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Enhancing Plasmonic Nanostructures Tunability by Employing Phase Change Materials

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Phase change materials (PCMs) are materials that can change their optical properties by switching between different phases in response to external stimuli, such as temperature, light, or electric field. This makes PCMs promising for tunability and reconfigurability of nanophotonic devices, including switches, modulators, and sensors. PCMs can be classified into two categories. The first category includes chalcogenide materials like Ge2Sb2Se4Te1 (GSST) and Ge2Sb2Te5 (GST), which change phase without altering their physical state but exhibit variations in their optical characteristics. The second category comprises materials such as gallium-based liquid metals (Ga-based LMs) and their alloys, such as Ga-In, Ga-Ag, and Ga-In-Sn, where both the physical state and optical properties undergo changes during phase transitions. The Ga-based LMs are particularly noteworthy due to their low melting points, allowing for solid-liquid phase transitions at room temperature. In this talk, we show how hybridizing PCMs with plasmonic materials like gold (Ag) or silver (Ag) enhance their functionality and performance in applications requiring precise control over optical properties. We also show how the phase transition of the PCMs can be actively controlled by the light absorption of the hybrid nanostructure, and how this phase transition affects the optical responses of the nanostructure, such as absorption, scattering, and extinction cross-sections. We also investigate induced photothermal process, heat transfer mechanism, and electric field enhancement of the hybrid nanostructure, as functions of the laser wavelength and intensity variations. We employ a self-consistent approach that couples electromagnetism with thermodynamics, employing numerical simulations to study the interactions between light and material properties. The findings demonstrate that hybrid nanostructure can achieve remarkable tunability and reconfigurability of its optical properties.

Keyword-1

Phase change materials

Keyword-2

Plasmonic nanostructures

Keyword-3

Induced photothermal process

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