Study on the Preparation of ZYO Thin Films by Middle Frequency Alternative Magnetron Sputtering and Their Properties

SUN Ruo-nan, ZHUANG Da-ming, ZHANG Gong
(Department of Mechanical Engineering, Tsinghua University, Beijing 100084, China)

Abstract: Y-doped zinc oxide (ZYO) thin films were prepared by middle frequency alternative magnetron sputtering on glass substrates with ZYO ceramic targets. The influences of Y_2O_3 content and substrate temperature on microstructures, optical and electrical properties of the thin films have been investigated. The results show that the ZYO films are of the structure of wurtzite type with high c-axis orientation. The lowest resistivity of the films in this work is $1.18\times10^{-3}\Omega\cdot$cm with the transmittance of over 80% at the visible region.

Key words: ZYO; magnetron sputtering; transparent conductive film; transmittance; resistivity
CLC number: TM615 Document code: A Article ID: 0529-6579 (2007) S1-0039-02

1 Introduction

At present, more and more research has been focused on TCO thin films based on zinc oxide because of their low material cost, low deposition temperature and stability in hydrogen plasma compared to ITO films[1-5] which is widely used in industrial manufacture for solar cells and flat panel displays. Among the elements doping in zinc oxide films, Al, Ga, B have been extensively investigated[6-9]. Furthermore, it was reported that Sc-doped ZnO film has very excellent electrical and optical properties[10]. Considering element Y is in the same family with Sc, it should play same of similar doping effects, with the advantage of much lower cost than Sc. So in this paper, ZYO films were prepared by middle-frequence alternative magnetron sputtering and the microstructures, optical and electrical properties of this film have been discussed.

2 Experiments

ZYO ceramic targets sintered from the mixed powder of ZnO (99.99% in purity) and Y_2O_3 (99.99% in purity) with the size of 250 mm$\times$120 mm$\times$6 mm were used as the sputtering targets. Three Y_2O_3 concentrations in the targets respectivly 2.5%, 4.0%, 5.5% were chosed. Glass is used as the substrates. The experimental parameters are listed in Table 1. Pre-sputtering of 5 min was carried out in order to clean the target surface before ZYO film sample deposition.

Tab. 1 The technological parameters for growing ZYO films by magnetron sputtering

Base pressure/Pa	3×10^{-3}
Argon gas pressure/Pa	0.8
Substrate tempreture/℃	50~300
Sputtering current/A	2.0
Sputtering time/s	120

3 Results

The ZYO thin films are of the structure of wurtzite type with high c-axis orientation prepared by different doped concentration targets (2.5%, 4.0%, 5.5%) and at different substrate temperatures (50, 100, 200, 300℃).

Under the deposition parameters in the Tab. 1, we observe the resistivity for the ZYO films of different doped concentration as a function of substrate temperature.

Fig. 1 shows that the resitivity of the films increases as the Y_2O_3 content increases at the same substrate tempreture and other deposition parameters. Meanwhile, resistivity of the films of the three different doping levels have the same variation tendency of decreasing as the substrate tempreture increases. From the figure, it can be seen when the doped concentration is 2.5% the decrease tendency of resistivity is most slightly. When Y_2O_3 conent is in a high level, the resistivity of the ZYO films is more sensitive to the sub-

①收稿日期: 2007-01-10
作者简介: 孙若男 (1983年生), 女, 硕士生; E-mail: sunruonan00@mails.tsinghua.edu.cn
(C)1994-2020 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

strate temprete.

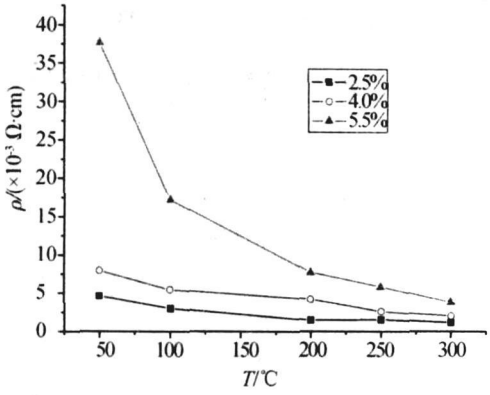

Fig. 1 Resistivity for the ZYO films of different doped concentrationas a function of substrate temperature

The average visible transmittance of the films at substrste temperature 250℃ with three doping levels (2.5%, 4%, 5.5%) is 83.01%, 82.61%, 82.86%, respectively. The change of doped concentration dosen't influence transmittance much.

The average transmittance of the ZYO films of doped concentration 2.5% at different temprete (50, 100, 200, 300℃) within the visible wavelength range (400 ~ 800 nm) is 79.21%, 82.29%, 83.01%, 82.85%, respectively. And the maximum is obtained at 200 ℃.

References:

[1] BETZ U, KHARRAZI M O, MARTHY J, et al. Surface & Coatings Technology, 2006, 200: 5751—5759.

[2] HOSONO A H, OHTA A H, ORITA A M, et al. Vacuum, 2002, 66: 419—425.

[3] CHEN Xin-liang, XUE Jun-ming, ZHAO Ying, et al. Materials Review, 2006, 20 (5): 22—25.

[4] LI Jia-liang, JIANG Hong-yi, NIU Jin-ye. Advanced Ceramics, 2006 (1): 1.

[5] PARK Sang-moo, IKEGAMI Tomoaki, EBIHARA Kenji. Thin Solid Films, 2006, 513: 90—94.

[6] LOKHANDE B J, PATIL P S, UPLANE M D. Physica B: Cond. Mat. 2001, 59: 302—303.

[7] SANG Baosheng, YAMADA Akira, KONAGAI Makoto. Solar Energy Materials and Solar Cells, 1997, 49: 19—26.

[8] FANG Ze-bo, PENG Xing-ping, TAN Yong-sheng, et al. Chinese Journal of Rare Metals, 2004, 28 (3): 502—504.

[9] KLUTH Oliver, SCHÖPE Gunnar, RECH Bernd, et al. Thin Solid Films, 2006, 502: 311—316.

[10] MINAMI Tadatsugu, YAMAMOTO Takashi, MIYATA Toshihiro. Thin solid films, 2000, 366: 63—48.

中频磁控溅射法制备氧化锌钇薄膜及其性能研究

孙若男, 庄大明, 张 弓

(清华大学 机械工程系, 北京 100084)

摘 要: 利用中频磁控溅射法, 溅射氧化锌钇 (ZYO) 陶瓷靶材, 在玻璃基底上制备 ZYO透明导电薄膜。研究了氧化钇掺杂量和基底温度对薄膜的结构、电学性能和光学性能的影响。结果表明, ZYO薄膜为钎锌矿型结构, 呈 c轴择优取向, 平均可见光透过率 (400~800 nm) 达到 80%以上。制备的 ZYO薄膜具有的最低电阻率为 $1.18\times10^{-3}\Omega\cdot cm$。

关键词: ZYO; 磁控溅射; 透明导电薄膜; 透过率; 电阻率

中图分类号: TM615

(C)1994-2020 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net