Surface morphology of textured transparent conductive oxide thin film seen by various probes: visible light, X-rays, electron scattering and contact probe

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Fluorine doped tin oxide thin films (SnO_2:F) are widely used as transparent conductive oxide electrodes in thin-film solar cells because of their good electrical and optical properties. Thus, the surface morphology has an important influence on the optical properties of SnO_2 thin films. On a rough surface light is diffusely scattered, which extends the optical path of light inside the active layer of the solar cell and in that way improves light absorption and solar cell conversion efficiency. In this work, we investigated the surface morphology of undoped and doped SnO_2 thin films and its influence on the optical properties of the films. We have compared and analysed the results obtained by several complementary methods for thin film surface morphology investigation: atomic force microscopy (AFM), scanning electron microscopy (SEM), transmission electron microscopy (TEM) and grazing-incidence small-angle X-ray scattering (GISAXS). Based on the AFM, SEM and TEM results, we propose a theoretical model that reproduces well the GISAXS scattering patterns.

Keywords: surface morphology, surface roughness, thin films, tin oxide, light scattering, grazing-incidence small angle X-ray scattering

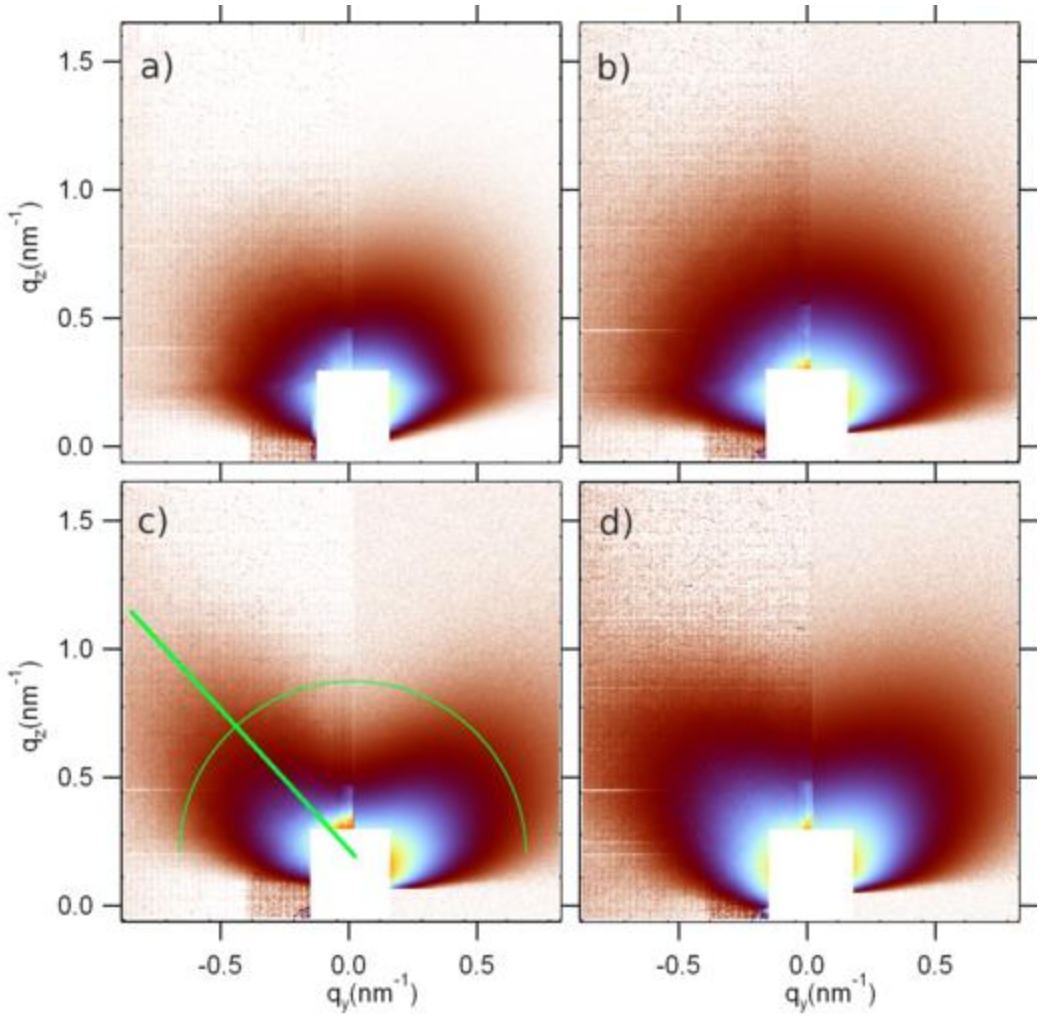

Figure 1. GISAXS pattern for SnO_2 single- and double-layer films on glass substrate for a grazing angle of incidence equal to α_c+0.1°. The left side of each subfigure represents experimentally obtained data, and the right side represents the result of the theoretical model application.