A new multilayer grating monochromator for the SIRIUS beamline @ SOLEIL

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SIRIUS

Motivations for upgrading the SIRIUS monochromator

The SIRIUS beamline of the SOLEIL synchrotron is currently equipped with a double crystal monochromator (DCM). Its Si (1,1,1) monochromator allows for 10^4 energy resolution in a range from 2.2 to 10 keV. Its 6 circles diffractometer allows for surface physics experiments for both solid and liquid phases.
Many elements of interest have K and L edges at energies close or below 2.2 keV and require a low energy monochromators. Crystals with large unit cell could be used but they are usually unstable under high flux of synchrotron radiation. Classical ruled gratings on the other hand have a low efficiency in this energy range. Solutions combining diffraction gratings and high reflectivity multilayer coatings have been investigated[1, 2, 3, 4, 5, 7, 6]. We have made for the SIRIUS beamline a quasi-checkerboard VLS grating which is used in combination with a multilayer mirror in a Petersen-like configuration. This solution looks promising in terms of total throughput.

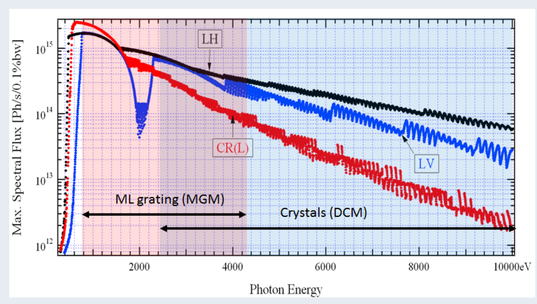


Figure 1: The currently available energy range on SIRIUS.

The SIRIUS beamline

- Versatile beamline
- Optimized for
  - diffraction (GIXD)
  - scattering (GISAXS)
  - fluorescence in grazing incidence condition
  - resonant or anomalous scattering at absorption edges of elements for soft matter , magnetism and semiconductors
- 2 different monochromators : DCM and MGM

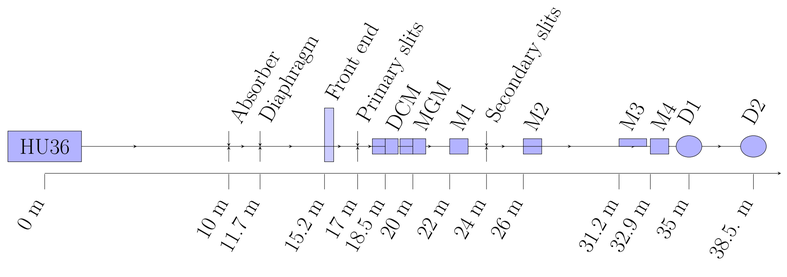
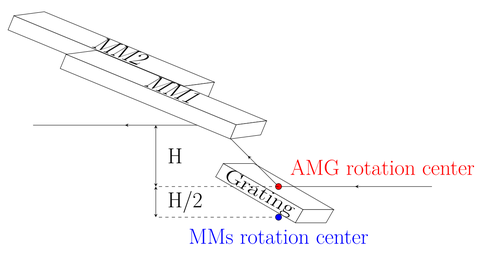


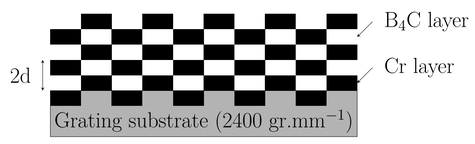
Figure 2: Schematics of the SIRIUS beamline (on scale).

Principle of the alternate multilayer grating monochromator

- 2400 groove per mm grating behaves crystal like cf. fig. 3b
  $\Rightarrow$ 2400 groove per mm yields high ultimate resolution
- Finely tuned angular law for grating yielding high flux
- Petersen-like with external focusing : fixed slits configuration
- 2 mirrors cover the path of the hit point in energy range



(a) Kinematic principle of the monochromator.



(b) Principle of the alternate multilayer grating.

Figure 3: Principle of the SIRIUS monochromator.

$\Rightarrow$ possibility to use x translation to maximize mirror period

- MM designed with a period gradient for high flux from 500 eV to 4.5 keV

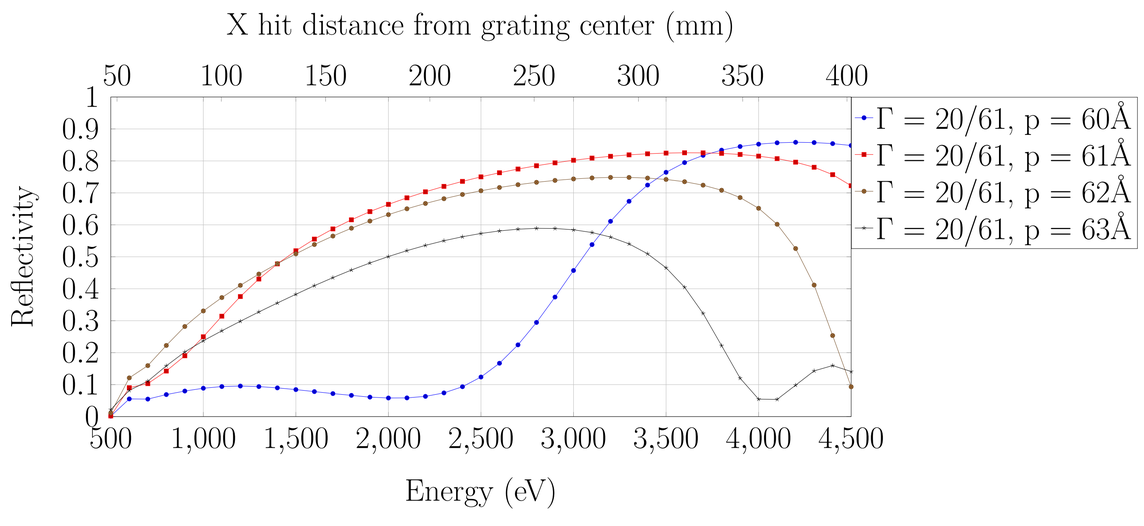
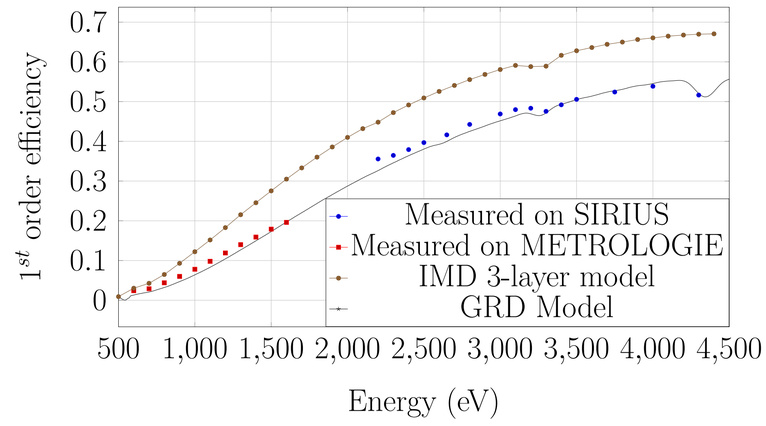


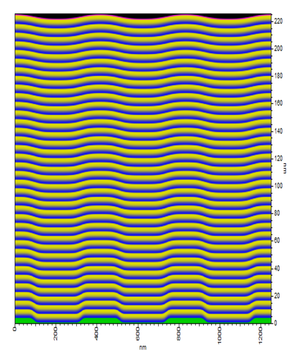
Figure 4: Expected reflectivity of the mirrors depending on the energy taking advantage of a small deliberate period gradient of the multilayer coating.

Measured efficiency of the grating

- Grating simulated with CARPEM
- Coating period mesured @ 8 keV and fitted with IMD
- Small period yielding non negligible interface effects : best model with index gradient and non conformity
- Achievement: great fit with GRD model up to 55% in first order !



(a) Measured efficiency of the new AMG grating.



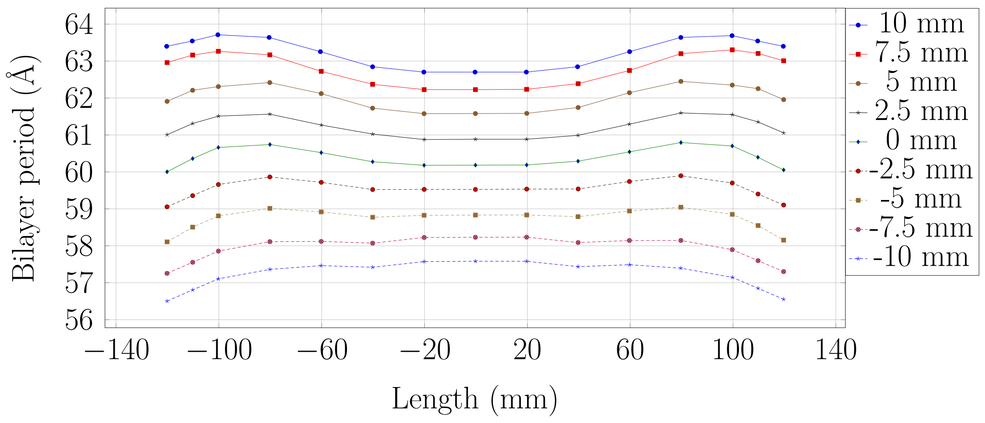
(b) The GRD Model for interdiffusion and non conformity.

- Side note : crystal behaviour with glitches (Ewald sphere intersects with -2 order)

Realization of the multilayer mirror

Amazing control over layer deposition (magnetron sputtering) allows :

- precise gradient across mirror
- deposition of homogeneous coating on 250 mm long mirror



The first EXAFS spectrum recorded on SIRIUS with the new MGM

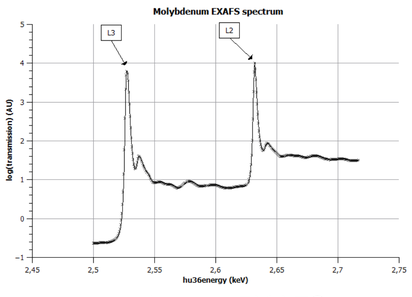


Figure 7: Mo L2 and L3 edges measured in an EXAFS spectrum with the SIRIUS MGM.

References

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