Microstructural, chemical and mechanical characterization of Si-O-N amorphous coatings obtained by magnetron sputtering

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Over the past decades there has been an increasing interest in preparation and study of silicon oxynitride (SiO_xN_y) thin films. The possibility of tailoring their optical and electrical properties by changing the composition makes them suitable for a large range of applications such as passivation and masking layers in microelectronics, solar cells or luminescent devices [1,2]. Also the mechanical properties of SiO_xN_y films are strongly dependent on film composition [3]. The aim of this study is to understand the influence of gas mixture during deposition on the composition and mechanical properties of SiO_xN_y thin films. For this, SiO_xN_y thin films were deposited by r.f. magnetron sputtering from a pure silicon target, under different Ar:N_2 gas mixtures. Before deposition the sputtering chamber was evacuated to 1×10^{-4} Pa and pre-heated to 90ºC. The working pressure was kept around of 1.33 Pa and a sputtering power for 150W was used to grow the films. Mirror polished AISI M2 steel and silicon wafers (100) were the used substrates.

The effect of N_2 fraction on the deposition rate was investigated. The film thickness was measured by profilometry and the results showed to be coherent with SEM cross-sectional micrographs ranging from 400 to 1750 nm. Grazing Incidence X-Ray Diffraction (GIXRD – incidence angle of 1º) showed that all the films are amorphous.

Composition and chemical bonding was evaluated by X-ray photoelectron spectroscopy (XPS) under Al K_α X-ray irradiation. Results show that Si, N, C and O are the dominant elements in the composition on the SiO_xN_y films surface. The bonding energy of carbon (C1s, 284.6 eV) was used to calibrate possible energy shift due to accumulated charges. Chemical composition and bond types were found similar for all the samples corresponding to silicon oxynitride phases. Additionally elemental composition of the sputtered SiO_xN_y films was measured by Rutherford backscattering spectrometry (RBS) using a 2 MeV He^+, and spectra were analyzed using the RUMP simulation code. Typical composition for the SiO_xN_y samples are x:15-20 and y: 45-50

Mechanical properties (hardness and Young's modulus) were investigated by nanoindentation. For similar contact depth, hardness and Young modulus decrease slightly with the increase of N_2 fraction. Typical values are 14-9 GPa for hardness and 160-113 GPa for Young Modulus.

Thermal stability of SiO_xN_y thin films was also studied. The samples were annealed in different atmospheres and the mechanical properties were evaluated by nanoindentation after the thermal treatments. The coatings appear stable for heating in N_2 atmosphere up to 900 ºC.

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References:

[1] T.S.Eriksson, C.G.Granqvist, J.Appl.Phys., 60 (1986) 2081.
[2] M.Ribeyro, I.Pereyra, M.I.Alayo, Thin Solid Films 426 (2003) 200.
[3] D.Criado, M.I.Alayo, M.C.A.Fantini, I.Pereyra, J.Non-Crystalline Sol. 35 (2006) 2319.