Summary

This thesis is divided into six chapters. The first chapter is the introductory chapter and it discusses about the nanomaterials we have used and its photophysical properties. It also tells the approaches we have applied to study the photophysics of those nanomaterials. Second chapter is all about the instrumentation techniques we have applied and rigorous data analysis. The next four chapters are the working chapters. The third chapter explores fundamental understanding of photoinduced brightness heterogeneity present in every nanomaterial and how easily it has been misinterpreted by photo brightening or optical trapping. An advanced PIE-FCS technique has been used to verify this phenomenon. Fourth chapter introduces facet engineered lead halide perovskites and their single particle blinking which concludes more facet gives you more room for interaction with the surface sentimental molecules which ultimately creates more trap defects. Thus, the blinking mechanism changes from less facet to more facet concluding more facet gives more trion. In the next chapter i.e., the fifth chapter we have explored the changes in trap states and optical properties in various phases of red perovskite and found that upon illumination the phase changes from emissive to non-emissive/low emissive. While the immobilized states dictate towards dominance of hot carrier trapping and trion formation in photobleached state, mobilized state nullifies the trion formation and supports multicarrier recombination model to explain the blinking behavious in solution state. The last chapter i.e., sixth chapter explores the effectivity of energy transfer efficiency from faceted nanocrystals to organic dye. Higher facet shows higher energy transfer efficiency via dexter pathway. Though efficiency increases with facet in ensemble study, single particle study tells similar per-dye efficiency irrespective of facetes. Across the working chapters, rigorous single-particle spectroscopy has been used to uncover the intrinsic photophysics of these nanomaterials before their deployment in practical optoelectronic

devices. We hope that the insights from this thesis will inspire young researchers and contribute to the informed design of next-generation quantum communication and photovoltaic technologies.