Tailoring optical properties of chromium-silicon mixed oxides by magnetron sputtering and oxygen ion beam implantation

R. Escobar Galindo[1], L. Vergara[1], O. Sanchez[1], N. Benito[2], G. Fuentes[3], R. Martínez [3], D.Duday [4], N. Valle[4], V. Joco[5], Carlos Palacio[4]

[1] Instituto Ciencia Materiales de Madrid ,ICMM-CSIC, 28049 Madrid, Spain.
[2] Departamento de Física Aplicada, Universidad Autónoma de Madrid, 28049 Madrid, Spain
[3] AIN, Centro de Ingeniería Avanzada de Superficies, 31191 Cordovilla, Pamplona, Spain.
[4] Centre de Recherche Public - Gabriel Lippmann, 4422 Belvaux, Luxembourg
[5]Centro de Microanálisis de Materiales, 28049 Madrid, Spain
rescobar@icmm.csic.es

Mixed metal-silicon oxides are very interesting materials because they are suitable for use, among others, as optical coatings with an adjustable refractive index. In most cases the synthesis of these coatings is completed by chemical vapour deposition (CVD) techniques although undesirable incorporation of chlorine, hydrogen or carboxyl groups to the films is frequently reported. In this paper we investigate the formation of chromium and silicon mixed oxides using two alternative methods. In first place, mixed chromium and silicon oxides were deposited by reactive magnetron sputtering. These films have been characterized by means of Rutherford backscattering spectrometry (RBS), with He ions at 3.035 MeV to make use of the resonance of alpha particles with oxygen at this specific energy, X-ray diffraction (XRD) and cross-sectional scanning electron microscopy so as to determine how the deposition conditions influence the characteristics of the material. We have found that the deposition parameter whose influence determines the properties of the films to a greater extent is the amount of oxygen in the reactive sputtering gas. Secondly, starting with chromium deposition on silicon substrates by reactive magnetron sputtering, we induce the formation of mixed oxides by reactive ion beam mixing bombarding the Cr/Si interface with oxygen. We have varied the ion dose (from $1x10^{17}$ up to $1x10^{18}$ ions cm^{-2}) and the implantation energy (40-100 keV) in order to modify the final composition of the coating. The composition profiles have been obtained with RBS, by changing the He energy from 3.035 up to 3.105 MeV, and with Elastic recoil detection analysis using a Time-of-Flight configuration (ERDA-TOF). Results have been compared with secondary ion mass spectrometry (SIMS) depth profiles and Monte Carlo TRIDYN simulations. Chemical and structural characterizations were carried out by X-ray photoelectron spectroscopy (XPS), angle-resolved X-ray photoelectron spectroscopy (ARXPS) and XRD. We have determined how structural changes obtained by varying the ion beam implantation parameters are related to the optical properties of the coatings (mainly refractive index and extinction coefficient) as measured by spectroscopic ellipsometry and Fourier-transform infrared spectroscopy.