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Niobium-doped titanium-dioxide thin films deposited by HiPIMS for optical and electrical applications

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Resumo:
Titanium dioxide (TiO2) films have been the subject of extensive studies for various applications in last few decades. Many studies focus on the use of dopants, such as niobium (Nb) to modify their electronic structure, producing optical, electrical, catalytic, and photocatalytic modifications in the films. This paper presents results of titanium dioxide films doped with niobium. The films were deposited through a high-power impulse magnetron sputtering (HiPIMS) system using titanium target 2 inches in diameter. The Ti target disc was provided with Nb inserts attached to holes distributed in the erosion zone. Films containing different Nb/Ti ratios were obtained by varying the plasma power from 50 W to 150 W. The samples were characterized through optical transmittance and reflectance spectroscopies, Hall resistivity, X-ray diffraction (XRD), and X-ray photoelectron spectroscopy (XPS). The XRD results show that the Nb doped TiO2 films were free of niobium oxides, which indicates that Nb atoms were incorporated into the TiO2 crystal lattice. The XPS analysis suggested that the electronic structure of Ti4+ states was altered due to the presence of pentavalent Nb replacing the tetravalent Ti. Electrical resistivity measurements indicated reduction in resistivity by several orders of magnitude due to same reason: the extra electrons of the niobium atoms were ejected in the conduction band, changing the electronic distribution in the crystalline lattice and consequently reducing its resistivity. The transmittance and reflectance measurements were similar to those of uncoated glass. Optical transmittance and reflectance measurements associated to Tauc model, allowed to obtain the band gap width that was shifted to the red region, indicating that these compounds can be successfully used as transparent conducting oxide (TCO) films.