VO_2-Based Thermochromic Thin Films for Energy Efficient Windows

Carlos Batista, Vasco Teixeira
University of Minho, Department of Physics, Campus de Gualtar, 4710-057 Braga, Portugal
cbatista@fisica.uminho.pt

Abstract

The latest approach on the improvement the energy efficiency of buildings is based on the use of thermochromic coatings on so-called "smart" windows. These coatings possess the ability of changing their optical properties as a consequence of a reversible structural transformation when going through a critical temperature. Vanadium dioxide is an example of a transparent thermochromic material which is a promising candidate for this kind of application. The change on its optical and also electrical properties takes place at 68ºC as a result of a first-order structural transition, known as Mott transition [1], going from a monoclinic to a tetragonal phase on heating. The low temperature semiconducting phase which is transparent to radiation in the visible and infrared wavelength range maximizes the heating due to blackbody radiation, while the metallic high temperature phase blocks the infrared radiation and maintains at the same time the transparency required, in the visible range, to keep an environment of natural light. A transition temperature of 68ºC is too high for this application and must therefore be reduced. Tungsten-doping of VO_2 has demonstrated to decrease the transition temperature in the greatest extent, when compared with other metals, and has therefore been the focus of most of the research [2].

In the current study, VO_2 thin films doped with different W at.% and consequent dissimilar switching temperatures, were successfully deposited onto SiO_2-coated float-glass substrates by reactive direct current (DC) magnetron sputtering. The doping methodology associated with optimized processing conditions allowed the production of W-doped VO_2 films with reduced switching temperatures and maximum transmittances at the visible region ranging 40%. Structural analyses have shown, for undoped films, single phase VO_2(M) films with (002) as the preferred crystal orientation plane. The addition of W favors the crystallization in the (011) direction which becomes dominant above a critical level of dopant concentration. The surface morphology of pure VO_2 films revealed elongated grains oriented within the film plane, and the doped ones have shown an increased tendency to be oriented out of the film plane as well as increased roughness. The relationship between W contents in the film and consequent transition temperature presented a linear behavior.

References:

[1] A. Zylbersztejn and N.F. Mott, Physical Review B 11 (1975) 4383-4395.
[2] I.P. Parkin and T.D. Manning, Journal of Chemical Education 83 (2006) 393-400.