflectivity and standing wave measurements. These multilayers are prepared by the magnetron sputtering with the thickness of Co and Mo_2C is about of 2.6 and 1.5 nm, respectively. They are annealed up to 600°C and to characterize the thermal stability of this system.

The measurement of reflectivity is firstly performed at the wavelength of 0.154 nm and can be used to obtain the thickness, roughness ad density of each layer from the fit of data. Then the reflectivity at 1.33nm, far away from the Co L3 edge, is measured as to confirm the fitted structural parameters. The measurements made at the synchrotron application wavelength of 1.59 nm, close to Co L3 edge, show a good stability up to 600°C. The Co L α (3d -2p3/2 transition) emission intensity induced by standing waves is measured. During this experiment, a SDD detector collects the intensity of fluorescence as a function of the angle of incidence of the radiation on the sample when it is scanned around the first Bragg peak.

By reflectivity, it is found that the imaginary part of Co layers for as-deposited, 300 and 600°C annealed sample is 24%, 33% and 40% of tabulated value, respectively, and the real part is quite close to the tabulated value. This is confirmed by the fluorescence induced by standing waves where again it is necessary to take into account of the value of the imaginary part to adjust the Co Lα intensity curve.

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S. Dziarzhytski - DESY

First results of in situ alignment of Kirkpatrick-Baez refocusing optics at the PG1 beamline of FLASH1

S. Dziarzhytski1, H. Weigelt1, G. Brenner1, Tobias Mey2 and N. Gerasimova3 1 – DESY, Hamburg, Germany; 2 – Laser-Laboratorium, Göttingen, Germany; 3- European XFEL, Hamburg, Germany We present the first results of commissioning and alignment of the new Kirkpatrick-Baez (KB) mirror mount at the PG1 beamline of FLASH1. This mirror mount was designed and produced at DESY. Newly developed compact mirror manipulators enable in-situ adjustment of KB optics with required accuracy to focus the FEL beam to a focal spot size of below 10 µm. Focusing properties characterization is done in on-line mode by employing a specially developed portable UHV compatible diagnostics chamber[1]. This easy to use diagnostics tool allows combining three measurement techniques which all are used for the determination of the KB optics focusing properties: focus imaging by luminescence crystal, in-situ analysis of photo ablation imprints on PMMA surfaces, and wave front measurements. [1] In situ focus characterization by ablation technique to enable optics alignment at an XUV FEL source N. Gerasimova, S. Dziarzhytski, H. Weigelt, J. Chalupský, V. Hájková, L. Vyšín, and L. Juha, Rev. Sci. Instrum. 84, 065104 (2013)

I. Kieffer - ESRF

Design of a new beamline for high resolution absorption spectroscopy at the ESRF: FAME-UHD

Isabelle Kieffer, Pierre-Alexandre Bertrand, William Del Net, Philippe Jeantet, Jérôme Lacipière, Eric Lahera, Alain Prat, Olivier Proux, Emmanuel Roy, Olivier Ulrich , Jean-Louis Hazemann

Due to an increasing demand for detection of highly diluted elements emerging from the FAME users community, a new beamline dedicated to high resolution spectroscopy and using analyzer crystals spectrometer will be built at the ESRF. This new beamline, FAME-UHD (French Absorption spectroscopy Beamline in Material and Environmental sciences - Ultra-High Dilution), will be complementary to the existing FAME beamline, with the same target scientific communities: environmental sciences, geology, materials, chemistry. The beamline is under construction and will be opened to users in 2016. FAME-UHD is supported by the french grand emprunt" EquipEx (EcoX) and CNRS-INSU. FAME-UHD will be built on a bending magnet port. It will be composed of a first vertically collimating low-pass filter mirror a double crystal monochromator with dynamical sagittal focusing by the second crystal low-pass filter mirror. A particular care is taken to optimize the photon flux and the vertical size of the beam since the quality of the high resolution spectra will highly depend on those two factors. This poster will first present the ray tracing calculations carried out in order to define the mirrors size and position. Indeed the sagittal focusing induces distortions in the vertical direction of the x-rays which degrades the vertical shape of the spot. It is thus necessary to determine the optimal size and position of the elements as a function of the possible horizontal acceptance. We will also present the thermal calculations carried out to optimize the design and the cooling system of the first mirror. Multicrystal Johann-type spectrometer is designed in order i) to discriminate the photons issued from the sample with an optimal energy resolution (c.a. 1-2eV) and ii) to collect these photons on a large solid

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angle. Several bent crystals are distributed around the sample in Bragg condition with respect to the selected photon energy. Optimization of the position of the different crystals has been done by following different criteria : size position and intensity of the diffracting spot on the detector. Two approaches are used for the design analytical and ray-tracing calculations and key results will be confronted to measurements with a prototype.

P. Miotti – CNR-IFN Padova

Portable spectrometer for photon in-photon out experiments in FEL beamlines

We present a prototype of an innovative compact and easy to install spectrometer designed for photon in-photon out experiments in FEL beamlines. The energy range covered using two interchangeable gratings is 30-800 eV. The typical case of use is single-shot x-ray emission spectroscopy or time-resolved pump-probe experiments. The instrument is designed to be mounted in different end stations, and at different distances from the target focal spot. It is equipped with an interchangeable arm that accommodates the entrance slit. This solution permits, when necessary, to insert a refocusing mirror in order to adapt the fixed diffraction grating geometry to the variable experimental chamber size. The entrance slit aperture is remotely controlled by a manual actuator, as for the two grating positions (this permits the grating selection and the fine position adjustment). To limit as much as possible the signal loss due to the gas in the target area, when gases are used as target, a shield is designed to envelop the instrument internally to the chamber where it is mounted. Moreover an ulterior aperture inserted in front to the entrance slit permit to increase the differential pumping capabilities. To maintain the pressure gradient between the inner ad outer parts of the shield, a pumping system is connected via a dedicated pumping flange to the spectrometer.
We discuss the design of the instrument and the characterization in the XUV range.

D. Duran, M. Thomasset – SOLEIL

Microfocalisation with Bimorph Mirrors on PROXIMA 2A at Synchrotron Soleil

D. Duran1, P. Gourhant1, M Thomasset1, S. Brochet1, J.F. Carré2, C. Lopez2, G. Fox1, M. Savko1, A. Thompson1, R. Signorato3, T. Moreno1, W. Shepard1

PROXIMA 2A is a fully tunable beamline at Synchrotron SOLEIL dedicated to micro-crystallography experiments on crystals of biological macromolecules. To produce a 10 µm x 5 µm focused X-ray beam with 1012 ph/s over the range of 5 to 15 keV, the beamline is equipped with two new generation bimorph mirrors in Kirpatrick-Baez (KB) configuration downstream of a U24 in vacuum undulator and a cryo-cooled channel-cut monochromator. Both 450mm-long mirrors were fabricated by SESO, and each contains a series of 12 high-voltage piezo actuators mounted laterally on the thick mirror substrate. The combined action of these actuators permits the curvature of the mirror to be fine-tuned by adjusting their voltages. Prior to installation on the beamline, the mirror surface profiles were tested, measured and fine-tuned while under power using a Long Trace Profiler in the Metrology lab at Soleil. Only a few cycles were necessary to adjust the actuators to obtain the best ellipse with the smoothest slope error on the mirrors (0.5 µrad rms or better). On the beamline, the X-ray cross-section at the entrance of the KB mirrors is about 2 x 1 mm, and each mirror is set at a grazing angle of 4 mrad. By optimizing the 12 electrodes with the same procedure as in the Metrology lab, the X-rays are neatly

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focused to its target value of 10 µm x 5µm. The optimization of the high voltage actuators is done in four steps:

1/ Determine a correction matrix by measuring the influence of the X-ray profile by each actuator on the mirror, and thus the curvature of the mirror.

2/ Measure the beam profile without any high voltage applied to the mirrors.

3/ Calculate the new voltages to be applied to the mirrors from the correction matrix that will optimize the curvature.

4/ Measure the beam profile with the new values of the high voltages applied to the mirrors.

After a few iterations of steps 3 and 4 the beam size is now 10 x 5µm on Proxima 2A. Here, we will present the results and discuss perspectives.

M. Kuhlmann – DESY

FLASH2 Beamline Concepts

FLASH2 is the major extension to the soft X-ray free-electron laser FLASH at DESY. An additional variable-gap undulator line in a new separate tunnel and a new experimental hall will turn FLASH into a multi-beamline FEL user facility. Online measurements of intensity, position, wavelength, wave front, and pulse length are optimized as well as photon beam manipulation tools such as a gas absorber and filters. The beamline system covers a wide wavelength range with beamlines capable to deliver down to 0.8 nm in the 5th harmonic. Also one of the user community's high interest areas, first harmonic wavelengths in the water window, is suited. In addition, other beamlines will cover the longer wavelengths from 6 nm - 40 nm and beyond. Proven concepts like the optical laser pump-and-probe instrument are taken over from the current operation scheme in an established way. Permanent endstations with specialized beamline layouts will be enabled.

C. Colldelram – ALBA

Design of a mechanically corrected mirror bender for sub-nanometer figure error

Design of a mechanically corrected mirror bender for sub-nanometer figure error Carles Colldelram, Claude Ruget, Josep Nicolas ALBA Synchrotron, Ctra. BP1413 km 3.3, 08290 Cerdanyola del Vallès, Spain. Email: josep.nicolas@cells.es The use of spring actuators to correct the residual slope errors of x-ray mirrors has been tested at ALBA as a valid technique to provide nanometer accuracy optical surfaces for x-ray mirrors. In particular, the technique has been applied to the focusing mirrors of the macromolecular beamline of ALBA (BL13-XALOC). These are two elliptically bent mirrors, for which root mean square values of slope errors of 55 nrad and 80 nrad have been achieved, for optical lengths of 300 mm and 600 mm respectively. In-situ measurements have confirmed that the figure error is preserved after installation and commissioning, and after more than 2 years of operation, including many bending and unbending cycles. In the case of these systems, the correction was basically limited by the resolution in force of the correcting actuators, which had been designed just for gravity sag compensation. However, there was an excellent agreement between the measurement and the prediction of the deformation. To improve the corrector actuators would, therefore allow for a better surface correction. In this work we present a project to develop a high accuracy mirror bender, designed to allocate high resolution correcting actuators, in order to reduce the residual figure error of the surfaces below one nanometer, while providing

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selectable focusing position by means of a high accuracy motorized bending mechanism. The proposed system is designed to be scalable in length, being the first prototype one meter long; and to operate in vertical or horizontal deflection. The system is also designed for ultrahigh vacuum compatibility. Among the mechanical features of the proposed system we have included a frictionless isostatic support for the mirror, to avoid any parasitic torsion or bending stress of the mirror. The bending torques are applied by motorized spring actuators. They include encoders and home switches for easy and safe operation. They also include high-resolution strain gauges, which provide direct feedback on the bending torque applied to the mirror. Another feature of the proposed system is a set of spring actuators, aimed for correcting the residual slope errors. The number and position of the actuators is calculated based on the initial figure of the mirror alone. The minimum distance between actuators is 22 mm. They are designed to provide either pulling or pushing force, at any longitudinal position of the mirror. The spring actuators are designed to provide high resolution and high stability of the correction. In addition to the mechanical design, we have developed several optimization algorithms. They are used to determine the position and forces required to correct the initial figure error of the mirror. We have also developed an automated process to implement these forces on the actual mirrors, as well as to obtain the design ellipse parameters. A prototype is being manufactured at the moment, and we foresee to obtain the first metrology results before the end of 2013.

J. Nicolas - ALBA

ART: A ray tracing suite optimized for beamline simulation and design

Josep Nicolas1, Alessandro Barla2 Jordi Juanhuix1 ALBA Synchrotron, Ctra. BP1413 km 3.3, 08290 Cerdanyola del Vallès, Spain. Istituto di Struttura della Materia, ISM-CNR, S.S. 14 km 163.5, I-34149 Trieste, Italy. The Alba ray tracing code (ART) is a suite of Matlab functions and tools designed for the ray tracing simulation of x-ray beamlines. The suite is a complete package of functions and graphic user interfaces that include Monte Carlo generation of usual synchrotron radiation light sources (bending magnets, undulators and wigglers) and ray propagation on the usual optical elements used in beamlines (mirrors, gratings and crystals). The code is structured in different abstraction layers, which can be accessed both from a graphical user interface (GUI) and from the Matlab console and scripts. This allows for high programmability taking advantage of the Matlab programming structure, but also for simplicity of use, as provided by the GUI. The most basic layer includes the generation of specific x-ray sources, and the interaction of rays with single optical elements. Above that layer, there is a set of functions that allows creating optical systems composed from several optical elements, for instance the orientation of the mirror and gratings of a monochoromator can be configured by simply setting the tuned energy of the monchromator. The highest level is the graphic user interface of ART, which handles the configuration and simulation of a whole beamline. One of the most useful features of ART is that the beamline configuration files are Matlab scripts themselves; this allows the user introducing code in the beamline configuration file. This is very useful during the design phase of the beamline, since one can change the geometry of the beamline and easily recalculate the required changes on the radii of curvature of the optics. This feature is also useful to check alignment sequences, before they are used in the actual beamline. The output of

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ART is based on histograms of rays, evaluated at the different propagation planes. They are normalized to provide physical values of photon flux and photon flux density. In addition, ART is capable of accumulating statistics on the histogram preserving the flux normalization. With this, one can perform beamline simulations using millions of rays, without memory allocation limits, and still with inmediate information. ART includes also several extensions tools that provide useful functionality for beamline design, and that can be used within design scripts. Examples of this are a tool for generating slope error files following the PSD of actual mirrors, or a tool to incorporate measured slope error profiles to the ray tracing. Other tools include functions to calculate tuning curves of undulators, or to determine power distributions at different optical elements. Also, having programmatic access to grating efficiency calculation using electromagnetic theory, allows for accurate and efficient optimization of beamline design.

F. Schaefers, A.A. Sokolov*, F. Senf, M. Mast, J.-S. Schmidt, F. Eggenstein, F. Siewert, A. Erko

The New XUV Optics Beamline at BESSY II

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At the BESSY-II synchrotron radiation facility a new Optics Beamline is presently set into operation within the framework of our newly established grating production facility /1/. It is coupled with a versatile Reflectometer /2/ as a permanent end station for at-wavelength characterization and calibration of the in-house produced precision gratings, mirrors, multilayered systems and novel nano-optical devices. The setup will be open for user operation in 2014 to carry out reflectivity projects in the XUV range (reflectometry, spectroscopy or scattering techniques). The bending magnet beamline has a resolution E/ΔE of appr. 10.000 (at 500 eV), a low divergence (0.5 mrad x 3.6 mrad, v x h) and a spot size (0.15 mm x 0.3 mm, v x h). The SX700 plane grating monochromator is equipped with two gratings (1200 and 600 l/mm). The 600 l/mm grating has been manufactured already in-house. Due to the wide mirror and grating angular range the beamline will provide a broad energy range between 10 eV and 2000 eV. Very high spectral purity will be achieved by (1) a higher order suppression system based on a four-mirror arrangement of different coatings insertable into the beam at different angles and (2) by a double set of absorber filters for high order suppression in a filter-slit unit chamber. Stray light and scattered radiation is removed by a set of in-situ exchangeable apertures and slits. Thus the new Optics Beamline together with the new 8-axes UHV- reflectometer is a powerful metrology tool and an unique scientific instrument for XUV reflectivity measurements in s- or p-polarisation geometry with linearly or elliptically polarised light on large samples up to 300 mm length and 4 kg weight.

Financial support of the European Community is gratefully acknowledged (ERDF-contract no. 20072013 2/43)

/1/ B. Loechel et al., Installation of a technological center for highly efficient optical gratings at Helmholtz-Zentrum Berlin (HZB), J. Phys.: Conf. Ser. 425 (2013) 212012
/2/ F. Eggenstein et al., A reflectometer for at-wavelength characterization of gratings, Nucl. Instrum. Meth. A710 (2013) 166–171

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A.J. Corso - CNR - IFN UOS Padova

Development of multilayer mirrors for Free Electron Laser applications

High brilliance extreme ultraviolet (EUV) femtosecond pulses with unprecedented photon fluxes are emitted by Free Electron Laser (FEL). Normal incidence multilayers (ML) are key elements in FEL beamlines and transport systems, and are used also to focus the beam in the experimental stations. Their use in place of a monochromator for wavelengths selection offers improved performances in wavefront preservation and efficiency. Ad hoc multilayer structures to be used in FERMI@ELETTRA transport system able to provide high reflectivity peak at the desired harmonic wavelength while rejecting the fundamental have been realized. They will be potentially employed also to realize delay line optical systems able to split the beam and temporally shift one component with respect to the other. Aperiodic multilayer has been ad-hoc designed and realized to focus the radiation in the EIS-TIMEX end-station, allowing experiments on warm dense matter dynamics. The survival of nanostructured coatings during experimental operation has been widely investigated. This task assumes particular importance when related to FEL applications, because of the high power of the sources. Extreme ultraviolet multilayers protected by capping layers of different materials were exposed to plasma source radiation generated with a table-top laser to study the irradiation damage mechanism to ultrashort beam. Threshold fluence was provided for each samples in order to determine the capability of the capping layer in protecting the structure underneath.

R. Sankari – MaxLab

Soft-X-ray beamlines at MAX IV

The presentation introduces the phase I soft-X-ray beamlines for the MAX IV project. The design principles resulting in SX700 based monochromator are presented together with the optical layout of those beamlines. The methods for modeling the beamlines and the critical parts within them are introduced.

F. Scholze - PTB

Characterisation of diffraction gratings by EUV scatterometry and GISAXS

Authors: Frank Scholze, Victor Soltwisch, Jan Wernecke, Michael Krumrey For more than 30 years, the Physikalisch-Technische Bundesanstalt has been strongly engaged in the field of metrology using synchrotron radiation. At present, at the electron storage rings BESSY II and MLS (Metrology Light Source), the activities extend over a broad range of fundamental and applied metrology in the spectral range from the far infrared to hard X-rays. EUV reflectometry and scatterometry has been developed in close cooperation with partners from industry and science for the characterization of optical elements for semiconductor lithography. In the X-ray spectral range, grazing incidence small-angle X-ray scattering (GISAXS) and X-ray reflectometry (XRR) are also used to investigate structural parameters of line gratings, especially pitch, duty cycle, groove width, and line height. We present the application of EUV scatterometry and GISAXS for the characterization of diffraction gratings with laminar or blazed structure. The examples cover commercially supplied gratings as well as test structures supplied by the Fraunhofer IOF. The gratings were produced using either interference or e-beam lithography or ruling technology. Although the diffraction efficiency in the EUV and soft X-ray spectral ranges of all gratings are comparable and reasonably close to the theoretical expectations, the diffuse scatter

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background in-between the diffraction orders differs by several orders of magnitude. For a blazed and a laminar grating, the direct determination of essential parameters like duty cycle and blaze angle by GISAXS is demonstrated.

K. Sawhney – Diamond

Further characterization of a super-polished bimorph mirror

The present push toward nano-focusing optics has created a need for mirrors with sub-nm figure errors and short focal length, but in addition there is immediate demand for X-ray optics capable of producing highly uniform "tophat" beams with user-specified sizes ranging from sub-micron to tens of microns. For both purposes, a novel super-polished active bimorph mirror has been developed [1], which provides variable focal distance and local figure control in the sub-nm range. This has been achieved by bringing two state-of-the-art technologies together: super-polishing using Elastic Emission Machining (EEM) from JTEC (Osaka) of an 8 channel, piezo bimorph mirror from SESO (France). In addition to the ex-situ characterization of the surface topography using the Diamond-NOM, the mirror has been extensively characterised on B16, Diamond's Test beamline using different *at-wavelength* metrology methods. These include pencil-beam measurements, grating shearing interferometry and X-ray speckle tracking technique. It has been shown that the *in-situ* metrology methods can be used to not only optimize the shape of the bimorph mirror and reduce figure errors, but also to correct and minimize the collective distortions of upstream beamline optics. Recent developments and characterisation of the super-polished bimorph mirror by using at-wavelength *in-situ* metrology will be presented.

D. Spiga – INAF/Brera Astron. Observatory

Mirror profile diagnostics from intra-focal X-ray imaging

One of the problems often encountered in X-ray optics is the assessment of the optical quality of mirrors that are not accessible to profile metrology. The direct proof of the optical performances can be obtained from an in-focus X-ray measurement, but this often requires a facility that is several meters long, and in addition does not provide a feedback to a actuator system, if present, because all the information regarding the mirror profile is collapsed into the the focal spot. However, this information can be retrieved from an intra-focus measurement, as usually done in Hartmann tests. We present an alternative method to diagnose the X-ray mirror profile, using an intra-focal, near-field image of the focused beam, without using an Hartmann plate. The method can be useful to drive the actuator array of an X-ray active mirror under X-ray full illumination.

F. Hennies – MAX IV

The MAX IV facility; a light source for the future

Currently a new synchrotron radiation source, the MAX IV facility, is under construction in Lund, Sweden. When becoming operational for users Jun e 21, 2016 the MAX IV facility will be the lowest emittance synchrotron light source in the world. The low emittance gives outstanding performance regarding brightness and coherence of the synchrotron light thereby enabling entirely new science. Here we first describe the details of the new MAX IV Laboratory light sources concentrating on the low emittance 3 GeV ring. Second we describe the already funded beamline

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program with e.g. a 10 nm focus hard X-ray beamline, soft X-ray beamlines with very high energy resolution and photon flux, and a high throughput macro-molecular beamline. Thirdly, we describe ongoing efforts to extend the beamline program and make full use of the outstanding properties of the radiation source.

A. Kime – Osaka Univ.

Development of an X-ray slope profiler for Wolter type telescope mirrors - Performance evaluation using geometric and wave-optical simulator

Wolter type I mirrors can fulfill the Abbe sine condition; therefore, they do not suffer from comatic aberration and can work as ideal imaging optics in the X-ray region. However, it is difficult to measure and fabricate such mirrors with high accuracy because of their steeply curved and aspherical shapes. In this study, we developed a novel X-ray slope profiler for Wolter mirrors; the profiler works on the basis of the pencil beam method and can determine slope error distributions on parabolic and hyperbolic mirror shapes. We investigated the feasibility of using our profiler for Wolter mirrors and estimated its expected accuracy using a wave-optical simulator based on the Fresnel-Kirchhoff diffraction theory. In addition, we examined the effects of positioning errors of the experimental setup used. Consequently, we found that our profiler can measure slope errors on a Wolter mirror for solar observation with sub-µrad accuracy even if experimental errors are present.

S. Qian - BNL

The developments of the NSLS II-NOM

The nanometer and nano-radian accuracy (nono-accuracy) measurements are extraordinary important for the National Synchrotron Light Source II (NSLS II). Recent tendency of synchrotron optics metrology is to use NOM system to reach nano-accuracy on testing near-plane mirrors. The NSLSII-NOM is developed with improvements on precise air-bearing system, solid hollow penta-prism, thermal stability, precise alignment method and noise reduction. Another purpose of developing NSLSII-NOM is to use it as a comparison device to develop new Nano-accuracy Surface Profiler (NSP) to test highly curved mirrors. The NSLSII-NOM's precise alignments are particularly introduced. 0.1 urad rms accuracy of stability, repeatability and comparison test result are presented.

E. Meltchakov – Lab. Charles Fabry-IOGS Palaiseau

Efficient and stable Al-based multilayer reflecting coatings for SR, FEL and astronomy

A need for reflecting optics in the extreme ultra-violet (EUV) range with specific spectral characteristics and enhanced temporal, thermal and radiation stability requires a new approach to the multilayer design and optimization of deposition process. We will report and discuss some aspects of the design, fabrication and characterization of reflecting multilayer coatings containing aluminum as low absorbing material for EUV applications, such as synchrotron radiation (SR), free-electron lasers (FEL) and solar plasma diagnostics. Recent advance in the development of tri-component Al-based multilayers has allowed us to produce the coatings having a high reflectivity in the range from 17 to 40 nm. The EUV peak reflectance higher than 50 % between 17 and 21 nm and more than 40 % at longer wavelengths was measured with new multilayers Al/Mo/SiC and Al/Mo/B4C at near-

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normal incidence. We will present also more complex multilayer structures, which reflect more than one wavelength and reject some others within the above-mentioned spectral range. A good temporal stability of optical parameters of Al-based multilayer coatings is observed over the period of more than 4 years. Furthermore, the multilayer structures remain stable upon heating to 350 °C.

F. Frassetto – CNR-IFN Padova

Toroidal mirrors in grazing incidence for micro-focusing of attosecond pulses

The design of optical systems for micro-focusing of extreme-ultraviolet (XUV) attosecond pulses through grazing-incidence toroidal mirrors is presented. Aim of the proposed configuration is to provide a micro-focused image through a high demagnification of the XUV source with the following characteristics: i) almost negligible aberrations; ii) long exit arm to easily accommodate at the output the experimental setups required for the applications of the focused attosecond pulses; iii) possibility to have an intermediate region where the XUV beam is collimated, in order to insert a plane split-mirror for the generation of two XUV pulse replicas to be used in a XUV-pump/XUV-probe setup. We present the analytical and numerical study of two optical configurations characterized by two sections based on the use of toroidal mirrors. The first section provides a demagnified image of the source in an intermediate focus that is free from defocusing but has a large coma aberration. The second section consists of a relay mirror that is mounted in Z-shaped geometry with respect to the previous one, in order to give a stigmatic image with a coma that is opposite to that provided by the first section. The configuration that is presented aims to achieve spot sizes in the 5-10 um range with a demagnification higher than 10 in a compact envelope. The quality of the focus at the output is strongly depending on the fine alignment of all the optical elements and on the repeatability of the pointing of the laser beam that is used to generate attosecond pulses. To assure a reliable “day-by-day” operability of the beamline, a genetic algorithm controls all the movement of the three focusing optics (seventeen degrees of freedom) in order to optimize the spot quality. We present the characterization of the configuration obtained with visible light, in particular we demonstrate the coma compensation and the reliability of the genetic algorithm to converge to the optimum focusing.

M. Stoermer – Helmholtz-Zentrum Geesthacht

X-ray mirror development using the HZG sputtering facility during the last five years

Very long x-ray mirrors are required for beam transport at the upcoming free-electron lasers and synchrotron sources. An x-ray mirror is a combination of a substrate and a coating [1]. The demand for 1 meter long x-ray mirrors has increased during the last five years, since surface finishing technology is also able to process long mirror lengths on the sub-nanometer level [2]. Nowadays, thin-film fabrication is able to deposit some tens of nanometers of a suitable single layer material onto these substrates [3]. After deposition, the mirrors should provide excellent x-ray optical properties with respect to thickness errors, roughness values and slope errors; then, the mirror will transport the x-ray beam with high reflectivity, high beam flux and preserved wavefront to the experimental stations. An overview of the achieved results, current developments and new opportunities will be given.

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References [1] VDI/VDE guideline 5575, part 4, (2011). [2] H. Sinn, J. Gaudin, L. Samylova, A. Trapp and G. Galasso, CDR: X-Ray Optics and Beam Transport (XFEL.EU TR-2011-002). [3] M. Störmer, F. Siewert, J. Gaudin, Proc. SPIE 8078, 80780G-1 (2011). * michael.stoermer@hzg.de

M. Vervest – COSINE

Deconvolving mirror surface properties from X-ray probe-beams

For large future space-based X-ray missions it will be important to be able to characterize the properties very large mirror surfaces (of the order of hundreds of square meters). Due to time and manufacturing constraints it is practically impossible to do so fully using traditional tactile or optical profilometry methods. We present a study into the measurement of a mirror's surface quality based on the properties of a reflected X-ray probe beam. This type of measurement leads to a convolution of the beam with the surface properties. In order to retrieve the actual surface properties, one needs to disentangle the beam contribution from the observed reflected image: we have developed a numerical approach and we'll show some of the results. Additionally, we discuss how individual pencil beam measurements sampling a small fraction of the entire mirror surface can be compared to metrology obtained during the mirror manufacturing, and used in a statistical manner to predict the eventual performance of the entire mirror assembly.

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Metrology opportunities at BEAR

BEAR is a beamline al Elettra (Trieste, Italy) which delivers photons in the visible-soft-X range and offering a co-focal suite of optical and emission spectroscopic techniques with linear (*s* or *p* incidence) and variable elliptical polarized light including reflectivity (specular/diffuse), absorption (transmission, partial/total electron or photons yields), photoemission, fluorescence, luminescence. Beamline activity - oriented to basic science (electronic and structural properties with emphasis on surfaces, interfaces, low dimensional systems) gave rise to metrological procedures of use in the characterization of optical elements (multilayer mirrors, gratings, filters, detectors), polarimetry and the determination of optical constants. Present poster is focused on the presentation of metrological activity. BEAR is accessible through scientific proposals (http://www.elettra.trieste.it/userarea/user-area.html) or through commercial contracts (offers requests to be placed at BEAR_com@iom.cnr.it).

L. Raimondi, N. Mahne, C. Svetina, D. Cocco, F. Capotondi, E. Pedersoli, M. Kiskinova, B. Keitel, G. Brenner, E. Plönjes, T. Mey, K. Mann, and M. Zangrando

FERMI@Elettra K-B active optics system at the DiProI end-station

Kirkpatrick-Baez (K-B) active X-ray optics system is a good choice for focusing the free electron laser (FEL) pulses delivered by FERMI, the first seeded EUV-SXR FEL user facility operated at Elettra Sincrotrone Trieste. The present work reports the results obtained tuning this optical system used at the Diffraction and Projection Imaging (DiProI) beamline in order to improve and optimize its performance in terms of quality and size of the focal spot onto the sample controlling the fluence as well.

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To characterize the performance and develop reliable and reproducible focusing procedures we performed a campaign of measurements with several diagnostic systems, including a wavefront sensor mounted after the DiProI chamber. Online wavefront measurements have allowed for optimizing the bending acting on the mirrors curvature and the angle positions (pitch and roll) of the K-B system. The experimental results are compared with the predictions from simulations obtained using the WISE code, starting from mirror actual surface metrology characterization. Filtering the Fourier transform of the mirror surface profiles we have analyzed the impact of spatial wavelengths on the focal spot degradation. From the wavefront measurements we have inferred a focal spot of 10 µm x 10 µm confirmed by the PMMA ablation imprints. The results from simulations with the WISE code are in agreement with the measurements and for different energies of the incident beam we established the threshold when the focal spot degradation is not affected by the spatial wavelengths of the K-B mirror surfaces.

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