X-ray diffraction and scattering techniques for characterization of nanoscale structures and dimensions on a multipurpose laboratory XRD platform

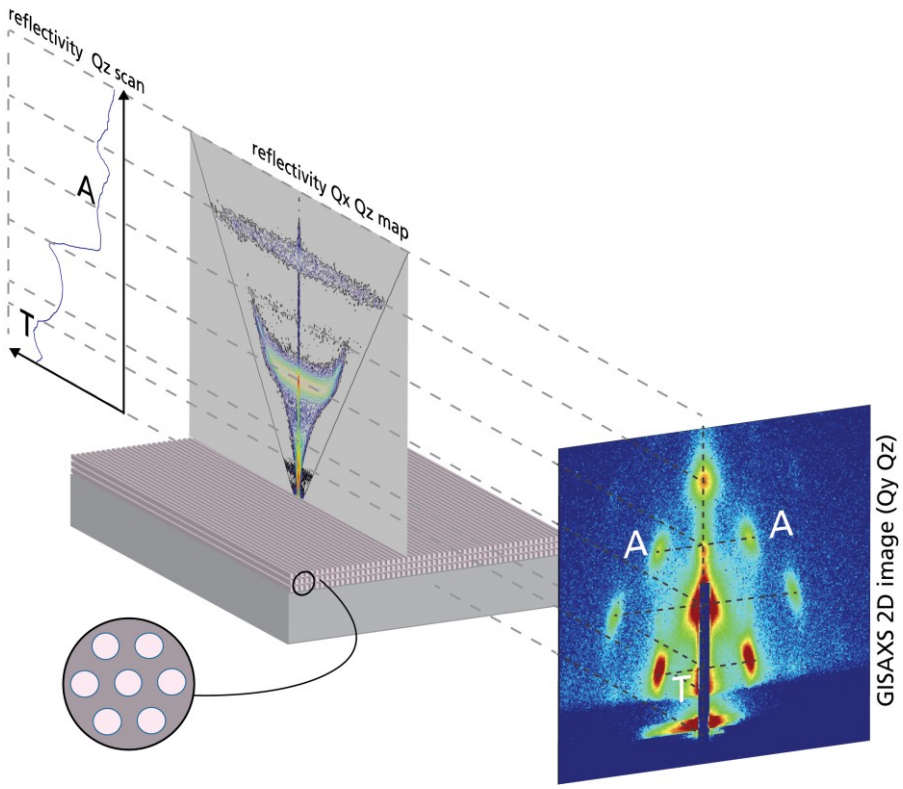
M. Gateshki[1], J. Bolze[1], P. Kidd[2], J. Bolivar[3]

[1]*PANalytical B.V. Lelyweg 1 (7602 EA), PO Box 13, 7600 AA Almelo, The Netherlands,*
[2]*PANalytical Research Centre, SINC University of Sussex, Brighton, BN1 9SB, United Kingdom*
[3]*PANalytical B.V., Sucursal en España, 28224 Pozuelo de Alarcón, Spain*

milen.gateshki@panalytical.com

Abstract The wavelength of X-rays is of the order of Angstroms, i.e. comparable to interatomic distances, which makes them ideal probes for studying atomic and nanoscale structures. X-ray scattering and diffraction are techniques widely used in materials characterization. Due to the large penetration depth of X-rays in matter these techniques can gain averaged structural information that is representative over a macroscopic sample volume. Unlike imaging techniques, X-ray diffraction and scattering do not provide direct images of the structures, but intensity distribution data in reciprocal space and data analysis software is required to translate these into real space structural information. These X-ray methods can be applied to virtually any sample type, ranging from powders and liquids to solid materials, fibers and thin films. Samples to be analyzed can be crystalline, semi-crystalline or amorphous. Sample preparation is often minimal and the measurements are usually non-destructive.

In this contribution we give an introductory overview of various X-ray analytical techniques that can all be applied for nanomaterial analysis on a single multipurpose XRD platform in the lab. These include X-ray reflectivity (XRR) for thickness analysis of layered systems; small- and wide-angle X-ray scattering (SAXS/WAXS) for nanoparticle size and shape analysis; and grazing incidence small-angle X-ray scattering (GISAXS) for surface related studies. Application examples will be given for samples such as nanoparticle systems, mesoporous materials, polymers, colloids and multilayer thin films.



A schematic illustration of the relationship between features observed using both reflectivity and 2D GISAXS. The sample is a thin mesoporous SiO_2 film supported on a Si wafer. The nominal diameter of the pores is 7.1nm.