Study on the properties of VO_2 as thermochromic coating for smart windows

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In the present work, we present the latest **results of the National project EXOTHERMO on the properties of thermochromic VO_2 as coating for smart windows and energy efficient buildings.** It is well known that vanadium dioxide (VO_2) undergoes, at a critical temperature (T_c) of about 68°C, a semiconductor to metal (STM) transition, which is accompanied by a decrease in resistance and infrared transmittance, making the dioxide a promising material for smart window coatings in buildings.

VO_2 thin films were prepared by both the RF sputtering and the Atmospheric Pressure Chemical Vapor Deposition (APCVD) techniques, and the dependence of their thermochromic properties on substrate type, buffer layer, thickness and growth parameters employed were investigated. The substrates used were crystalline Si, uncoated glasses (fused silica and float glass) and pre-coated glasses with SiO_2, ZnON and SnO_2. The films were characterized using SEM, XRD, T-dependant micro-Raman, and spectral transmittance (200 to 2500 nm) as a function of temperature (25 to 90 °C).

Room temperature grown RF sputtered VO_2 films, initially amorphous with no thermochromic properties, they became polycrystalline monoclinic VO_2, after annealing in forming gas (95% N_2-5% H_2) at 500°C for 5min,. Films produced at temperatures less than 300 °C were polycrystalline V_2O_5 and annealing in forming gas at temperatures between 350-500°C was needed in order to get VO_2. The minimum substrate temperature required in order to get thermochromic films was 300°C to 400°C. These films exhibited transition temperature varying from 68 to 45°C. To reduce the transition temperature, two types of dopants (W or Mg) were introduced using simultaneous co-sputtering from two metallic targets (vanadium and the dopant). Lower T_c values have been obtained by adjusting the concentration percentage of the dopants. The lowest T_c, from the W-doped thermochromic films with 0.6 to 1.5 at% W, was measured at 20-25°C through T-dependant micro-Raman. Respectively, the Mg-doped films with 7 to 8.7 at% Mg display the lower Tc at 37.2°C, measured by transmittance hysterisis loop at 2000 nm.

The APCVD grown films (using vanadyl (V) triisopropoxide as single-precursor) were investigated for their properties in various growth conditions such as N_2 flow rate through the vanadium bubbler, deposition period and growth temperature. As found out, only coatings grown on SnO_2-precoated glass substrates presented thermochromic behaviour, this being optimized for a growth temperature of 450 °C, a deposition time of 30 min and a N_2 flow rate of 4 $Lmin^{-1}$. The respective transition temperature was found to be 66 °C, which was reduced down to 44 °C after doping with W.

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