Temperature-controlled plasmonic response of magnetron sputtered VO_2 thin film - gold nanoparticles hybrid materials

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Monoclinic VO_2 (m-VO_2) undergoes a Metal-Insulator Transition (MIT) at ~67°C and is therefore labelled as thermochromic. In this study, we first demonstrate how magnetron sputtering of a vanadium target in an Ar/O_2 mixture can be optimized to synthesize films containing m-VO_2 nanocrystals. In our synthesis conditions, the thermochromic material is obtained at a precise oxygen flow rate and in optimized annealing conditions.

In the second part, numerical results (CAvity Modelling Framework, CAMFR) are compared to the optical properties of the synthesized films. Thanks to simulations, we show how the nanostructuration can be tuned to improve VO_2 film properties for application as smart windows. By varying the VO_2 nano-ribbon width, periodicity, and the film thickness, one can enhance the performance in terms of energy saving and opacity as compared to a dense film of identical thickness [1].

In the final part, we demonstrate how the m-VO_2 films can be combined with gold nanoparticles (Au-NPs) to obtain tunable plasmonic signal according to the temperature. Au-NPs are grafted onto the VO_2 film surface using (3-aminopropyl) trimethoxysilane (APTMS) linkers. A 10nm-shift in wavelength of the plasmonic peak is evidenced and quantified as a function of the temperature. In parallel, a 2D version of this platform has been simulated to understand the underlying physics and provide pathways to further improve the optical shift thanks to the CAMFR tool. The here-mentioned work may pave the way towards the elaboration of thin film materials with superior optical accordability which can potentially be used in applications such as colour display, protection against counterfeiting, and opto-electronics chips.

References:

[1] G. Savorianakis, K. Mita, T. Shimizu, S. Konstantinidis, M. Voué, and B. Maes, “VO_2 nanostripe-based thin film with optimized color and solar characteristics for smart windows,” *J. Appl. Phys.*, vol. 129, no. 18, p. 185306, May 2021, doi: 10.1063/5.0049284.