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Formation mechanism and mechanical properties of titanium oxynitride (TiO_xN_y) thin films deposited by reactive dc magnetron sputtering

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In this work, the formation of titanium oxynitride (TiO_xN_y) thin films during a reactive dc magnetron sputtering process was investigated. TiO_xN_y thin films were deposited on glass substrates from Ti target at different sputtering power, using O_2 and N_2 as reactive gases. The structural, surface morphology, chemical-bonding and mechanical properties were analyzed by grazing incident x-ray diffraction (GIXRD), atomic force microscope (AFM), X-ray photoelectron spectroscopy (XPS), and nano-indentation techniques, respectively. The GIXRD spectra show the amorphous structure and polycrystalline structure with the increasing of the sputtering power. We found that the peaks shift of TiN structure to the higher angle due to the oxygen incorporation into the crystal lattice. The roughness of the films increases along with the increasing of sputtering power. From the XPS analysis reveals the formation of TiO_2, TiO_xN_y and TiN by considering the Ti-2p, O-1s, and N-1s XPS spectra of the films. These results indicate that the sputtering power affects the formation of the TiO_xN_y thin films. The mechanical properties i.e. hardness and elastic modulus obtained by nano-indentation are in the range of 5.97-12.63 GPa and 85-120 GPa, respectively. The mechanical property of the films relates the crystal structure and the chemical states. The increasing of sputtering power enhances the formation of titanium nitride structure and leads to achieve the mechanical property.

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