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Process characterization of reactive magnetron sputtering using two reactive gases for tuning the properties of TaOxNy thin films

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The reactive magnetron deposition technologies are widely used in research and industry, with an increasing interest over the past two decades for the synthesis of more complex compounds such as oxynitrides and carbonitrides. The aim of this study is to investigate the reactive sputtering process of Ta target in a mixture of Ar, O_2 and N_2. The use of two reactive gases increases the complexity of the process by the presence of competing surface and volume reactions. The Ar/O_2 and Ar/N_2 single reactive gas processes were investigated separately, in terms of hysteresis behavior resulting from variation of the reactive gas flow. The reactivity of the process is analyzed by using the electrical characteristics of the discharge, the total and partial pressure of the gasses and the optical emission intensity of selected spectral lines. The reactive gas flows corresponding to maximum reactivity of each process are chosen as reference, and used to calculate an optimum ratio of reactive gas flows. The so determined ratio (2.5) is used as a fixed parameter in the analysis of the hysteresis behavior of the two reactive gases process, as such an optimum process windows enabling maximum tunability was identified. The TaO_xN_y thin films were investigated in terms of microchemical, microstructural, mechanical and optical properties, the changes in the sputtering process being directly related to the changes of the obtained layers. Although the gas flow ratio is kept constant a modified chemical composition of the layers was observed, depending on the chosen setpoint in the reactive process. These changes determine corresponding modifications of the optical properties, with a tuning range of refractive indices from 3.3 to 2.15 and optical band gap variation from 1.7 to 3.6 eV.
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