THE INFLUENCE OF GROWTH TEMPERATURE ON THE PROPERTIES OF ZINC OXIDE BY THERMAL OXIDATION

Kesan Pertumbuhan Suhu Ke Atas Sifat-Sifat Zink Oksida Menggunakan Oksidasi Haba

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Abstract

Zinc thin films were successfully deposited on Si substrate by thermal evaporation method under constant base pressure of $1.604x10^{-4}$ Pa. Thermal oxidation of the deposited film was carried out at two different growth temperatures of 300°C and 500°C. The effects of growth temperature on the properties of zinc oxide were investigated. Thermal oxidation for constant time 1 hour in horizontal tube furnace in air condition was carried out. The white-silver zinc thin films were changed to black-brown zinc oxide after thermal oxidation at temperature 500°C. FESEM results show that the zinc particles were almost round shape with nanostructures in size. ZnO nanowires were successfully obtained at low growth temperature of 300°C and the size become decrease as the growth temperature was increased to 500°C. The XRD results confirmed that ZnO was started to oxidize at growth temperature of 300°C with the sharpest peak obtained was indexed to ZnO(101). However, the oxidation of Zn was not fully completed while there are Zn peaks appear at this temperature. At growth temperature 500°C, all the peaks were indexed to ZnO with the sharpest peak was ZnO(101) meaning that the oxidation was completed. The calculated particle sizes were varied from 27.841nm to 36.788nm for ZnO at 300°C and 0.697nm to 161.18nm for ZnO of 500°C.

Keywords: Zinc Oxide, Silicon, Thermal Evaporation, Thermal Oxidation

Abstrak

Filem nipis zink telah berjaya didepositkan pada substrak Si oleh kaedah penyejatan haba di bawah tekanan asas tetap $1.604x10^{-4}$ Pa. Pengoksidaan thermal telah dijalankan ke atas filem yang telah didepositkan pada dua suhu yang berbeza iaitu 300°C dan 500°C. Kesan-kesan pertumbuhan suhu pengoksidaan telah disiasat terhadap sifat zink oksida. Pengoksidaan termal untuk masa malar 1 jam dalam relau tiub mendatar dalam kehadiran udara telah dijalankan. Filem nipis zink putih diubah menjadi zink oksida hitam coklat selepas pengoksidaan haba pada suhu 500°C. Keputusan FESEM menunjukkan bahawa zarah zink hampir membentuk bulat dengan saiz nanostruktur. Nanowayar ZnO telah berjaya diperoleh pada pertumbuhan suhu yang rendah iaitu 300°C dan saiz menjadi berkurangan apabila suhu pertumbuhan meningkat kepada 500°C. Hasil XRD mengesahkan bahawa ZnO mula teroksida pada suhu pertumbuhan 300°C dengan puncak paling ketara yang diperoleh diindeks ke ZnO (101). Walau bagaimanapun, pengoksidaan Zn tidak siap sepenuhnya kerana masih terdapat puncak Zn muncul pada suhu ini. Pada suhu pertumbuhan 500°C, semua puncak diindeks kepada ZnO dengan puncak paling ketara ialah ZnO (101) yang bermaksud pengoksidaan telah berlaku sepenuhnya. Saiz zarah yang dikira berbeza bermula dari 27.841nm hingga 36.788nm untuk ZnO pada 300°C dan 0.6966nm hingga 161.18nm untuk ZnO 500°C.

Kata kunci: Zink Oksida, Silikon, Pengewapan Haba, Oksidasi Haba

Introduction

Recently zinc oxide (ZnO) thin film was listed as one of the most interesting semiconductor oxides due to its special characteristics. Other than its wide band gap of 3.27eV, it is also have a large excition energy bonding of 60meV [1]. It has attracted much attention in order for many applications such as solar cells, gas sensor, nanolaser and other photoluminescent devices. There are several techniques were used to synthesize ZnO thin films for example sputtering, spray pyrolysis, sol-gel, chemical vapor deposition, r.f magnetron sputtering, pulsed laser deposition, etc. Besides, one of the simplest methods was thermal oxidation method that is less interest was paid. Thermal oxidation method also requires a relatively simple and low-cost procedure that does not need any catalyst or higher temperature growth [2]. By comparing to the catalyst-assisted growth, direct oxidation of metallic zinc can produce ZnO nanostructures with a large-scale growth capabilities and high purity owning to the elimination of intermediaries involved in catalytic chemical synthesis of oxide nanostructures [3]. The oxidation of Zn foils or powders under oxygen gas flow results the variation of ZnO nanostructures morphologies [1]. There have been a few reports of synthesizing zinc oxide by thermal oxidation methods [1-10]. Based on some reports, ZnO nanostructures were formed at growth temperature (420°C) and boiling temperature (907°C) of Zn while decomposition of ZnO was reported at a temperature up to ~1400°C [3]. As prevention, the growth of ZnO nanostructures should stop below the decomposition temperature of Zn.