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Oxidation of sputter-deposited vanadium nitride epitaxial films: a novel approach to obtain thermochromic VO2 films

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Vanadium dioxide (VO_2) undergoes a metal-semiconductor transition at T_c = 68°C. In the semiconductor state (temperature lower than T_c), VO_2 presents a monoclinic structure, high transmittance in the infrared region and high electrical resistivity, while as metal (temperatures higher than T_c) exhibits tetragonal rutile structure, low transmittance and low electrical resistivity. The abrupt change of these properties makes this material suitable for several industrial applications, such as near-infrared modulation in smart windows, thermal solar collectors and so many others. However, the numerous phases belonging to the V-O system still challenge the production of pure VO_2 with excellent thermochromic properties.
To obtain thermochromic VO_2, we have chosen to modify the sputtering oxidation coupling method [1] using another precursor: vanadium nitride (VN). We have already shown that polycrystalline VN is an interesting precursor to synthesize thermochromic VO_2 films. In this work, single crystallized VN thin films were deposited on MgO substrates by reactive magnetron sputtering. The epitaxial as-deposited VN films (50 nm thick) were annealed in a pre-heated furnace at different durations and three temperatures in the range of 450°C-550°C. Raman spectrometry, X-ray diffraction, SEM and TEM were performed for structural and morphological characterizations of the epitaxial VN films and the VO_2 ones. The thermally-induced properties of the oxidized VN films were analyzed, in the 30-120°C temperature range, in terms of their electrical resistance employing four-point probe method and their emissivity modulation properties by infrared camera. The choice of the correct values during the annealing process, altogether with the results from characterization techniques, provide us to identify the accurate parameters to achieve thermochromic VO_2 films.
[1] X. Xu et al., Appl. Surf. Sci. 257, 8824, (2011).

Keywords
Vanadium dioxide, Thermochromic films, Epitaxial growth