Monoclinic VO_2 (m-VO_2) exhibits a Metal-Insulator Transition (MIT) at approximately 67°C, making it a thermochromic material of interest. In this study, we initially show the optimization of magnetron sputtering using a vanadium target within an Ar/O_2 mixture to synthesize films that are 200 nm thick and contain m-VO_2 crystals. Our synthesis process involves precise control of the oxygen flow rate and subsequent annealing of the films in O_2 for 120 minutes at 500°C.

In the first segment of our research, we validate our numerical findings obtained through the CAvity Modelling Framework (CAMFR) by comparing them to the optical properties of the synthesized films. Our simulations demonstrate how nanostructuring via ribbon-like structures can be adjusted to enhance film properties for potential applications in smart windows. By varying parameters such as the width of VO_2 nano-ribbons, periodicity, and film thickness, we can achieve improved energy efficiency and a less opaque appearance compared to a dense film with the same thickness.

Secondly, we conducted experimental research where we combined m-VO_2 films with gold nanoparticles (AuNPs) to achieve tunable plasmonic signals in response to temperature variations. Our study demonstrates the successful grafting of AuNPs onto the surface of the VO_2 film using (3-aminopropyl) trimethoxysilane (APTMS) linkers. We observed a noticeable shift in the wavelength of the plasmonic peak, which was quantified as a function of temperature for two distinct platforms: one with NPs positioned on top of the VO_2 film and another with NPs embedded within the film. Additionally, our investigations into resistivity and optical hysteresis revealed that the presence of AuNPs amplifies the resistivity drop by one order of magnitude and enhances the transmission drop by 15%. Furthermore, it reduces the critical temperature by 5°C and narrows the hysteresis width.

In a groundbreaking development, we have successfully synthesized thermochromic VO_2 nanostructures in various forms, including tilted nanocolumns, zig-zags, and helices, utilizing the innovative GLancing Angle Deposition (GLAD) technique. Our optical and ellipsometry analyses have revealed a significant anisotropy that correlates with the sample's rotation during measurement. This unique type of sample introduces a new dimension of control beyond temperature alone, allowing us to fine-tune its optical response. By combining both factors, we 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 applications as colour display, protection against counterfeiting, opto-electronics chips or energy-saving smart windows.