Tunable plasmonic platforms made of thermochromic VO_2 thin films combined with gold – nanoparticles.

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Monoclinic VO_2 (m-VO_2) is a thermochromic material characterized by a critical temperature of 68°C. m-VO_2 is a very interesting candidate for applications in optics and electronics.
In this study, thermochromic VO_2 coatings were synthesized by reactive magnetron sputtering by carefully tuning the deposition process. The deposited m-VO_2 films were then used to benchmark numerical simulations carried out through the CAvity Modelling Framework (CAMFR). Thanks to the simulations, we demonstrated how film nanostructure, i.e., the formation of VO_2 nanoribbons, might enhance film's optical properties for smart window applications. Numerically optimized ribbon width, periodicity, and height improves energy efficiency while reducing coating opacity as compared to a "dense" film of identical thickness [1].
Secondly, gold nanoparticles (Au-NPs) prepared by a wet chemistry method were successfully combined with the VO_2 films. In this case, a significant wavelength shift of the plasmonic peak is observed as a function of temperature for two distinct platforms: one with the Au-NPs located on the surface of the VO_2 film and another with the Au-NPs embedded inside the coating. Additionally, resistivity and optical hysteresis revealed that the presence of Au-NPs amplifies the resistivity drop by one order of magnitude and enhances the optical transmission drop. Furthermore, it reduces the critical temperature and narrows the hysteresis width.
Finaly, we have successfully synthesized thermochromic VO_2 nanostructures by depositing the coating under oblique incidence. In this case, optical and ellipsometry analyses revealed a pronounced anisotropy of the film optical properties. This type of sample introduces a new dimension of control beyond temperature alone. By combining both factors, one can achieve a versatile and multi-dimensional tunability. The here-mentioned work may pave the way towards the elaboration of thin film materials with high optical accordability and better performance which can potentially be used in fields such as color display, protection against counterfeiting, opto-electronics chips or energy-saving smart windows.

[1] G. Savorianakis, K. Mita, T. Shimizu, S. Konstantinidis, M. Voué, and B. Maes, J. Appl. Phys. 129, 185306 (2021).