Tunable Nanophotonic Filter Based on Thermochromic Vanadium Dioxide

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Mid-infrared filters, which selectively transmit a part of the infrared spectrum while reflecting or absorbing the rest, have a number of applications in optical sensing, spectroscopy, coherent light sources, and tunable radiative thermal control by switching between transparent and opaque states. Vanadium dioxide (VO_2), which undergoes a thermochromic insulator-to-metal phase transition around 340 K, exhibits a dramatic difference in optical constants between the insulating and metallic phases. In this study, we design, fabricate and characterize a tunable nanophotonic filter made of two VO_2 thin films sandwiching a silicon spacer on an infrared-transparent substrate. High transmission with a peak around 5 micrometer in wavelength due to interference inside the silicon spacer is predicted at lower temperature with insulating VO_2. This transmission filter can be switched off by heating¬ past the transition temperature, at which the structure becomes almost opaque with metallic VO_2. The theoretical transmittance and reflectance of the structure were simulated using the transfer matrix formulation for multilayer thin films incorporated with Ray tracing method for the incoherent substrate layer. The structure will be fabricated with thin-film deposition and furnace oxidation methods, and temperature-dependent spectral transmittance will be measured using Fourier-transform infrared spectroscopy to experimentally demonstrate the ability to switch between transmitting and opaque states in the infrared spectra.