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Structural, Morphology and PL Properties of ZnO Film Deposition on Porous Silicon

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ABSTRACT

ZnO thin film was deposited on glass and porous silicon by spray pyrolysis technology with fixed parameters consist (substrate temperature 400C^o, deposition rate 100nm/min), and the measurements of structural (XRD), morphology (AFM) and photoluminesces (PL) refer to good growth of ZnO after using porous silicon more than using glass and that's come from sponge like structure of porous silicon and large spastic area of porous silicon (about 500m^2/cm^3).

Keywords: Porous silicon; ZnO films; XRD;AFM; PL.

الخصائص التركيبية والمورفولوجية والاستضاءة الضوئية لغشاء اوكسيد الزنك المرسية على سيلكون مساحي.

الخلاصة

تم ترسيب غشاء رقيق من مادة أوكسيد الزنك على شريحة من الزجاج وأيضا على سليكون مسامي بواسطة تقنية الرش الحراري الكيميائي حيث تم استخدام معاملات ثابتة وهذه المعاملات تتضمن درجة الحرارة الشريحة (400 درجة مئوية) ومعدل الترسيب (100 نانومتر\دقيقة) والقياسات التركيبية XRD والطبوغرافية AFM والاستضاءة الضوئية PL تشير الى ان مادة أوكسيد الزنك تنمو بصورة أفضل على السليكون المسامي منها على الزجاج وذلك يرجع الى هيكل السليكون المسامي مثلالإسفنج والتوسع في المساحة السطحية لها (تقريبا 500 متر^2\سينتيمتر^3).

INTRODUCTION

ZnO has a direct bandgap of 3.37 eV at RT and a high exaction binding energy of 60 meV. During the last few years, people have given ZnO widespread attention because of its tremendous applications, such as transparent conductive contacts, solar cells, laser diodes, ultraviolet lasers, thin films transistors [1], etc. the direct growth or deposition of high-quality ZnO on Si substrate will introduce a rather large stress between ZnO and silicon due to the large mismatch in the thermal expansion coefficient and the lattice constants [2].So the was several report refer to good growth with high crystallite of ZnO film after deposition on porous silicon. In the present work, ZnO thin films are deposited on porous silicon substrates by thermal spray pyrolysis. In addition, study the effect of porous silicon on properties of ZnO film.

Experimental Work

Experimental work consist deposition ZnO thin film (200nm thickness) by Thermal Spray Pyrolysis (TSP) with substrate temperature (400C°) and spray rate (3ml/min) and deposition rate (100nm/min) and gas pressure (2Par) on glass and porous silicon substrate.

That porous silicon prepared by electrochemical etching with parameters (etching time 20 min, etching current density 30mA/cm^2, and silicon orientation <111>).

Results and Discussion

A. Structure Properties

The Figure (1) showing the XRD of the ZnO thin film prepared by chemical spray pyrolysis and deposited on glass substrate, diffraction pattern was recorded for a range of 2θ from 20° to 60° at 2° glancing angle. The ZnO film was crystallized in the wurtzite phase (polycrystalline structure) and presents a preferential orientation along the c-axis, the strongest peak (002) observed at 2θ = 34.3° and that these result match with JCPDS cards (36-1451)[3].

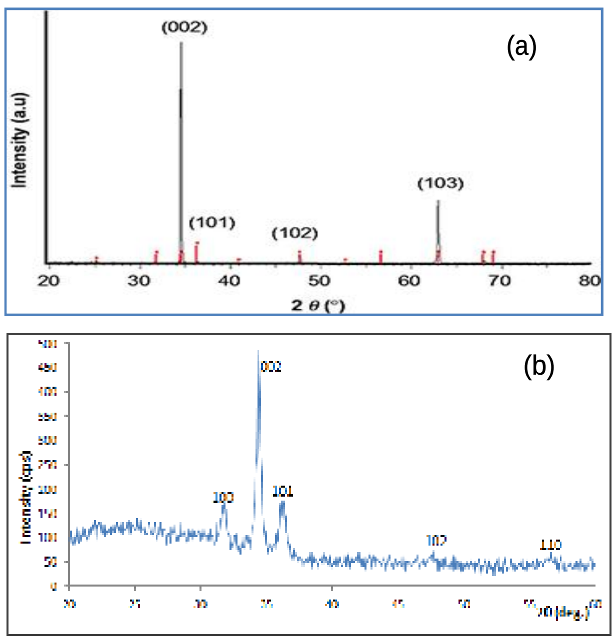

Figure (1): (a) JCPDS of ZnO[3] (b)XRD spectral of ZnO film deposition on glass

XRD results for the ZnO/PS layers refer to exhibited a dominant diffraction peak at 2θ=28.3825 degree, corresponding to the PS (111) layer. The diffraction peak at (31.8744, 346070, 36.4616) degree corresponds to the (100), (002), (101) respectively plane of the ZnO film, which indicates that the ZnO thin film was highly oriented along the c-axis vertical to the PS layer and the sharp diffraction peak from the ZnO film with a weak FWHM indicates the high quality of the ZnO film.

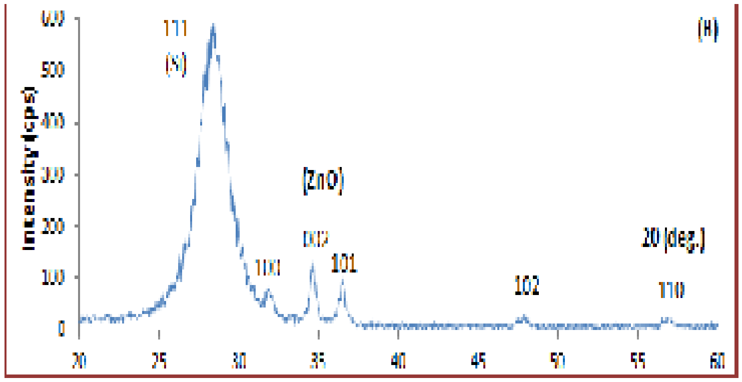

Figure (2): XRD spectral of ZnO film deposition on PS.

B. Morphology Properties

AFM of ZnO deposition on glass image showing the non - uniform surface with some void spaces. Instead of spherical shapes, elongated rod-like architecture with rough surface is noticed. The Average grain diameter was about (119 nm), roughness average (0.942 nm) and RMS (1.14 nm) so from the value of roughness we note that the ZnO thin film homogenous surface and this mean that the temperature of substrate staple in deposition of ZnO.

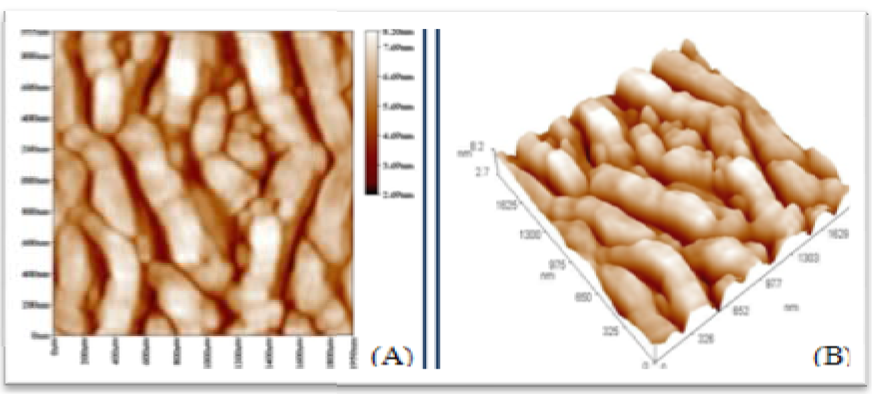

Figure (3): AFM image in 2D and 3D showing surface morphology of ZnO film deposition on glass

Form figure (4) ZnO partially filling or completely covering pores of PS. The surface of the PS layer is a sponge-like structure that consists of large number of ‘pores’ and voids’. These ‘pores’ and ‘voids’ make PS an adhesive surface for accommodating ZnO into its pores. Thus, the ZnO thin film acted as a transparent capping and providing a good coverage of the crystallite surface on the PS substrate, which could improve the structural stability of the PS substrate. In addition, PS special structure has been reported to have a very large internal surface that can induce large adsorption of ZnO spices[4].

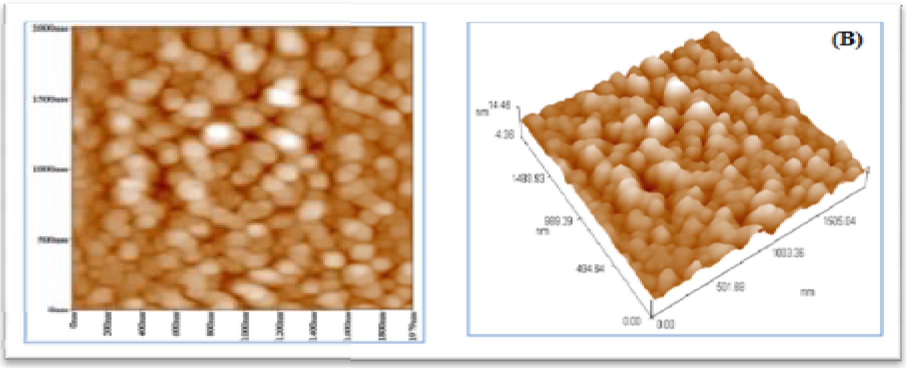

Figure (4): AFM image in 2D and 3D showing surface morphology of ZnO film deposition on PS

C. Photoluminescence

The PL spectra of the ZnO films in figure (5) exhibited four peaks: UV emission peak around 381 nm, green luminescence at 425 nm and 483 nm, greer- yellow band at 520 nm,. The first peak due to UV emissions is attributed to band-to-band transitions, excitonic emissions, and donor-acceptor pair transitions. The green and green-yellow bans are due to the deep level emissions in green region, which is attributed to oxygen vacancies, zinc interstitials or zinc vacancies[5].

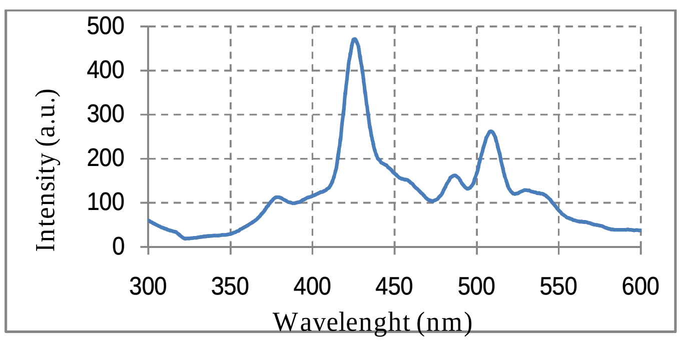

Figure (5): PL Spectral of ZnO film deposition on glass

The PL spectral of ZnO deposition on PS with thickness (100nm) recorded decreasing in shifting in UV emission peck to 368nm due to the near band emission (NBE) in the wide band gap of ZnO from the direct recombination of the photc-generated charge carrier or recombination of free exactions through an exciation-excitation collision process [6].The increasing of energy gap (3.37ev) refers to good growth ofZnO film on PS [7].

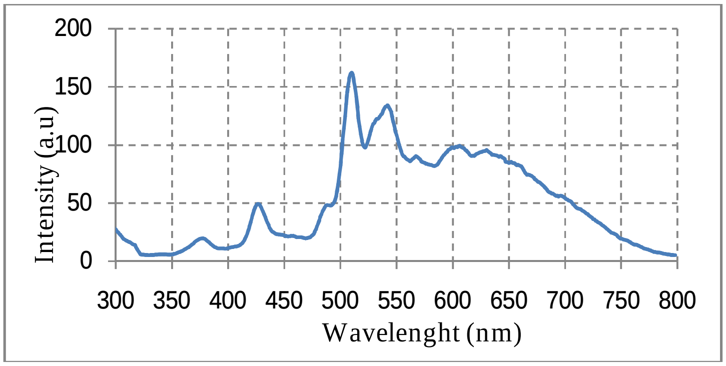

Figure (6): PL Spectral of ZnO film deposition on PS

Conclusion

The main advanced from deposition of ZnO thin film on PS by Spry Pyrolysis Technology is XRD Spectral showed that crystallite growth on ZnO particle on PS more than using glass as a substrate, AFM image of ZnO refer to uniform distribution of ZnO particle on PS, PL spectral Showed when using PS as a substrate to ZnO the UV emission increasing.

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