Controlling Optics with Thermo-Plasmonics

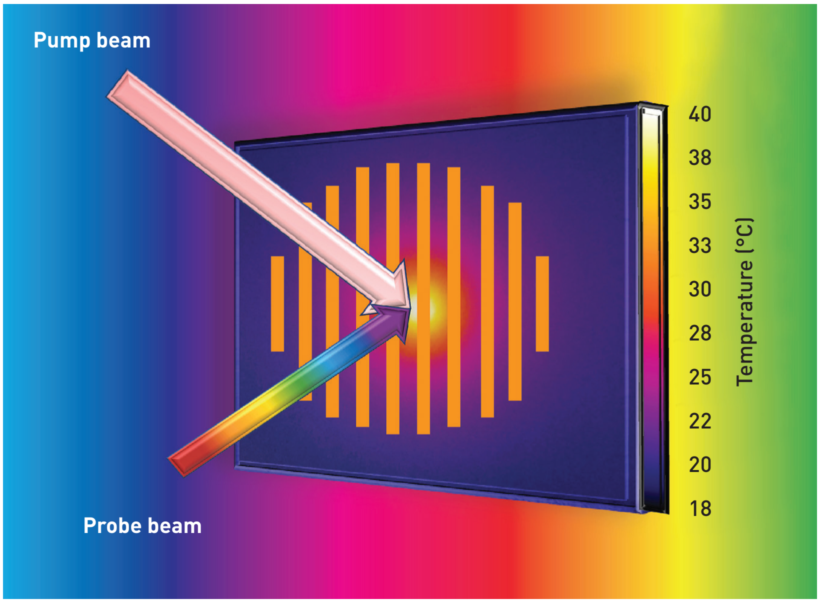
Thermo-plasmonics is an interdisciplinary research field dealing with the generation of nanoscale heating through the interaction between a suitable, resonant light source and noble-metallic nanoparticles (NPs). In recent years, thermo-plasmonics has been successfully employed in research fields ranging from electronics[1] to medicine.[2]

We have extended the utilization of thermo-plasmonics in optics by realizing a novel generation of light-controlled optical components. This achievement has been enabled through bridging the photothermal properties of gold nanoparticles and the thermo-sensitivity of liquid crystalline materials.[3,4]

As a proof of concept, we used the thermo-plasmonic heating of gold nanorods to activate and deactivate the diffractive properties of a reverse-mode diffraction grating made of nematic liquid crystal (NLC) and a polymerizable liquid crystal (PLC). The grating is completely "hidden" and appears as a transparent optical window in the off state because of the initial refractive-index match between the PLC-rich and NLC-rich regions. Photo-exciting the NP-containing structure with a suitable light source (λ = 808 nm) causes thermo-plasmonic heating, inducing a refractive-index mismatch between the PLC and NLC and resulting in a highly efficient diffractive structure.

Additionally, we showed that the same structure can realize a variable waveplate, thus enabling a new method for detecting and predicting photoinduced temperature variations as well as for controlling the phase retardation of a polarized light beam. The realized optical components do not require optical power in the diffraction off state thanks to the reverse-mode working principle.

Our findings represent the first demonstration of reconfigurable thermo-plasmonic-activated optical components. These results[4] open a new scenario in light-controllable photonics—one that could prove particularly important for polymers that do not allow electric-field control. What's more, NPs with exotic shapes such as triangle, cube and hexagon could be useful in developing on-chip photothermal sensors, thus adding a new level of flexibility to existing photonic devices. We are pushing this versatility even further through the realization of a new generation of biomedical thermal sensors by exploiting the interplay between thermo-plasmonics and water-based liquid crystal thermometry. OPN



A schematic representation of a thermo-plasmonic-activated reverse-mode diffraction grating.

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