Challenges in development of an undulator-based photoluminescence spectroscopy beamline

Kirill Chernenko[1], Rainer Pärna[2], Marco Kirm[2], Weimin Wang[1], Antti Kivimäki[1]

[1]*MAX IV Laboratory, Lund University, Lund, Sweden*
[2]*Institute of Physics, University of Tartu, Tartu, Estonia*
kirill.chernenko@maxiv.lu.se

Synchrotron radiation has proved to be an irreplaceable excitation source for photoluminescence studies of wide band gap materials [1]. The Finnish-Estonian Beamline for Atmospheric and Materials Sciences (FinEstBeAMS) [2], located at the 1.5 GeV storage ring of the MAX IV Laboratory (Lund, Sweden), is a multidisciplinary beamline aimed at studies in VUV and soft X-ray energy ranges. Its instrumentation includes a dedicated PhotoLuminescence End Station (PLES) [3]. The beamline's photon source is an elliptically polarizing undulator, and the photon beam is monochromatized by a grazing incidence monochromator of cPGM type. This makes the PLES stand out from the previous generation of photoluminescence beamlines that typically utilize bending magnet radiation and normal incidence monochromators. Such a solution provides significant advantages. Undulator generates photon flux which is 1-2 orders of magnitude higher than flux that can be achieved with a bending magnet. Combined with the cPGM monochromator, it affords superior photon flux at the end station (10^{11}-10^{12} ph./s) while maintaining high energy resolution (R~3000). The energy range provided by the beamline extends into the soft X-ray region, up to 1300 eV, that opens a possibility for X-ray excited optical luminescence studies and irradiation of the samples for studies of radiation-induced processes. The beam spot size on the sample is in the order of hundreds of micrometers, which simplifies light collection and allows efficient measurements of small samples.

At the same time, this beamline design results in several experimental challenges. The main one is connected to relatively high efficiency of higher diffraction orders in grazing incidence monochromators: higher undulator harmonics transmitted by the monochromator decrease quality of monochromatic radiation. Moreover, the undulator produces such a high number of photons in the soft X-ray energy range that scattered radiation also becomes a significant issue. Another issue arises from increased mechanical complexity of the system: time required for changing excitation energy becomes quite long, taking about 70% of overall measurement time in the excitation spectra measurements.

To solve the issue of higher-order and scattered radiation, a new grating with optimized grooves profile and optical coating was developed. To eliminate motion time affecting the measurements, control scheme for continuous scanning was implemented. In this report, the implemented solutions as well as the detailed characteristics and experimental capabilities of the beamline and the end station will be discussed.

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