Nanoscaled control of VO_2 insulator-to-metal transition by plasmonic single-nanoantenna

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It is well-established that, when illuminated at the right wavelength, gold single nanoantennas feature plasmon excitation [1]. This plasmon excitation gives rise to, among other effects, electromagnetic field concentration close to the antenna surface, which allows to manipulate light at the nanoscale by strengthening the light-matter interaction and the nonlinear response. Active materials, i.e., materials whose properties change under the application of an external stimulus, are often combined to plasmonic antennas to obtain metasurfaces with enhanced optical properties [2,3]. Among these materials, the VO_2 phase transition material is one of the most studied owing to its insulator-to-metal transition, induced by heating, occurring at relatively low critical temperature (68°C) [4].
Here, we exploit a laser-induced pumping effect, obtained by placing a single gold nanoantenna on top of a VO_2 film, to steer the phase transition in the VO_2 thermochromic material. In this combined experimental-theoretical study, we show how the size and permittivity of the nanometer-scale VO_2 regions where phase transition occurs is affected by the geometry of the single nanoantenna under different pumping conditions. It turns out that a higher VO_2 phase transition effect is obtained for pumping of the longitudinal or transversal localized surface plasmon depending on the antenna length. Moreover, we demonstrate that the antenna-VO_2 hybrid is characterized by a picosecond dynamics, useful for the realization of fast nano-switches.
The determination of the key parameters underlying the antenna capability of inducing the phase change and producing a hybrid nonlinear optical response is desirable for the design and realization of optimized nanostructures, such as nanoscale nonlinear optical devices and switches.

References

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Figures

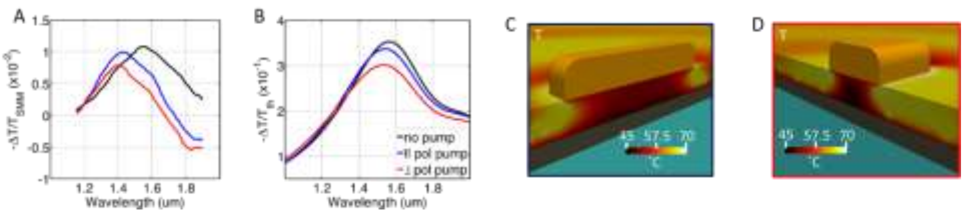

Figure 1. Measured normalized spatial modulation transmission and (B) simulated normalized differential transmission of the system as a function of the probe wavelength. (C, D) Colormap of the simulated temperature in the system under pumping (C) parallel and (D) perpendicular to antenna length.