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THERMOSENSITIVE REVERSIBLE TUNABILITY EFFECT OF HYBRID DIELECTRIC SYSTEM

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At present work dynamic tuning of electric and magnetic resonances in bio integrated all-dielectric silicon nanoparticles was demonstrated experimentally. Nanoparticles was decorated with polyelectrolytes to accelerate a hydrophobic effect and achieve dynamic polyelectrolyte response with shell swelling vs temperature.

During last time all-dielectric nanophotonics have emerged with the multitude of Mie-type resonances regulating various linear and nonlinear optical properties of non-plasmonic nanostructures. For application of such system in nanophotonic structures require precise tuning of their optical properties. Regulation can be reached with different approaches such as a liquid crystals coating, mechanical stretching, thermo-optical effect and etc. Nevertheless, most of these methods demands a strong external stimulus (for example, illumination) or it could be limited by spectral response and efficiency of tuning. Here we report a new concept of assembly of similarly charged polyelectrolyte (PE) to accelerate swelling was suggested. Swelling is an important characteristics of PE multilayers, however, difficult to achieve with temperature. Herein, possible reversible swelling behaviour of PEs is explained by the contribution of hydrophilic repulsive and hydrophobic attractive forces in the formation of collapsed and gel phases.

In this work a new mild and reversible approach to tune the optical properties of silicon nanoparticle (Si NP) using a thermo-sensitive polyelectrolyte shell. For decoration of positively charged Si NP, we used mixture of both negatively charged heparin (Hep) and sodium polystyrene sulfonate (PSS). Such PE assembly started swelling during the heating in contrast to the similar system of oppositely charged PEs. Thus, here we increase repulsion interaction between hydrophobic and hydrophilic parts by temperature. To approve the thermodynamic favorability for the hydrophobic-hydrophilic interaction of PE shell, we performed quantum chemical calculations using density functional theory (DFT). The results of calculations reveal that self-assembly of functional monomeric unit of associate Hep + PSS via hydrogen bonding is thermodynamically convenient (by 7.9 kcal/mol in terms of Gibbs free energies). Our observation showing the possibility of controlling Mie resonance by the PE shell engineering demonstrates that these hybrid systems can have highly sensitive optical response which is easily manipulated through temperature.

In summary we have shown the possibility for resonant light-induced tuning of a reversible change in Mie-type resonances up to 60 nm within the visible range due to the changing thickness of the PE shell. This design of polyelectrolytes assemblies is fundamental for application of the system with a high-density shell and paves the way for next-generation nanophotonic systems.