DISLOCATION ENERGY PER UNIT LENGTH FOR SnO_2Ag/GLASS THIN FILMS

Komijani,*
B. Firoozi*
B. Moradibastani*
S. Sadatserky*
M. Moradi**

Abstract

In recent years the structures of thin layers have been widely studied, because of their properties that are unattainable in bulk materials. The aim of this paper is to present the dislocation energy per unit length of the SnO_2Ag thin films deposited on Glass. Dislocation energy per unit length of a 20 nanometer SnO_2Ag thin films with 10 and 90 percents of Ag and SnO_2, respectively, have been calculated using low angle incident x-ray scattering. Results obtained by the proposed experimental test, is then compared with the theoretical analysis data. The dislocation energy's per unit length of the SnO_2Ag thin films at temperatures of 25, 325, 525 and 625 ^{o}C, has been theoretically obtained equals to 1.3679 $(nm)^2$Gpa, 2.138$(nm)^2$Gpa, 1.7551$(nm)^2$Gpa and 1.8959(nm)2Gpa, respectively.

Keywords: Glass, Dislocation energy, thin films, X-ray Diffraction (XRD)

* Dept. of physics, faculty of science, Arak University, Arak 38156-8-8349, Iran
** Mechanical Engineering Department, Amirkabir university of Technology, Tehran

Introduction

Mechanical properties of thin films have an important role in each application due to stability of thin film systems, depending on mechanical properties of films [2]. Inconstancy of film occurs due to the residual stresses and inadequate cohesion of film to substrate. In the last years, this matter has been indicative of researcher's attention to mechanical properties of thin films. Inconsistency of lattice constants of film and substrate makes residual stresses in thin films. Dislocation energy is important issue in the range of mechanical properties. When the film thickness increases, it becomes energetically favorable for misfit dislocation at the interface between film and substrate to reduce the stress in the film [3].

Theoretical

Dislocation energy per unit length is given by [1]:

$$\frac{E}{l} = \frac{b^2}{4\pi(1-\nu_f)} \frac{2\mu_f\mu_s}{(\mu_f+\mu_s)} \ln\left(\frac{\beta t_f}{b}\right) \quad (1)$$

Where l is the dislocation length per unit area and is equal to $\frac{2}{s}$ for a square of edge dislocation: $(l = \frac{2s}{s^2} = \frac{2}{s})$.

μ_f ,μ_s, b andν_f, represents the shear modulus of the film and substrate, Burgers vector and Poisson's ratio of the film, respectively [10, 11, 12]. t_f Is the thickness of the film and β(FWHM) is a constant value which depends on the kind of film .i.e. is the characteristic parameter of the lattice [10, 11, 13, 14].

Results

The aim of this paper is to calculate the dislocation energy per unit length for SnO_2Ag thin films at temperatures of 25, 325, 525 and 625 ^{o}C. SnO_2Ag represents the film and glass is the substrate. The film's thickness is 20 nanometers. Properties of SnO_2Ag and glass are listed in table (1) [4 to 7] and table (2).

Table 1: Material properties used in this study

Material	Poisson's ratio	shear's modulus (Gpa)	lattice constants (nm)
SnO_2Ag	0.3007	98.58	0.46
Glass	--------	26.2	0.53

Table 2: β Numerical value used in this study

Material	β in 25 °C	β in 325 °C	β in 525 °C	β in 625 °C
SnO_2Ag	0.2362	0.1378	0.1968	0.2362

Figs. 1, 2, 3 and 4, are plotted by XRD unit for SnO_2Ag/Glass thin films with 20nm thickness of SnO_2Ag at temperatures of 25, 325, 525 and 625 °C respectively.

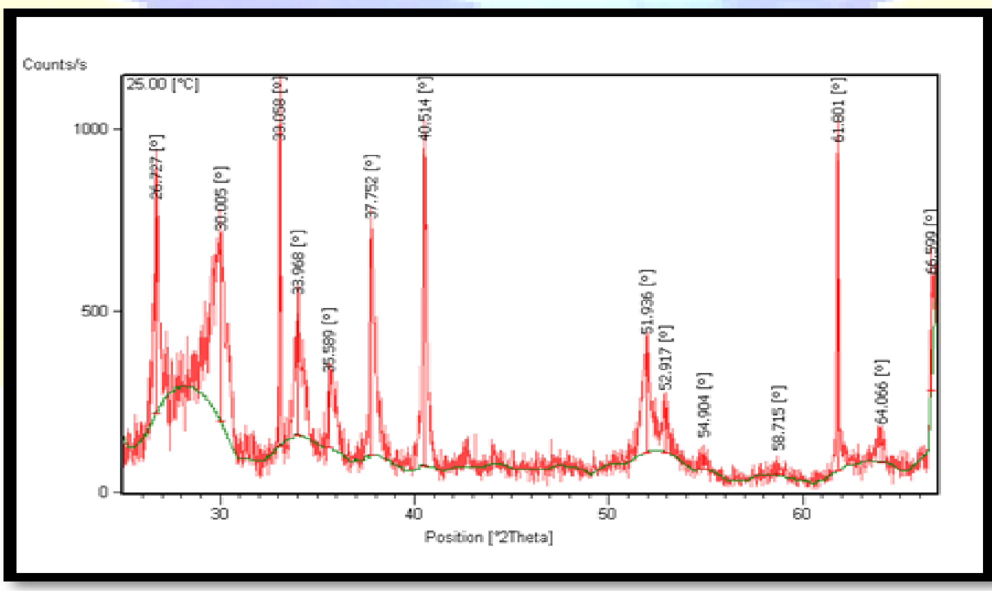

Fig1.XRD pattern result of sno_2Ag thin film at 25 ^{oC}

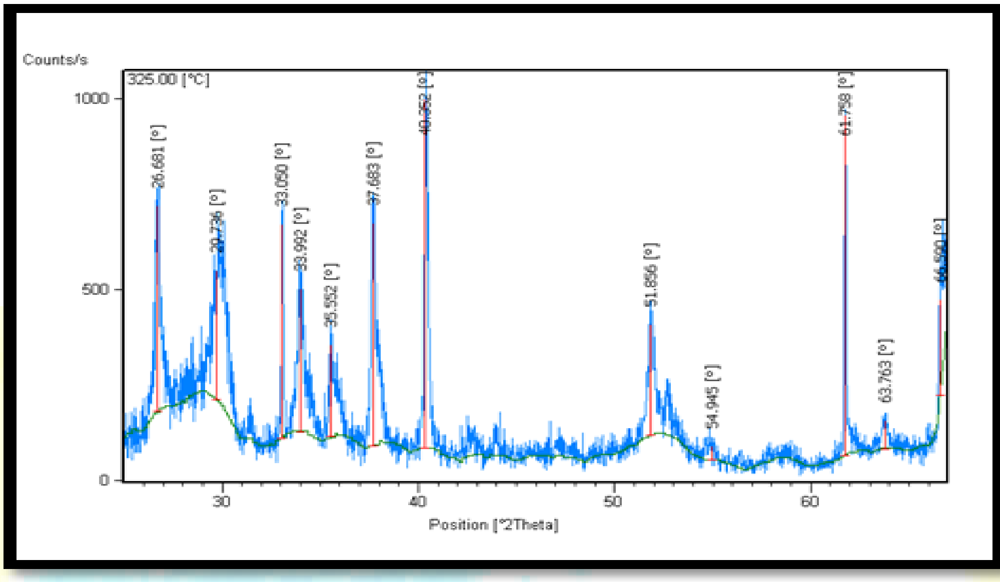

Fig2. XRD pattern result of sno_2Ag thin film at 325 ^{oC}

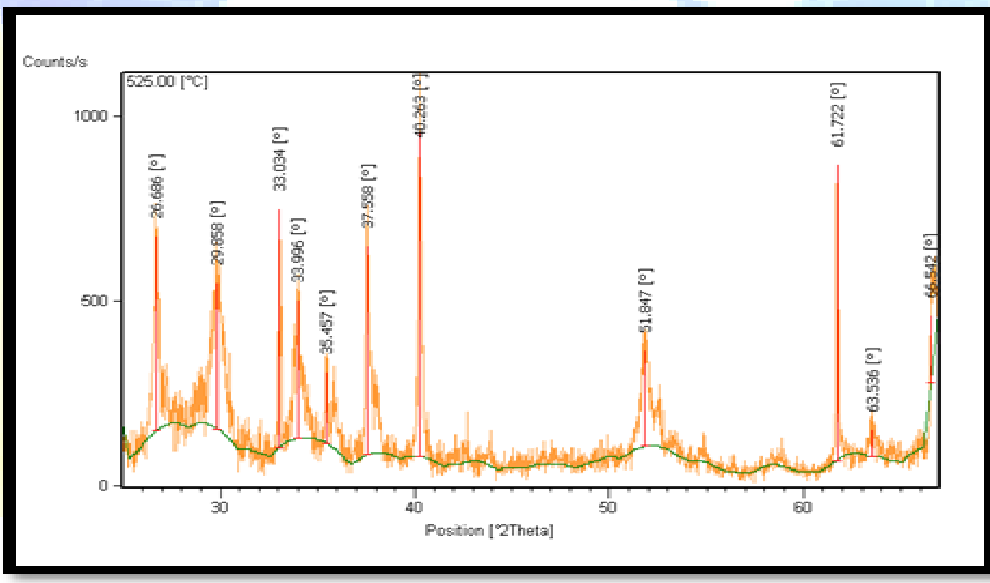

Fig3. XRD pattern result of sno_2Ag thin film at 525 ^{oC}

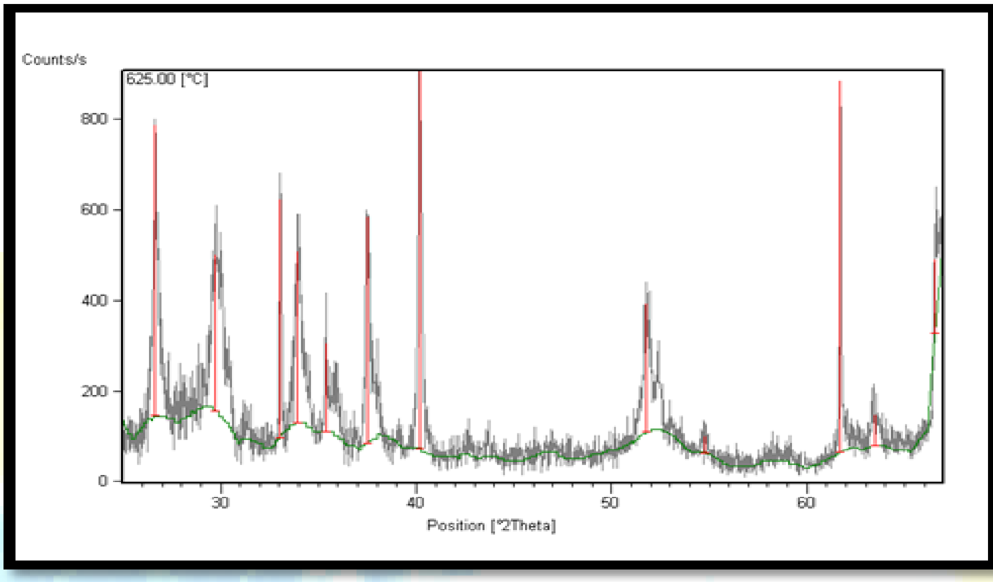

Fig4. XRD pattern result of sno_2Ag thin film at 625 ^{oC}

The maximum intensity's of Figs. 1, 2, 3 and 4 arises in 2θ =33.05 , 2θ =40.35 , 2θ =40.26 and 2θ = 40.17, with Miller index's of (101), (210), (111)and (111), respectively for SnO_2Ag thin layer [8, 9]. Thus, miller index of SnO_2Ag film whit thickness of 20nm at temperatures of 25, 325, 525 and 625 ^oC are (101), (210), (111) and (111), respectively. Using tables1, 2 and figs.1,2,3 and 4 and Eq. (1), The dislocation energy's per unit length of the SnO_2Ag thin films at temperatures of 25, 325, 525 and 625 ^oC, has been theoretically obtained equals to 1.3679 $(nm)^2$Gpa, 2.138$(nm)^2$Gpa, 1.7551$(nm)^2$Gpa and 1.8959$(nm)^2$Gpa, respectively.

Fig. 5 show the dislocation energy versus the β of the film for SnO_2Ag/glass whit thickness of 20nm at temperatures of 25, 325, 525 and 625 ^oC.

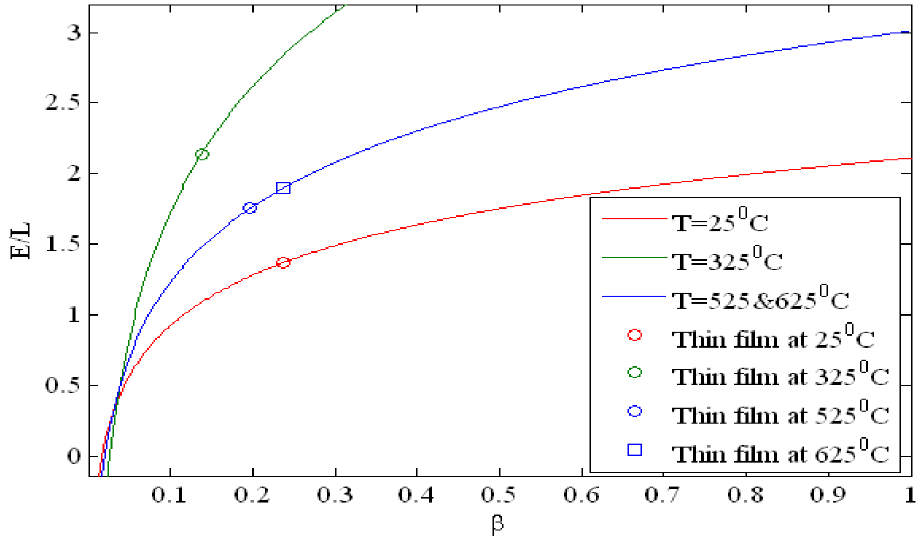

Fig5. Graph of the dislocation energy versus the β , for SnO_2Ag/glass whit thickness of 20nm

Fig.5 shows, the curve of the dislocation energy versus the β of SnO_2Ag whit thickness of 20nm at temperatures of 525 and 625 ^oC are the same. Fig.5 shows, with increase of the β of SnO_2Ag film at 325 ^oC in the SnO_2Ag/glass thin films whit thickness of 20nm, dislocation energy increases by the harsher slope, against of the SnO_2Ag film at525 ^oC (or 625 ^oC). On the other hand, with increase of the β of SnO_2Ag film at 525 ^oC and 625 ^oC, dislocation energy increases by the harsher slope, against of the SnO_2Ag film at 25 ^oC . Fig.5 show that, in the extent of the very modicumβ, the dislocation energy changes acutely, but in the extent of the largishβ, the dislocation energy will change slowly. Fig.5 shows, in the extent of zero until 0.1 of theβ, Figure curves of the SnO_2Ag/glass at (525 ^oC (or 625 ^oC) and 25 ^oC) or (25 ^oC and 325 ^oC) or (525 ^oC (or 625 ^oC) and 325 ^oC), were cut each other. Thus, the dislocation energy of the SnO_2Ag/glass thin films at 525 ^oC (or 625 ^oC) and 25 ^oC, in the β of 0.030, are 0.30$(nm)^2$Gpa. On the other hand, the dislocation energy of the SnO_2Ag/glass thin films at 25 ^oC and 325 ^oC, in the β of 0.035, are 0.39$(nm)^2$Gpa. Finally, the dislocation energy of the SnO_2Ag/glass thin films at 525 ^oC (or 625 ^oC) and 325 ^oC, in the β of 0.037, are 0.47$(nm)^2$Gpa. Thus, the dislocation energy of the SnO_2Ag/glass thin films at 525 ^oC (or 625 ^oC) and 25 ^oC, in the β of 0.030, and the dislocation energy at 25 ^oC and 325 ^oC, in the β of 0.035, and the dislocation energy at 525 ^oC (or 625 ^oC) and 325 ^oC, in the β of 0.037, are equal to each other.

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