Journal of Non-Crystalline Solids 432 (2016) 292–299

Contents lists available at ScienceDirect

Journal of Non-Crystalline Solids

journal homepage: www.elsevier.com/locate/jnoncrysol

He^{+} induced changes in the surface structure and optical properties of RF-sputtered amorphous alumina thin films

F.O. Ogundare [a], I.O. Olarinoye [b,*]

[a] Department of Physics, University of Ibadan, Ibadan, Oyo, Nigeria
[b] Department of Physics, Federal University of Technology, Minna, Niger, Nigeria

ARTICLE INFO

Article history:
Received 23 August 2015
Received in revised form 10 October 2015
Accepted 12 October 2015
Available online 22 October 2015

Keywords:
Alumina films;
Optical constants;
Ion;
Radiation;
Stopping power

ABSTRACT

High quality 50 nm thick stoichiometric amorphous aluminium oxide films were reactively sputtered on microscope glass slide substrates. The films were exposed to energetic (2.20 MeV) He^{+} at different ion fluences of 6×10^{12} ion/cm^2; 1×10^{13} ion/cm^2; 2×10^{13} ion/cm^2; 3×10^{13} ion/cm^2; and 4×10^{13} ion/cm^2. The effect of the ion irradiation on the optical, structural phase and surface properties of the alumina films was investigated via UV–VIS–NIR spectroscopy, X-ray diffraction analysis and the atomic force microscopy respectively. The transmission and absorption spectra of the irradiated films showed variation that depended on ion fluence. The refractive index, extinction coefficient, optical conductivity, dielectric constant and energy loss functions of the films were also affected by He^{+} irradiation. Optical band gap and films' structural phase were however not altered by the ion irradiation. The variation in optical constants induced by radiation was attributed to electronic excitation and increase in surface roughness of the films.

1. Introduction

The exposure of solid materials to particulate and electromagnetic ionising radiation has been established [1–3] to have tremendous micro-structural effects on the solid. For materials in thin film form, these effects are strongly dependent on the film's chemical nature, thickness, structural phase, and radiation parameters such as: energy, linear energy transfer (LET), fluence, mass, charge, and dose [1–9]. In many cases, the changes in the micro-structure manifest as optical and electrical properties variations.

Photon and ion irradiation of thin films and their devices could be deliberate due to some inherent benefits. The use of radiation for material characterisation is one of such beneficial intentional exposure. The radiations that are commonly used for material characterisation include: photons in X-ray diffraction (XRD); electrons in scanning electron microscopy (SEM), transmission electron microscopy (TEM) and electron beam lithography; ions such as protons and helium in PIXE and RBS respectively. Although these techniques provide useful information about material structure and constituents, they can however cause serious temporary/permanent unplanned modification to the properties of thin film materials. The understanding of interaction and effect of irradiation of materials during these analytical procedures is thus highly essential. On the other hand high energy photon and ion irradiation has become an effective tool for introducing [9–16] planned modification in the structural, mechanical, electrical and optical properties of thin film based materials and devices. In such instances, the tailored properties are chosen based on the requirement of the desired application. However, for such thin film's property engineering, prior knowledge of the effect of different radiation parameters is required. This possibility of modifications of thin film properties by irradiation requires that attention should be paid to this effect when developing thin film devices for use in radiation environments. Therefore, the effects of irradiation on such thin film materials/devices, if not known before, must be established.

Aluminium oxide in thin films is a material that has been used in several technological applications due to their excellent optical properties [17–21]. One of the commonest optical applications of alumina thin films is in protective optical coatings due to its high: transparency [17], dielectric constant [19,20], refractive index [18], chemical and thermal stability [21,22]. In nuclear science and technology, alumina thin films are used in fusion reactors [23] and have a potential of being used as RF windows in International Thermonuclear Experimental Reactor [24]. A crucial problem that may occur, as earlier pointed out in such radiation environment is radiation induced modification of its properties. Design of optical coatings such as antireflective coatings or filters requires that such properties remained unaffected by harsh environmental conditions such as ionising radiation exposure. Consequently, the possible use of alumina film based materials for optical functions in radiation environment requires prior knowledge of the variation of its properties with radiation quality factor and dose. Furthermore, aluminium oxide thin film has a potential to be used as thin film layer for protective coating for luminescent phosphors used for radiation dosimeters (luminescence phosphor). For such applications, the high transparency

* Corresponding author.
E-mail addresses: olarinoyeleke@gmail.com, lekeola2005@yahoo.com (I.O. Olarinoye).

http://dx.doi.org/10.1016/j.jnoncrysol.2015.10.026
0022-3093/