Ions as spies: What does really happen during the formation of functional materials?

Modern technology pursuits the production of high-performance optoelectronic devices such as laptops, mobile phones and solar cells, which must be not only high efficient but also sustainable and environmental friendly. This fact imposes, however, a serious challenge to Chemists, demanding the development of new materials with optimized structure-related properties. Examples of such properties are luminescence, magnetism, electric or thermal conductivity, achieved through a high control over the formation of their crystal structure. The main objective of this project is to unravel the complex chain of events leading to nucleation and phase transitions, besides the formation of side products or reaction intermediates, tracking the ionic path from desolvation to the incorporation to the final product. For this purpose, a new technique called *in situ* luminescence analysis of coordination sensors (ILACS) was created. This approach introduces lanthanide ions as local “spies” to the structure of the studied compound. The spectroscopic properties of these ions are influenced by changes in the coordination environment, allowing to track structural transformations under real reaction conditions using fast charge-coupled device (CCD)-based detectors, in combination with *in situ* X-ray diffraction *(*XRD) analysis in the synchrotron facilities and also in common university laboratories. This work presents a summary of the resulting application of *in situ* measurements for studying the formation of emissive complexes, semiconductor and plasmonic nanoparticles as well as the future research on photoactive inorganic nanomaterials at the University of Kiel.