Spatiotemporal organization of biological membranes using nanophotonic tools

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The quest for optical imaging of biological processes at the nanoscale has driven in recent years a swift development of a large number of nanoscopy techniques. These, so called, super-resolution methods are providing new capabilities for probing biology at the nanoscale by fluorescence. While these techniques conveniently use lens-based microscopy, the attainable resolution severely depends on the sample fluorescence properties. True nanoscale optical resolution free from these constrains can alternatively be obtained by interacting with fluorophores in the near-field. Indeed, near-field scanning optical microscopy (NSOM) using subwavelength aperture probes is one of the earliest approaches sought to achieve nanometric optical resolution. More recently, photonic antennas have emerged as excellent alternative candidates to further improve the resolution in the near-field by enhancing electromagnetic fields into regions of space much smaller than the wavelength of light. Here, I will describe our efforts towards the fabrication of different 2D antenna arrays for applications in nano-imaging and spectroscopy of living cells with unprecedented resolution and sensitivity. In particular, I will show that in-plane dimer antennas provide giant fluorescence enhancement factors up to 10^4–10^5 times, together with nanoscale detection volumes in the 20 zL range. We have taken advantage of the superior optical performance of these in-plane antennas arrays together with their extreme planarity to enquire on the nanoscale dynamics of multicomponent lipid bilayers. Our results reveal for the first time the coexistence of fluctuating nanoscopic domains on both Liquid order and Liquid disorder phases of mimetic membranes, in the microsecond scale and with characteristic sizes below 10nm. These nanoscale assemblies might be reminiscent to those naturally occurring in living cells that in the absence of proteins and/or other stabilizing factors, are poised to be highly transient.