Application of scaling law in the analysis of growth and annealing behavior of ZnO films

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The scaling theory is applied to study the growth and annealing behavior of ZnO films grown on Si substrates. ZnO films were deposited on Si substrate by reactive magnetron sputtering. It is found that ZnO film has three nucleation stages. In the initial nucleation stage, the intrinsic defects on Si substrates may be responsible for the surface roughening and the density of surface defects determines the nucleation density of ZnO films. In the low-rate nucleation stage, the deposition rate plays a role of controlling the morphological evolution and the lattice mismatch stress may be released in this stage. The second nucleation of ZnO films may result from the bombardment of energetic ions or atoms on the surface of Si substrates. The influence of growth temperature is also studied on the growth behavior. It is found that the grain sizes of ZnO films have an increase behavior with temperature up to 500oC, and then decrease at 750oC. The growth behavior of ZnO is related to the reconstruction of Si (001) surface. A growth model is suggested in the paper. At last, we applied the dynamic scaling theory to the analysis of the annealing behavior of ZnO films. A coarsening transition is found to be at temperature of about 790oC. For the annealed films above and below the temperature, the coarsening behavior is dominated by different diffusion processes, which are assigned to be the mechanism of VO and Zni diffusion, respectively. The result may be helpful for the fabrication of ZnO film with low n-type conductivity or even p-type conductivity.