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Studies of laser induced-MOCVD zinc oxide films

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Abstract—Thin films of ZnO have been prepared by the double photobeams ultraviolet laser induced- metallorganic chemical vapour deposition (MOCVD) technique. The structure and transparent photoconductive property of these films are investigated by X-ray diffraction(XRD) , reflecting electron diffraction(RED) , scanning electron microscopy(SEM) and ultraviolet visible absorption spectrometry(UV) . The experiment shows that the technique produces superior quality films of polycrystal ZnO and possesses higher deposition rate, lower temperature of growth and far better transparent photoconductive property than those grown by the conventional CVD or MOCVD technique.

1-INTRODUCTION

Zinc oxide(ZnO) in pure form is a n-type semiconductor with wide band gaps near 3. 3ev, with large piezoelectric and optical coupling constants. Thin films of ZnO with high conductivity and optical transparency have been applied to solar cells[1, 2] , surface acoustic wave devices[3] , transparent conducting materials[4], and gas sensors [5] . A variety of techniques, including sputtering[6] , chemical vapor deposition (CVD) [7], and metallorganic -CVD technique(MOCVD)[8,9]. To obtain uniform films of ZnO at high deposition rates and low temperature of growth, we have studied laser induced MOCVD technique with double-beams. The transparent photoconductive property of these films are reported in this paper.

2-EXPERIMENTS

The experimental arrangement for photodepositing the ZnO film is shown in Fig.1.

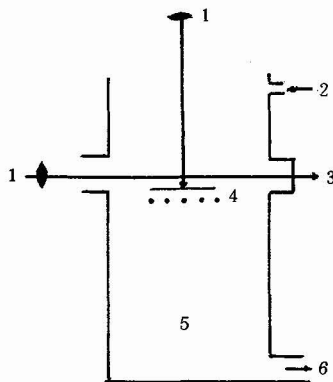
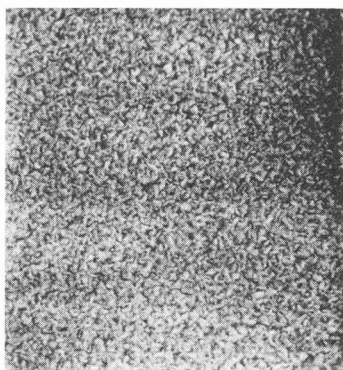
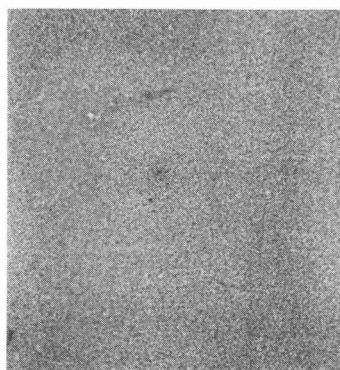


Fig.1 Experimental arrangement: 1.photon source 2.reactant gases
3.power meter 4.substrate 5.reactior 6.to vacuum pump

Using purity dimethyl zinc (DMZ) as a zinc source He-N₂O mixture as the carrier gas, excimer laser $\lambda = 266\text{nm}$ as photon source, the pressure in the reactor is 2 Torr, on glass and mica substrates, at room temperature to 240°C. The substrate is placed on a temperature controlled heater. The nonstoichiometric (Oxygen-deficient) zinc oxide (ZnO_{1-x}) polycrystalline films are formed when the temperature of the substrate is between 80-240°C. The irradiation of focused laser beam parallel and perpendicular to substrate surface. These ZnO_{1-x} films (thickness 50-200 nm) with lower resistivities and higher optical transmission are obtained at deposition rate 300nm/min. The films are characterized by SEM, RED and UV spectrometry. The results are shown in the Fig.2.3.4. The opposite intensity of XRD line are listed in table 1.



(a)



(b)

Fig.2 SEM morphology (X5.00K) of ZnO films on (111) single crystal silicon (a) grown at 220°C; (b) grown at 420°C



(a)



(b)

Fig.3 RED morphology of ZnO films on (111) single crystal silicon at 220°C. (a) polycrystalline diffractive ring; (b) the direction of the C-axis

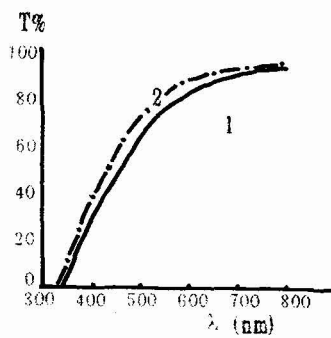


Fig.4 The UV absorption spectrum
1--deposition rate 230nm/min
2--deposition rate 200nm/min

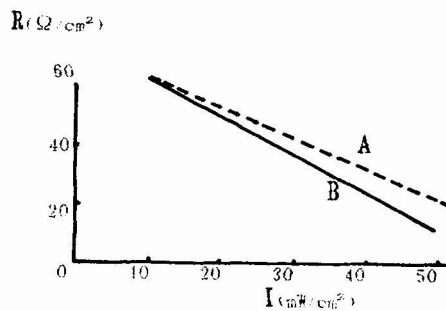


Fig.5 The photoconductivity of ZnO films (thickness 150nm)
A--deposition rate 230nm/min
B--deposition rate 200nm/min

TABLE 1. The opposite intensity of XRD lines

substrates*	XRD line opposite intensity				
	100	002	101	102	103
pyre	0.04	1	0.02	0.06	0.09
mica**	0.02	1	0.01	0.03	0.05

* substrates temperature 220°C

** direction <001> of the mica

3-CONCLUSIONS

The electron diffraction experiment indicates that laser induce MOCVD technique can produce uniform films at a high deposition rate (300nm/min) Fig.2. The maximum crystal orientation is along C-axis, the temperature range is 80-240°C and the best structural perfection is obtained on mica substrate and the growing direction of ZnO suits mica(Fig.3 and table 1). These films are always characterized by the presence of (002) as the strongest line(table 1). The ZnO films obtained by laser-induced MOCVD technique possess far better transparent photoconductive property (Fig.4-5), higher deposition rate and lower temperature of growth than obtained by other methods.

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