Tackling High Data Rates in GISAXS: Current Status and Future Challenges

M. Schwartzkopf

Deutsches Elektronen-Synchrotron (DESY), Notkestr. 85, D-22607 Hamburg, Germany
matthias.schwartzkopf@desy.de

With the emergence of 3rd generation synchrotron sources and 2D single photon count detectors with fast readout, *in situ* and *operando* real-time GISAXS investigation of nanoscale process kinetics with high acquisition throughput becoming more and more relevant [1]. The high time resolution in the millisecond regime allows for instance the determination of kinetics of initial nucleation and subsequent cluster growth during sputter deposition and enables a precise investigation of gold cluster growth kinetics under conditions advancing towards industrial manufacturing [2,3,4]. All of those studies yield results to identify four different stages of growth including their thresholds with sub-monolayer resolution during the first 8 nm of deposited gold. Each stage can be characterized by a predominant surface process and its intrinsic kinetics: nucleation, diffusion, adsorption and grain growth. The quantitative analysis is based on an analytical geometrical model [2]. This novel approach allowed simulating, visualizing and unambiguously interpreting gold nanocluster growth kinetics in terms of nanoscopic processes (Figure 1). Morphological real space parameters such as cluster size and shape, centre-to-centre distance, and the onset of long-range connectivity (percolation) are extracted, being of key importance for a high efficiency of plasmonics, sensors, and catalysts.

However, these fascinating experimental opportunities raise further challenges regarding data analysis of extensive data sets. In this context, the software package DPDAK developed at DESY (Hamburg) in collaboration with MPIKG (Golm) operates in a user defined plugin framework for specified reduction of huge amount of scattering data [5]. The software allows visualizing and quantifying the evolution of key scattering features in convenient clear presentations as contour plots even during the experiment. In near future, the rise of even more advanced light sources and much faster detectors with higher pixel density will enable submillisecond time-resolved GISAXS experiments and in turn potentiate the necessity for a fast data reduction and analytical modelling.

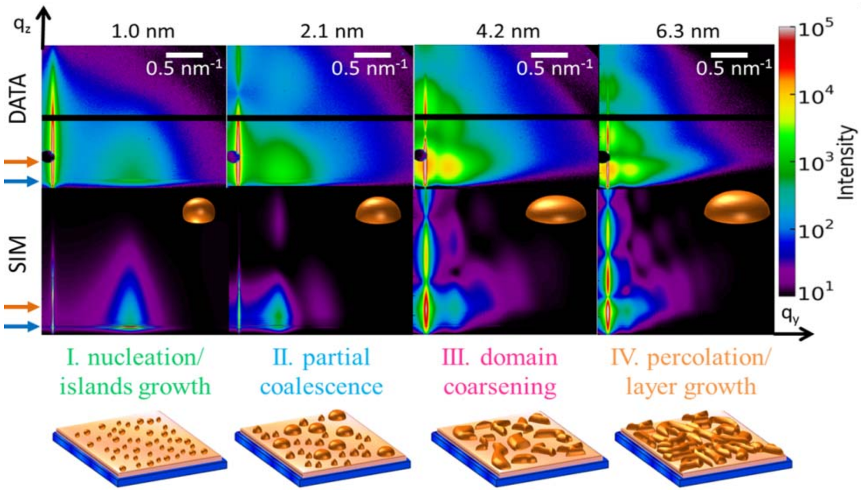

Figure 1: Sputter deposition of Au on PS. **Upper row:** Selected 2D GISAXS patterns with increasing effective Au film thicknesses δ_{Au}. The critical angles of PS (blue) and Au (orange) are indicated by arrows. **Middle row:** model-based simulation of the GISAXS pattern, based on the object shape sketched in the upper right corners. **Lower row:** Sketch of the cluster growth morphology with ongoing sputter deposition in the four stages of growth. See [4].

References

[1] Schwartzkopf, Roth, Nanomaterials **6**, 239 (2016).
[2] Schwartzkopf et al., Nanoscale **5**, 5053 (2013).
[3] Schwartzkopf et al., ACS Appl. Mater. Interfaces **9**, 5629 (2017).
[4] Schwartzkopf et al., ACS Appl. Mater. Interfaces **7**, 13547 (2015).
[5] Benecke et al., J. Appl. Crystallogr. **47**, 1797 (2014).