Depth-Sensitive Grazing Incidence Crystallography: From Atomic to Mesoscopic Scale In-plane Structures

Dr Valeria Lauter[1]
[1]ORNL, Oak Ridge
lauterv@ornl.gov

Grazing Incidence Neutron Scattering experiments simultaneously measure specular reflection, off-specular scattering (OSS) and grazing incidence small angle scattering (GISANS) and deliver the most exhaustive and detailed information on the 3-dimensional structure of thin films and hidden interfaces on enormous length scale [1].
A high brilliance neutron sources, the first and second target stations at the Spallation Neutron Source at ORNL, provide unique conditions for experiments on small thin-film samples with complex structures for wave vector transfer extended from the total reflection region to inverse interatomic distances. The latter scales are accessible with grazing incidence diffractometry (GID) with its extreme sensitivity to near surface and interfacial phenomena, as well as to nuclear and magnetic scattering length density distributions across the thickness of thin film heterostructure. Such sensitivity is absent in conventional diffractometry.
The solution to access the in-plane atomic scale structures with the depth sensitivity implemented in the M-STAR reflectometer design [2] is a new option specialized for measurements of the grazing incidence lateral diffraction. This option will combine diffractometry with reflectometry using the same beam-forming and polarization set up, the advantages of ToF mode, as well as the depth-sensitivity. In view of the remarkable possibilities provided by the GID, it is also important to note that out-of-plane magnetization and the antiferromagnetic structures, which are not accessible in conventional reflectometry, will be measured with GID . This property is essential for studying systems with perpendicular anisotropy, as well as with an anti-ferromagnetic structure.
Acknowledgement:
This research used resources at the SNS and the HFIR, which are DOE Office of Science User Facilities operated by the Oak Ridge National Laboratory (ORNL). This research used resources of the Spallation Neutron Source Second Target Station Project at ORNL. ORNL is managed by UT-Battelle LLC for DOE's Office of Science, the single largest supporter of basic research in the physical sciences in the United States.

References
{1} H. Lauter, V. Lauter and B. Toperverg, Polymer Science: A Comprehensive Reference, ed.
{2} K. Matyjaszewski and M. Möller, Elsevier, Amsterdam, 2012, pp. 411–432.
{3} Lauter V.V., Wang K., Mewes T., Glavic A., Toperverg B.P., Ahmadi M., Assaf B.A., Hu B., Li M., Liu X., Liu Y., Moodera J.S.,
{4} Rokhinson L.P., Singh D.K., Sun N.X., "M-STAR: Magnetism Second Target Advanced Reflectometer at the Spallation Neutron Source", Review of Scientific Instruments, 93, 103903 (2022).