Reconfigurable nanoparticle assemblies guided by the topological defects of liquid crystals

Shu Yang

Department of Materials Science and Engineering, University of Pennsylvania, Philadelphia, Pennsylvania, United States

Abstract. Assemblies of functional nanoparticles (e.g. metallic and quantum dots) will lead to unique optical properties for potential applications in sensing, imaging, and light modulation. However, it remains challenging to dynamically and reversibly switch the assembly and disassembly of nanoparticles for a large shift of optical responses given a specific stimulus. Liquid crystals (LCs), owing to their anisotropy in molecular ordering, offer a new route to direct nanoparticle assemblies, and thus, optical responses. Here, I will show how we have brought together these two materials by patterning surface topographies, topologies, and chemistries to guide the molecular alignment of LCs on surfaces and interfaces. In turn, these surface cues create and control topological defects that allow trapping, transportation, and actuation of nanoparticles. Specifically, we show dynamic tuning the (dis)assembly of gold nanorods (AuNRs) in topological defects of nematic LCs confined within micropillar arrays near the phase transition temperature. Due to their anisotropic shape, AuNRs favor side-to-side packing in the isotropic phase to maximize translational entropy at the loss of rotational entropy but switch to end-to-end assembly in LC defect core when cooled to the nematic phase, which is energetically more favorable to maximize their occupancy of the disclination line. In turn, the localized surface plasmon resonance peak wavelength can be reversibly shifted more than 100 nm. The interplay of LC defect core at nanoscale and surface cues at the microscale to create topological defects as demonstrated in our systems suggest a new route in the quest for active and highly sensitive optical devices.