# Quantum nano-plasmonics for biosensing and bioimaging on the level of single molecules and virions

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**Abstract**

Recent advances in quantum engineering at the nanoscale have enabled the construction of nanoscale mesoscopic systems with quantum emitters, metal and dielectric nanostructures. These systems can exhibit profound quantum electrodynamic properties due to various physical mechanisms, including Foerster energy transfer, plasmonic field enhancement, and strong optical matter-wave coupling. We show that it is possible to completely block or increase the emission rate of fluorescent molecules in such systems - by more than three orders of magnitude - by carefully designing the energy levels of a specific system formed using a strongly coupled dye molecules in the shell and a plasmonic nanoparticle. The use such a nanoscale emitter of light is a versatile tool for detection of ultra-small concentrations as well as visualization of biomolecules and virions. Two specific cases of biosensing and bioimaging will be described: (i) Real-time imaging of single troponin-T molecules (heart-specific troponin isoform specific markers of cardiomyocyte damage) in human blood serum and measurement of troponin-T concentration with a clinically important sensitivity of about 1 pg/mL; (ii) Detection of only virulent single SARS-CoV-2 virus particles, and their discrimination from non-infectious SARS-CoV-2 pseudovirus particles. The approach is based on the use of a single-molecule-counting method that employs bright fluorescent emitters bound to SARS-CoV-2 spike proteins. The detected fluorescent signal is able to count the number of spikes on the single virus particle - the index of virulence of SARS-CoV-2 particles.