Challenges in Advanced Material Characterizations: Complex Interplay of Order and Disorder

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Advanced materials are rapidly expanding area with a strong promise in a number of applications such as smart devices, low-profile energy sources, wearables and healthcare. Despite rising interest, a number of issues need to be addressed before such hybrid materials can be routinely commercialized. The ability to design organic and hybrid systems possessing high stability and excellent optoelectronic performance remains a major challenge. A key enabler for design strategies of such hierarchical heterostructures is elaboration of the structural properties on the different length scales.

In the talk will be presented novel approaches for direct, time-resolved observations of the structural and optoelectronic properties of thin films and nanocomposites. A combination of X-ray reflectivity, grazing incidence X-ray diffraction and grazing incidence small-angle X-ray scattering allows us to probe the structural properties and morphology of the low-dimensional systems. Among them in situ grazing incidence X-ray diffraction is an attractive way of the structural characterization and a time-resolved determination of order-disorder variations during thin film formation. These studies allow us to unravel complex order/disorder interplay at the different stages of solidification process. Furthermore, time-resolved X-ray studies open possibility to monitor the structural improvement of heterostructures applying different thermal budgets. Such structural changes can be simultaneously combined the current-voltage characteristics of the active layers. Understanding of the microstructural development during the film fabrication process will enable to control and optimize the active layers of functional devices. Moreover, multiscale investigations of the structural and transport properties provide new insights into performance and functionality of heterogeneous thin-film systems. In particular, X-ray nanodiffraction reveals complex order-disorder interplay and a local orientation, probing an interconnectivity by novel X-ray cross-correlation analysis. Perspectives of the spatially-resolved nanobeam studies at novel synchrotron radiation sources with exceptional opportunities to observe the structural features down to nanoscale will be further highlighted.