Gold nanoparticle—liquid crystal thin film shows off photonic and plasmonic flipping

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Video Abstract

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Abstract

By coupling gold nanoparticles with a film of liquid crystals, researchers have assembled a structure whose optical properties can be modulated plasmonically. Able to switch between reflective and transparent, this “photonic sandwich” could find applications as a controllable light filter or smart mirror. Under light of a certain color, electrons in plasmonic nanoparticles sway in unison, generating a distinct optical signature sensitive to the size and shape of the nanoparticles and their immediate environment. For that reason, plasmonic nanoparticles have been used as biological and chemical sensors. And because that quivering of electrons can generate heat, these tiny particles have been valuable in sizzling tumor cells away with better-than-surgical precision. Despite these advanced applications, researchers are just beginning to understand how photo-excited nanoparticles deliver heat to their surroundings. In that spirit, the research team explored how this delivery would affect an exceptionally receptive material: a thermotropic liquid crystal. Reported in MRS Communications Volume 8, Issue No. 2, the senior author was selected to deliver the 2019 MRS Communications Lecture on the subject. The team cast an array of gold nanoparticles between two small panes of glass and filled the space with a heat-responsive liquid crystal. In their natural state, the liquid-crystal molecules are twisted perpendicular to the surface on which they lie. The periodicity of this twisted structure dictates the natural color of the thin film. Adding heat causes the molecules to untwist and thus the film to lose its color. This transition is what makes color changes in thermometer strips and mood rings possible. By exploiting the gold nanoparticles’ plasmonic properties, the researchers discovered that they could force that same switching behavior over a small area using a laser beam—all in a matter of seconds. Switching the laser off allowed the molecules of the liquid crystal to cool and relax back to their original configuration. Notably, upon irradiation, modulation of the wavelength occurs first, followed by the amplitude. What’s more, anisotropic nanoparticles such as gold nanorods could be useful in developing on-chip biophotonic sensors or thermo-plasmonic-driven microfluidic reactors for water sterilization. The team is currently working to push that versatility even further by incorporating nanoparticles of different materials and chemical functionalization. But already, the application prospects are encouraging. Easily tunable and functional over a large area, the team’s design could add a new level of flexibility to existing photonic and plasmonic devices.