Table 4-1 Growth rate and resistivity of the various working pressure deposited AZO films.

	#1	#2	#3	#4	#5
RF power	50W				
Deposition time	120 min				
Substrate temperature	Room temperature (R.T.)				
Working pressure in Ar ambience	2.5mTorr	5mTorr	10mTorr	20mTorr	40mTorr
Film thickness (Å)	1640	1250	950	730	520
Growth rate (Å/min)	13.67	10.42	7.92	6.08	4.33
Resistivity (Ω-cm)	2.13×10^{-3}	1.88×10^{-2}	4.28×10^{-2}	1.83×10^{-1}	2.60×10^{-1}

Table 4-2 FWHM, average grain size, and resistivity of the 1200Å AZO films deposited at various working using 2wt% Al_2O_3 target and RF power = 50W.

Working pressure in Ar ambience	2.5mTorr	5mTorr	10mTorr
FWHM (deg.)	0.42	0.44	0.45
Avg. grain size (nm)	19.81	18.91	18.48
Resistivity (Ω-cm)	2.13×10^{-3}	1.88×10^{-2}	4.28×10^{-2}

Table 4-3 FWHM, average grain size, and resistivity of the 1600Å AZO films deposited at various RF power using 2wt% Al_2O_3 target.

RF power	50W	80W	100W
FWHM (deg.)	0.43	0.38	0.37
Avg. grain size (nm)	19.35	21.89	22.48
Resistivity (Ω-cm)	2.13×10^{-3}	2.09×10^{-3}	1.88×10^{-3}

Table 4-4 Peak position of the AZO films deposited at RF power = 80W using various substrate temperature and Al_2O_3 content of target.

Al_2O_3 content of target	0.5 wt%	1 wt%	2 wt%	4 wt%
Ts = R.T.	34.78°	34.8°	34.48°	34.36°
Ts = 150	34.87°	34.75°	34.82°	34.84°
Ts = 250	34.88°	34.9°	34.96°	

Table 4-5 FWHM and grain size of the AZO films deposited at RF power = 80W using various substrate temperature and Al_2O_3 content of target.

Al_2O_3 Content of Target	0.5 wt%	1 wt%	2 wt%	4 wt%
Deposited at Ts = R.T.	FWHM = 0.4° (grain size = 20.81nm)	FWHM = 0.4° (grain size = 20.81nm)	FWHM = 0.38° (grain size = 21.89nm)	FWHM = 0.42° (grain size = 19.80nm)
Deposited at Ts = 150℃	FWHM = 0.38° (grain size = 24.49nm)	FWHM = 0.34° (grain size = 24.48nm)	FWHM = 0.37° (grain size = 22.50nm)	FWHM = 0.33° (grain size = 25.23nm)
Deposited at Ts = 250℃	FWHM = 0.34° (grain size = 24.49nm)	FWHM = 0.33° (grain size = 25.23nm)	FWHM = 0.36° (grain size = 23.14nm)	

Table 4-6 Resistivity of the AZO films deposited at RF power = 80W and 1 hour of deposition time using various substrate temperature and Al_2O_3 content of target.

Al_2O_3 Content of Target	0.5 wt%	1 wt%	2 wt%	4 wt%
Deposited at Ts = R.T.	0.0238	0.00504	0.00209	0.001105
Deposited at Ts = 150℃	0.0208	0.00453	0.00153	0.01595
Deposited at Ts = 250℃	0.0134	0.00407	0.00150	

(Unit is Ω-cm)

Table 4-7 The dependence of growth rate and Al_2O_3 content of target of the AZO films deposited at Pw = 2.5mTorr, Prf = 80W and Ts = R.T.

Target with different wt% Al_2O_3	Growth rate (Å /min)
0 wt%	34.75
0.5 wt%	31.83
1 wt%	24.11
2 wt%	22.78
4 wt%	21.67

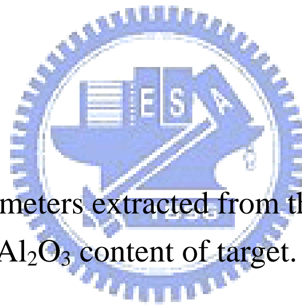

Table 4-8 The crystallinity parameters extracted from the XRD patterns of ~4000Å AZO films deposited by various Al_2O_3 content of target.

	Undoped ZnO	0.5wt%	1wt%	2wt%	4wt%
Peak position (deg.)	34.86	34.68	34.58	34.69	34.64
FWHM (deg.)	0.48	0.42	0.33	0.31	0.36
Avg. grain size (nm)	17.35	19.82	25.21	26.85	23.12

Table 4-9 Resistivity of the AZO films with different film thickness deposited at RF power = 80W using various Al_2O_3 content of target.

Film thickness	1600Å	3000Å	4000Å
0.5 wt% AZO	2.38×10-2	7.55×10-3	6.06×10-3
1wt%AZO	5.04×10-3	2.21×10-3	1.63×10-3
2wt%AZO	2.09×10-3	7.98×10-4	4.92×10-4
4wt%AZO	3.22×10-3	1.02×10-3	3.50×10-3

(Unit is Ω-cm)

Table 4-10 The crystallinity parameters and resistivity of the AZO films with different film thickness deposited at RF power = 80W using 2wt% Al_2O_3 target.

Film thickness	1600Å	3000Å	4000Å
Peak position (deg.)	34.48	34.70	34.69
FWHM (deg.)	0.38	0.36	0.31
Avg. grain size (nm)	21.89	23.12	26.85
Resistivity (Ω-cm)	2.09x10-3	7.98x10-4	4.92x10-4

Table 4-11 Resistivity of the AZO films deposited at RF power = 80W and O_2/Ar = 10% using different Al_2O_3 content of target.

Al_2O_3 content of target	0.5 wt%	1 wt%	2 wt%	4 wt%
Resistivity (Ω-cm)	Over range	Over range	6.04	Over range

Table 4-12 Optimum deposition parameters for the sputtered-deposited AZO films in this thesis.

Parameter	Optimum value
Deposition ambience	Deposition without any oxygen atmosphere
RF power	80W
Argon working pressure	2.5mTorr
Substrate temperature	250℃ (Select R.T. for low temp. process application)
Al_2O_3 content of target	2 wt%
Film thickness	4000Å or more

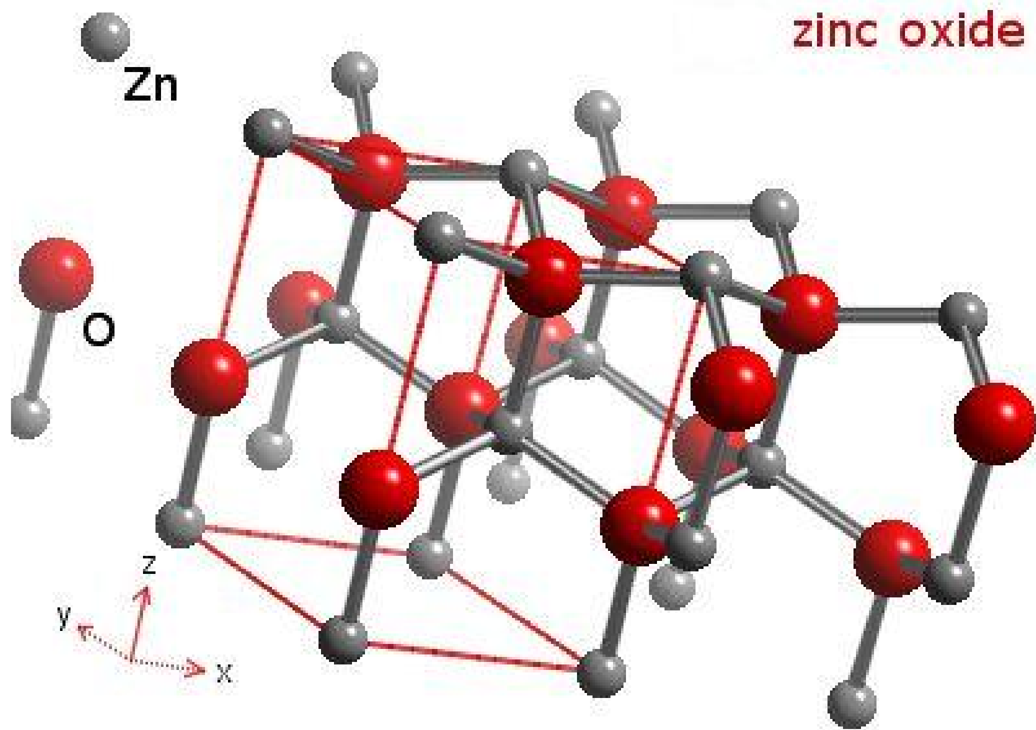

Fig. 1-1 Hexagonal wurtzite structure of zinc oxide.

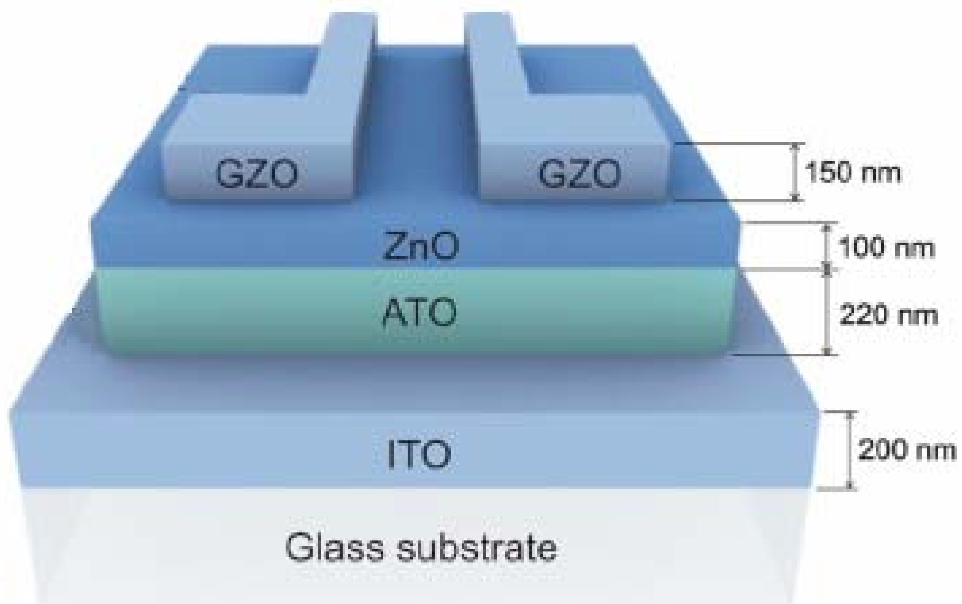

Fig. 1-2 ZnO-based Transparent Thin Film Transistor.

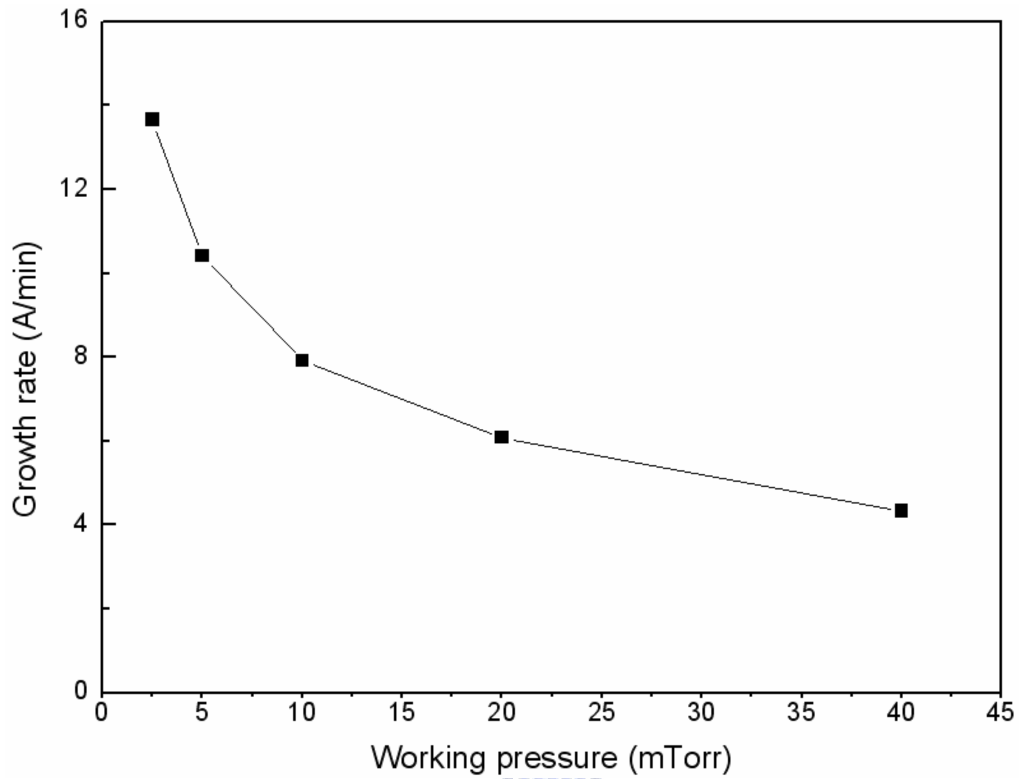

Fig. 4-1 The dependence of growth rate and working pressure (RF power = 80W).

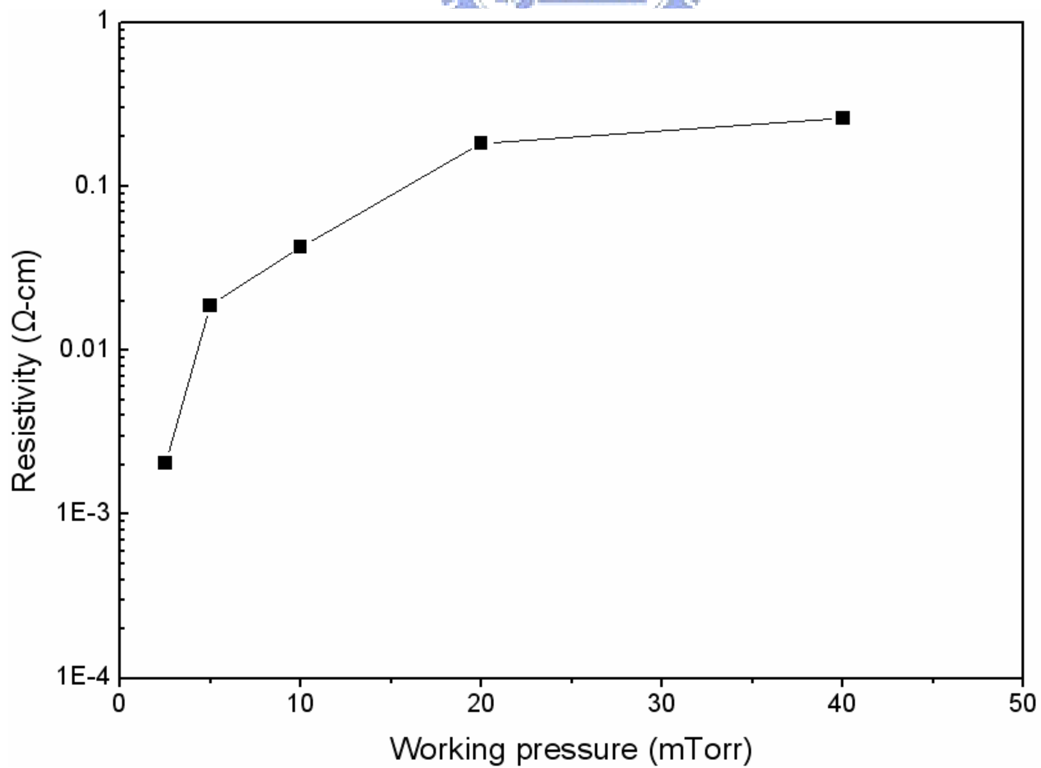

Fig. 4-3 The dependence of resistivity and working pressure (2wt% target, RF power = 80W)

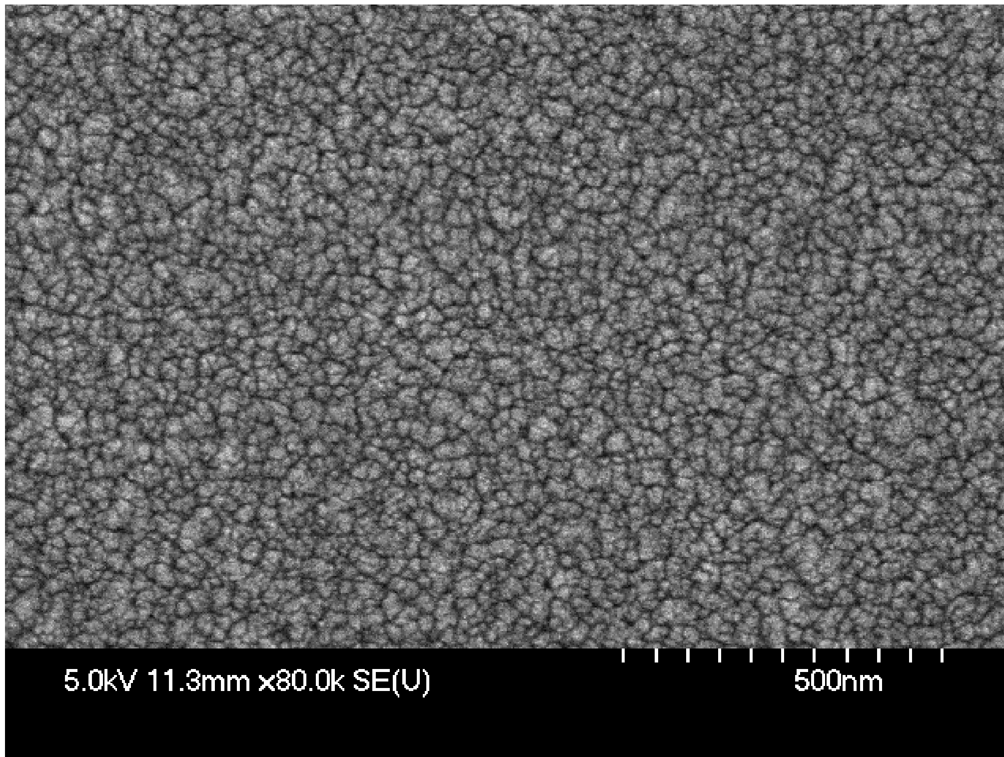

Fig. 4-4-1 SEM image of the 2wt% grown AZO film at Pw = 2.5mTorr.

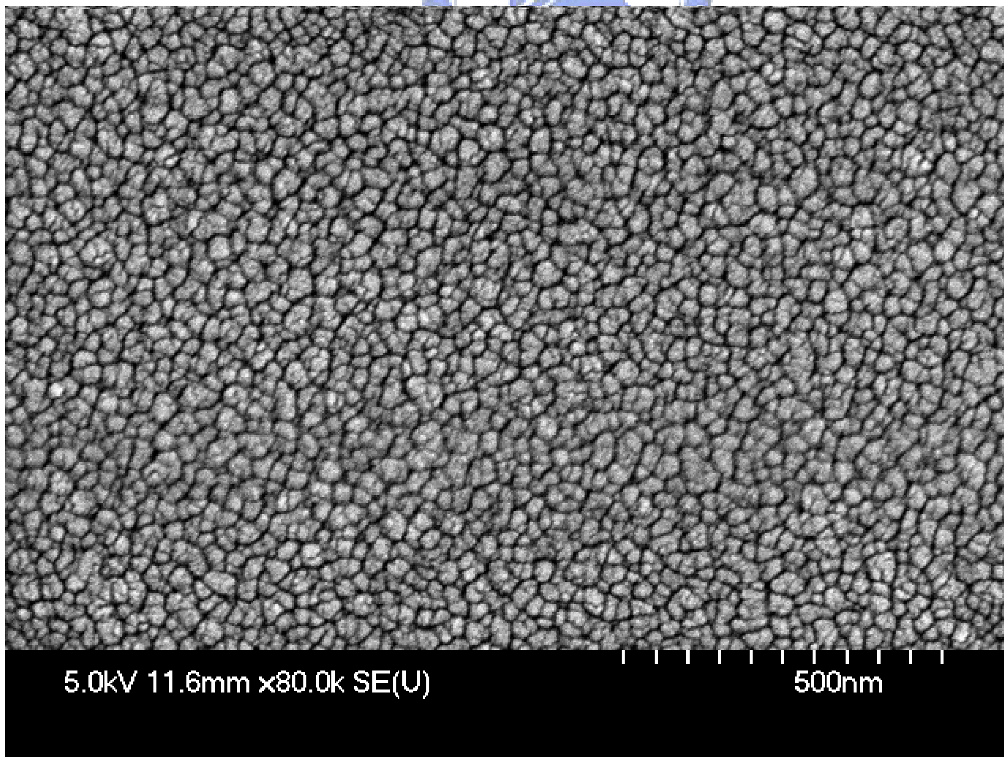

Fig. 4-4-2 SEM image of the 2wt% grown AZO film at Pw = 5mTorr.

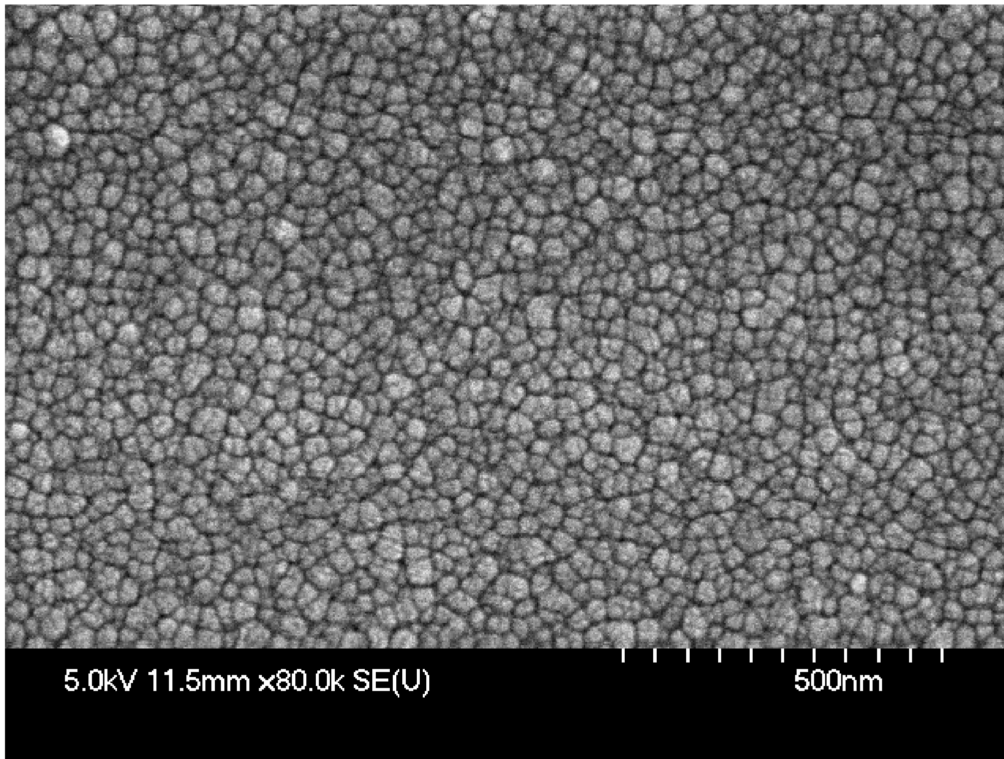

Fig. 4-4-3 SEM image of the 2wt% grown AZO film at Pw = 10mTorr.

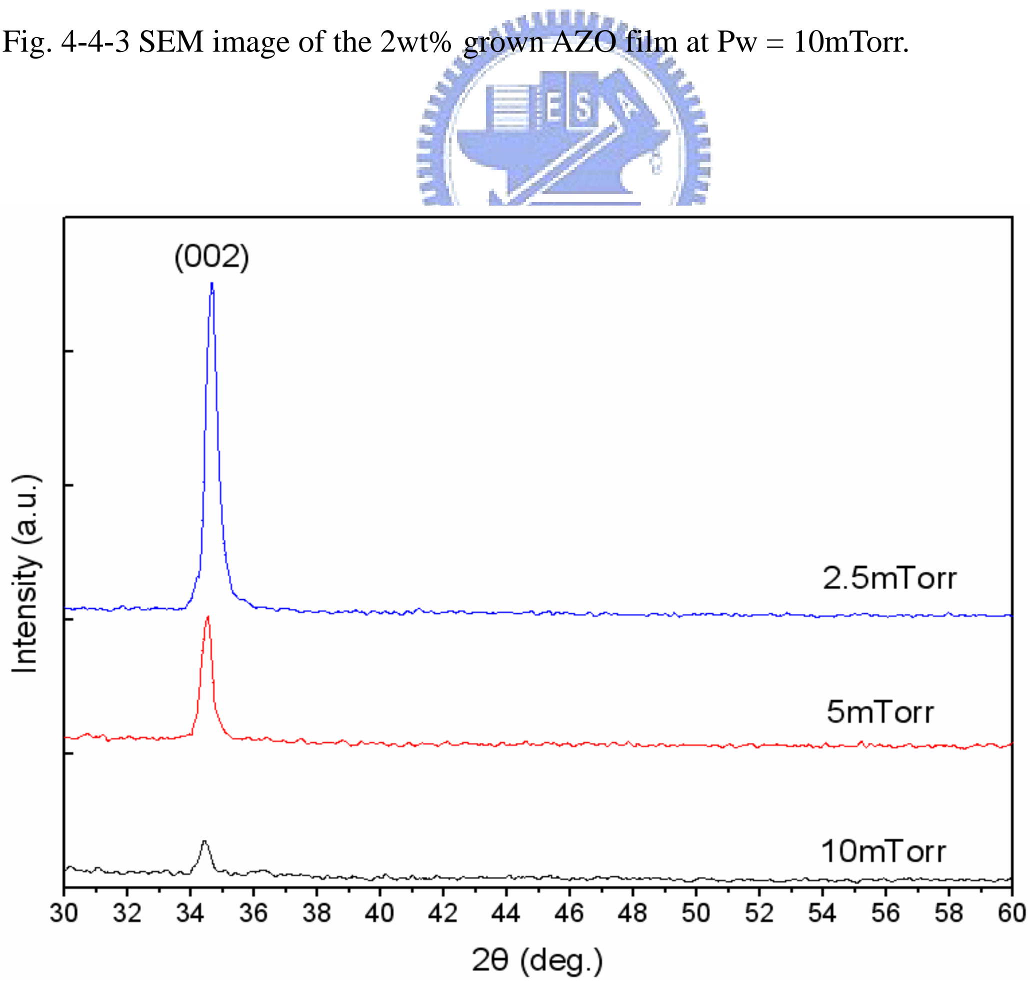

Fig. 4-4-4 XRD patterns of AZO films prepared by various working pressure. (2wt% target)

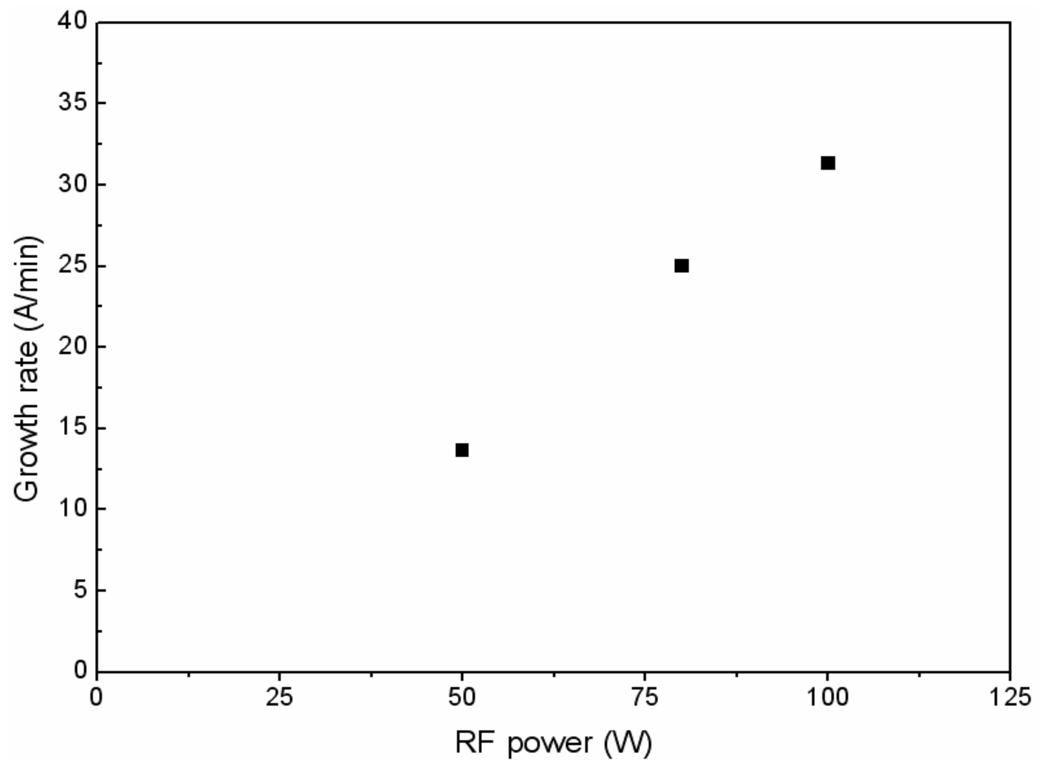

Fig. 4-5 The independence of growth rate and RF power. (2wt% target, Pw = 2.5mTorr)

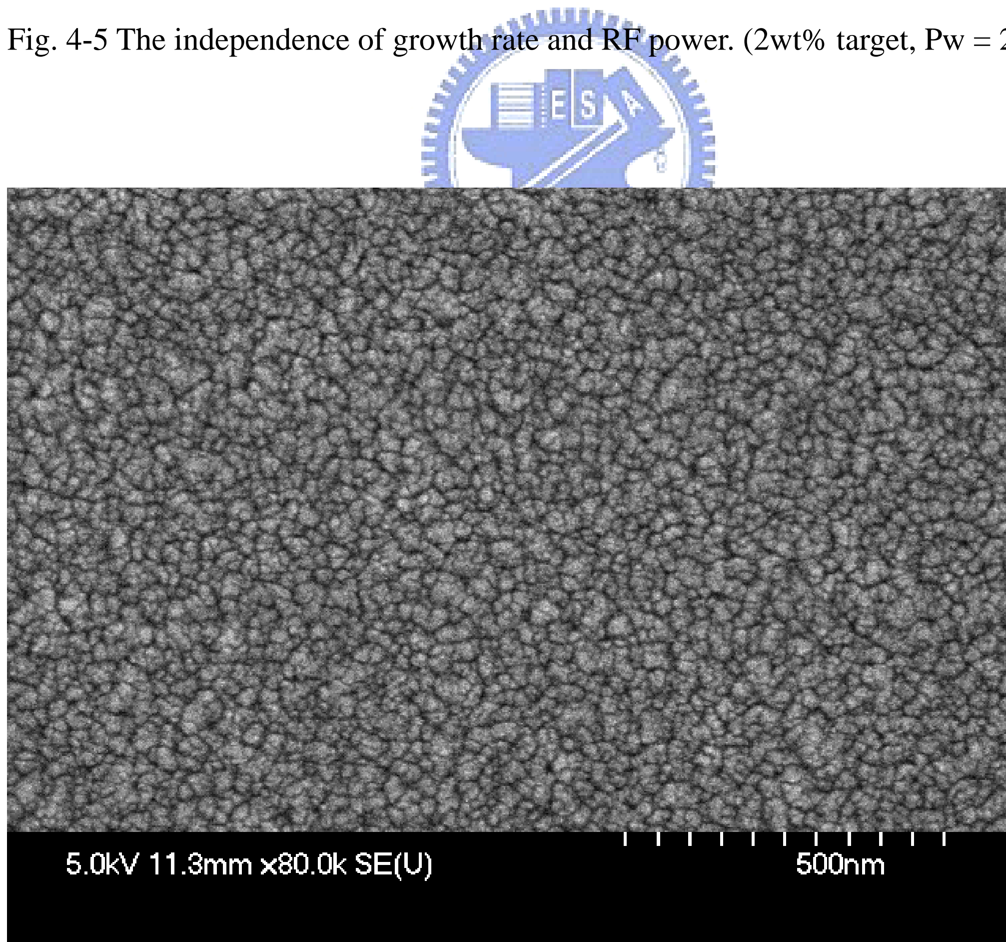

Fig. 4-6-1 SEM image of the 2wt% grown AZO film at Prf = 50W.

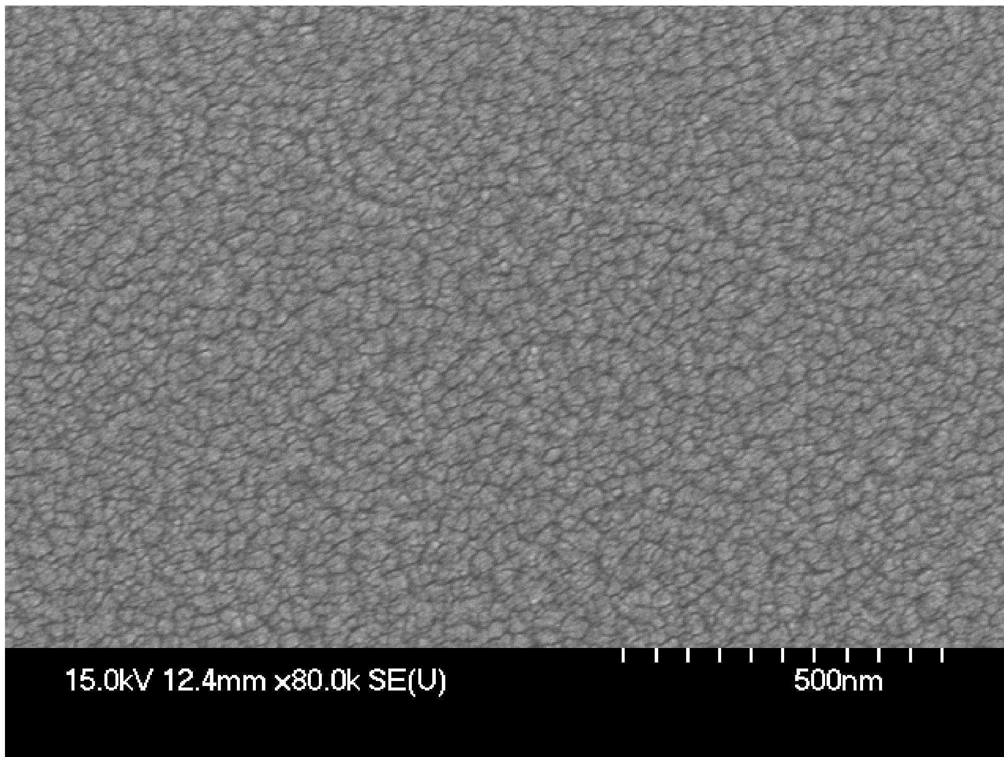

Fig. 4-6-2 SEM image of the 2wt% grown AZO film at Prf = 80W.

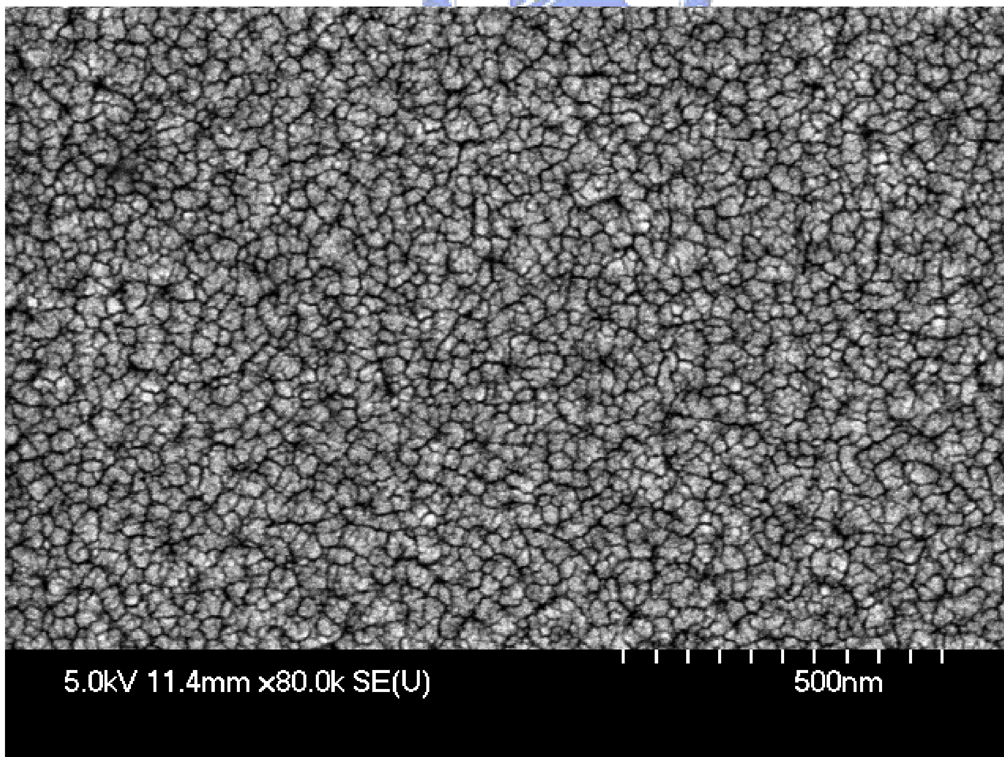

Fig. 4-6-3 SEM image of the 2wt% grown AZO film at Prf = 100W.

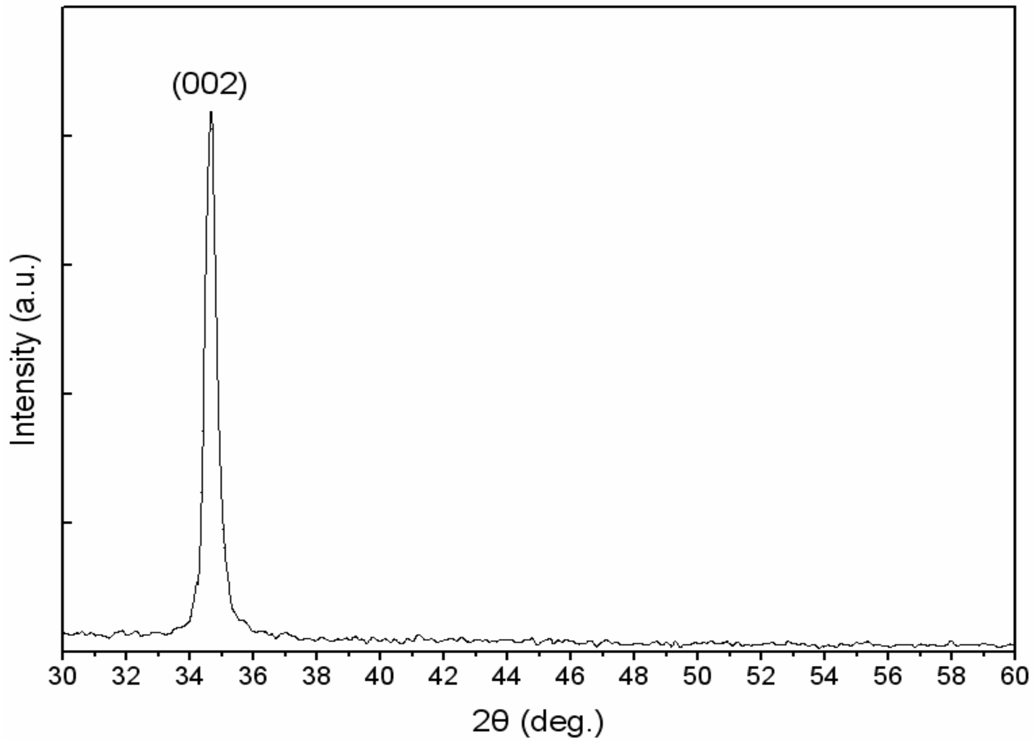

Fig. 4-7-1 The XRD pattern of the 2wt% grown AZO film at Prf = 50W.

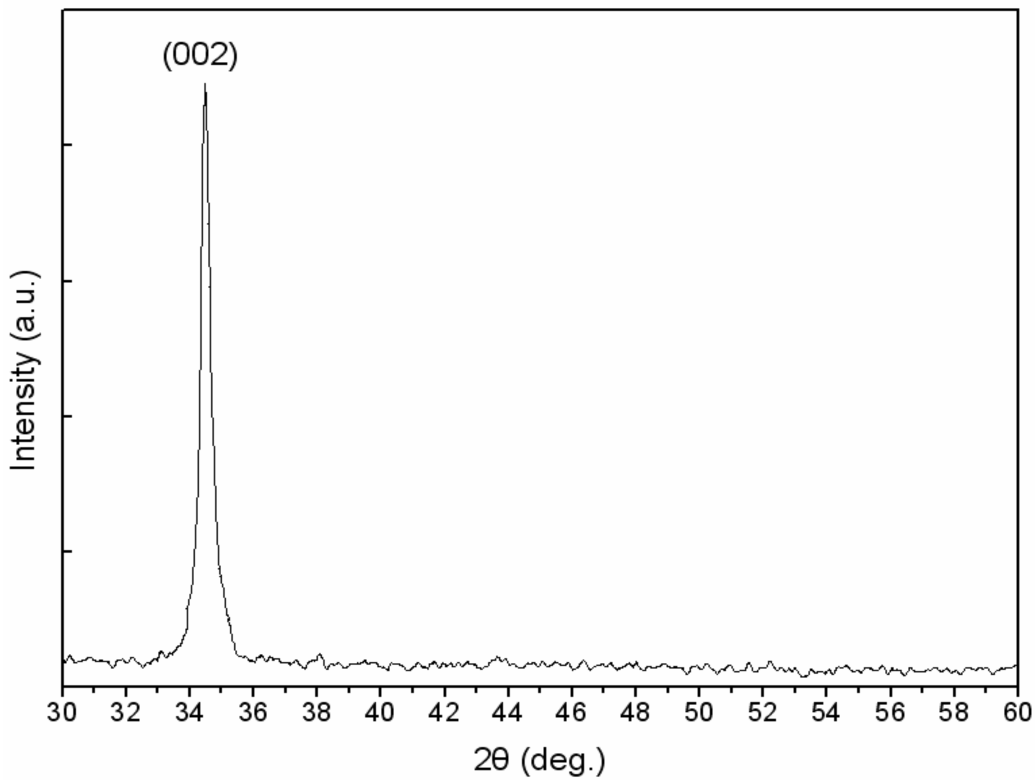

Fig. 4-7-2 The XRD pattern of the 2wt% grown AZO film at Prf = 80W.

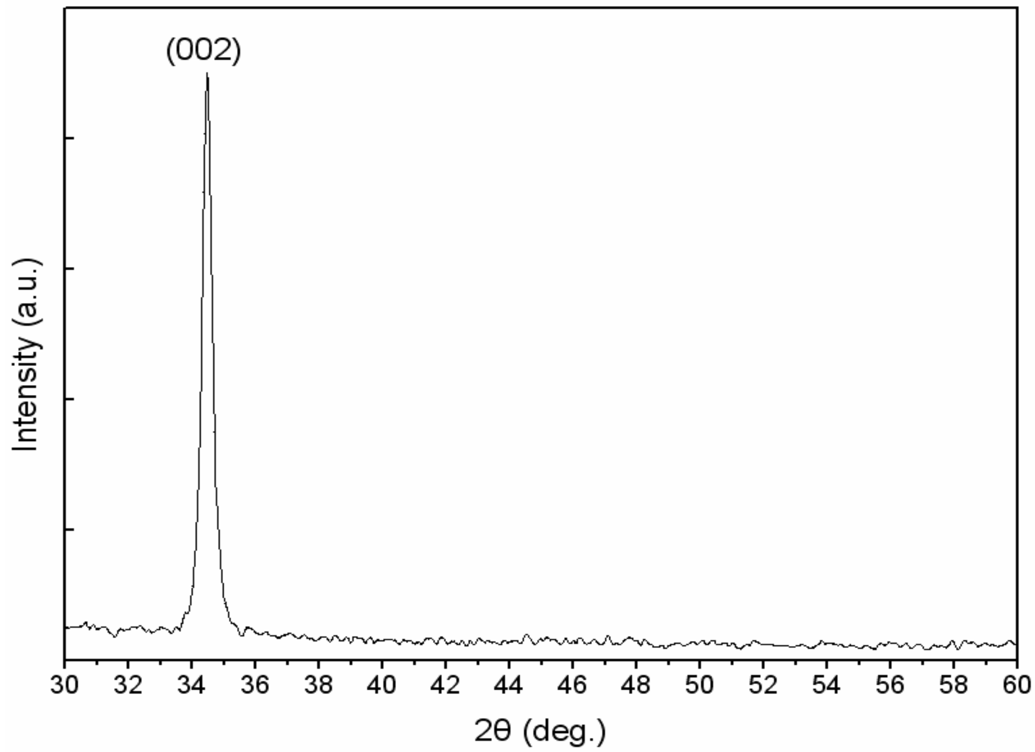

Fig. 4-7-3 The XRD pattern of the 2wt% grown AZO film at Prf = 100W.

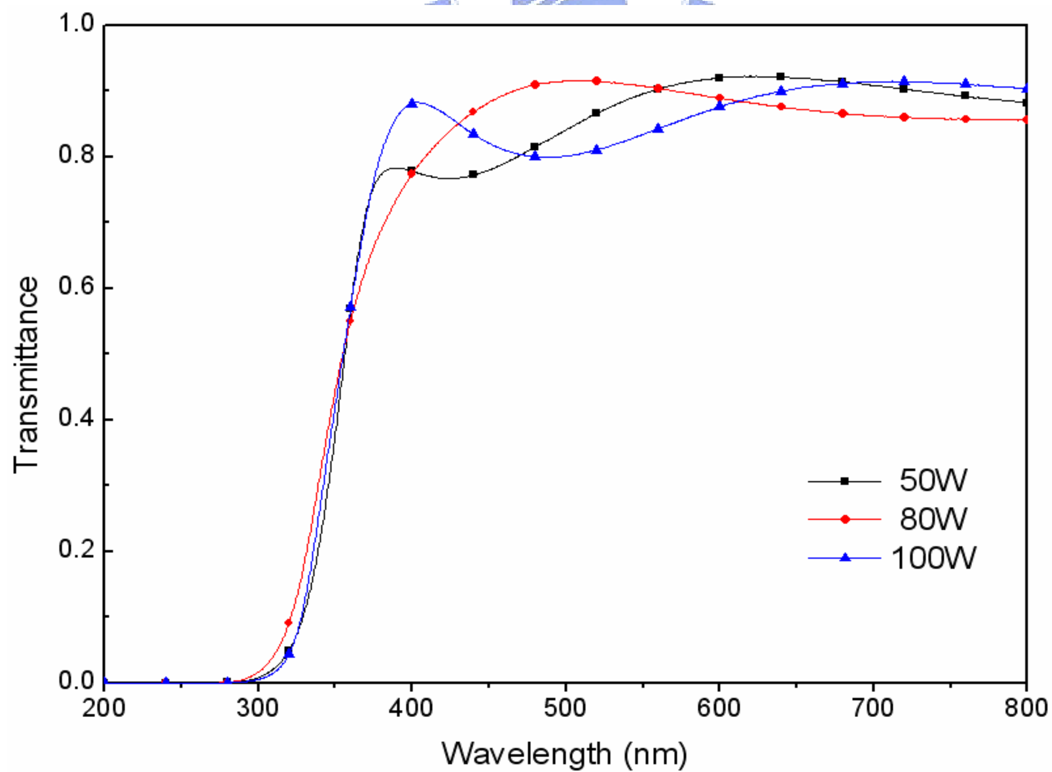

Fig. 4-8 The optical transmittance of 2wt% grown AZO films prepared by different RF power.

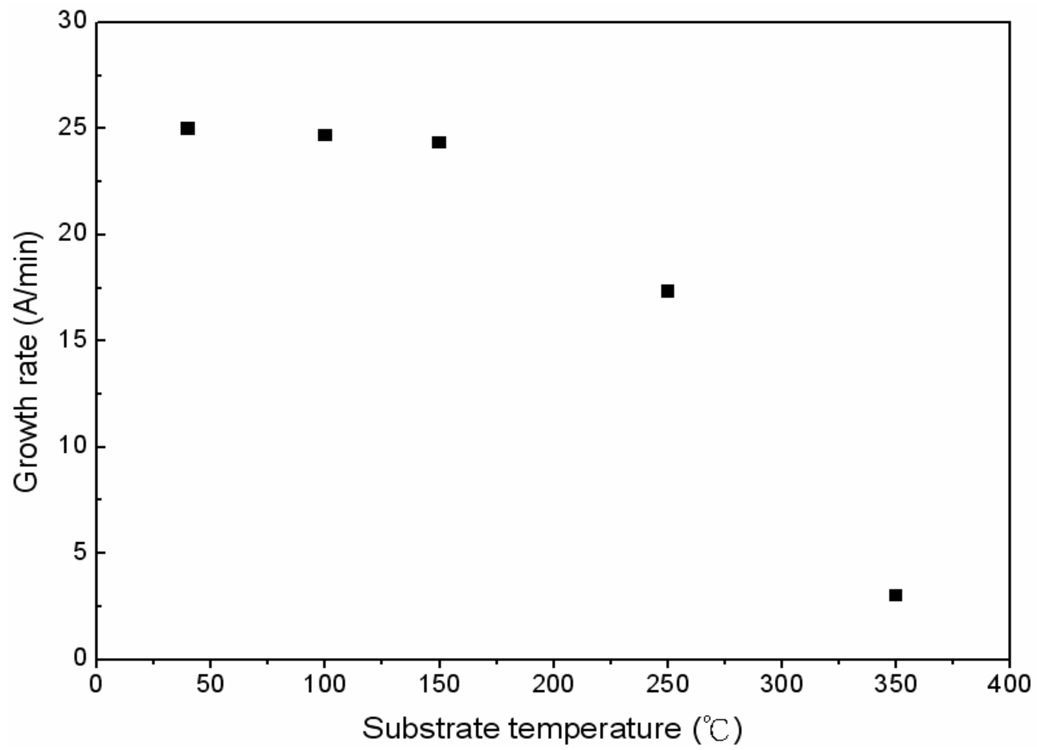

Fig. 4-9 The dependence of growth rate and substrate temperature. (2wt% target, Pw = 2.5mTorr, Prf = 80W)

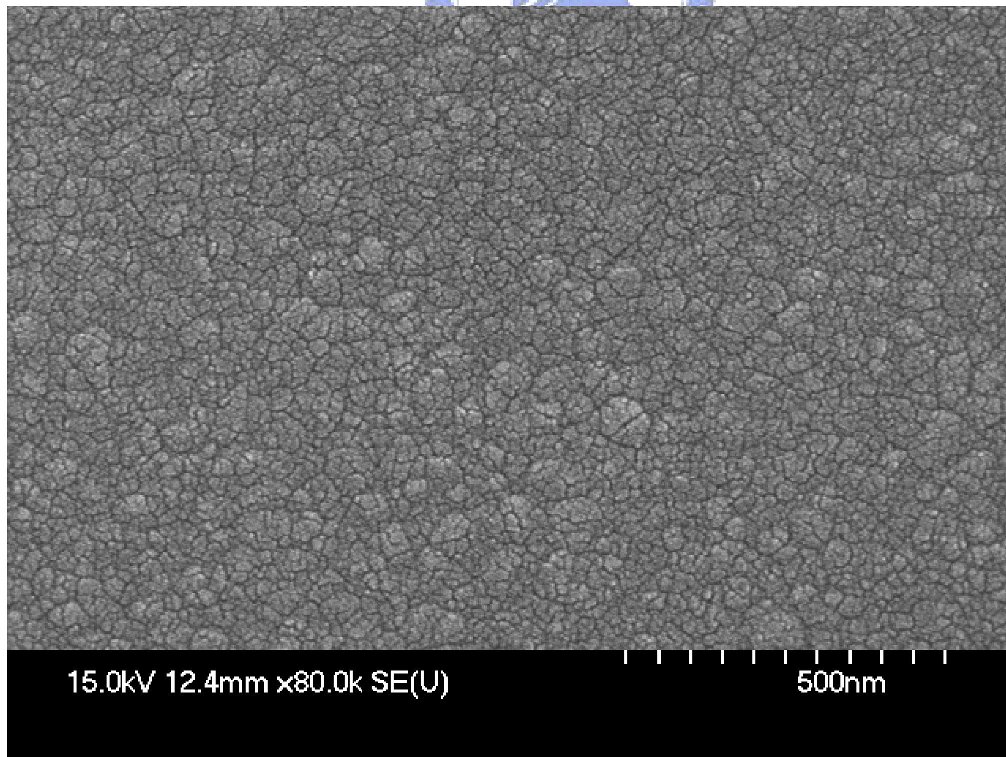

Fig. 4-10-1 SEM image of the 0.5wt% grown AZO film at Ts = R.T..

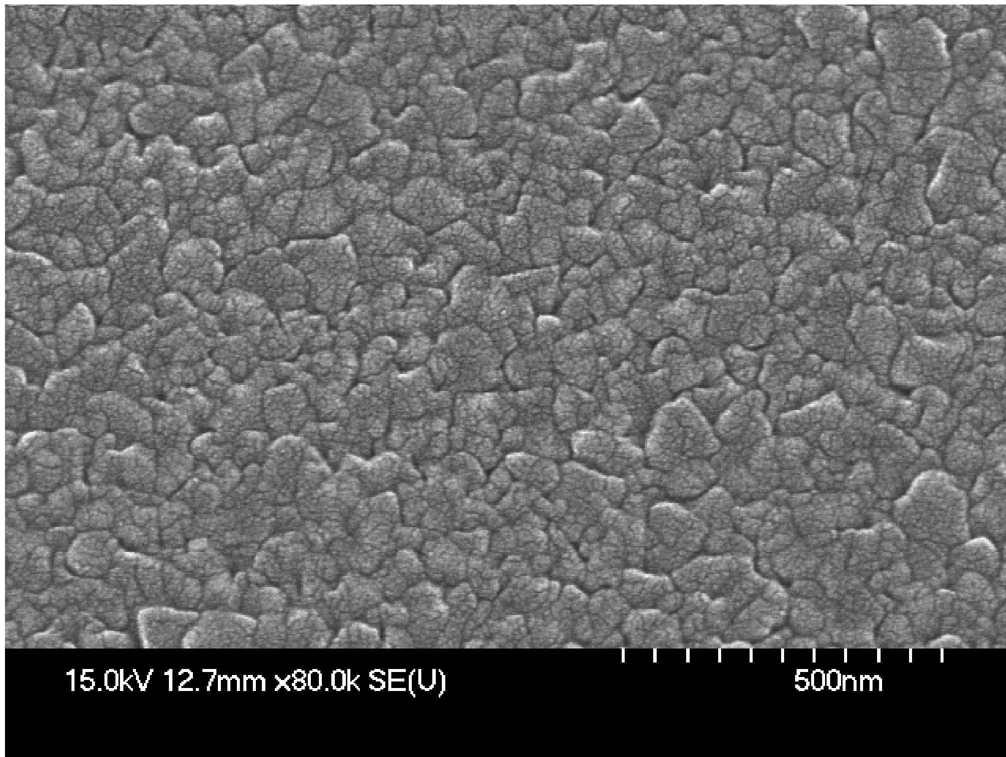

Fig. 4-10-2 SEM image of the 0.5wt% grown AZO film at Ts = 150℃.

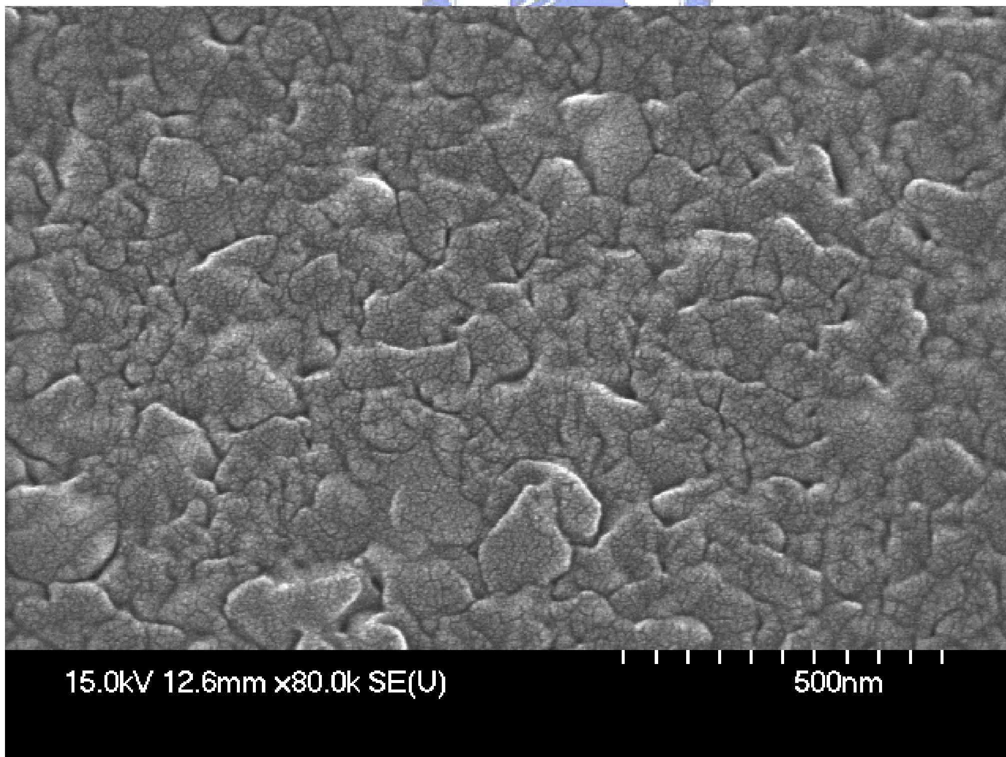

Fig. 4-10-3 SEM image of the 0.5wt% grown AZO film at Ts = 250℃.

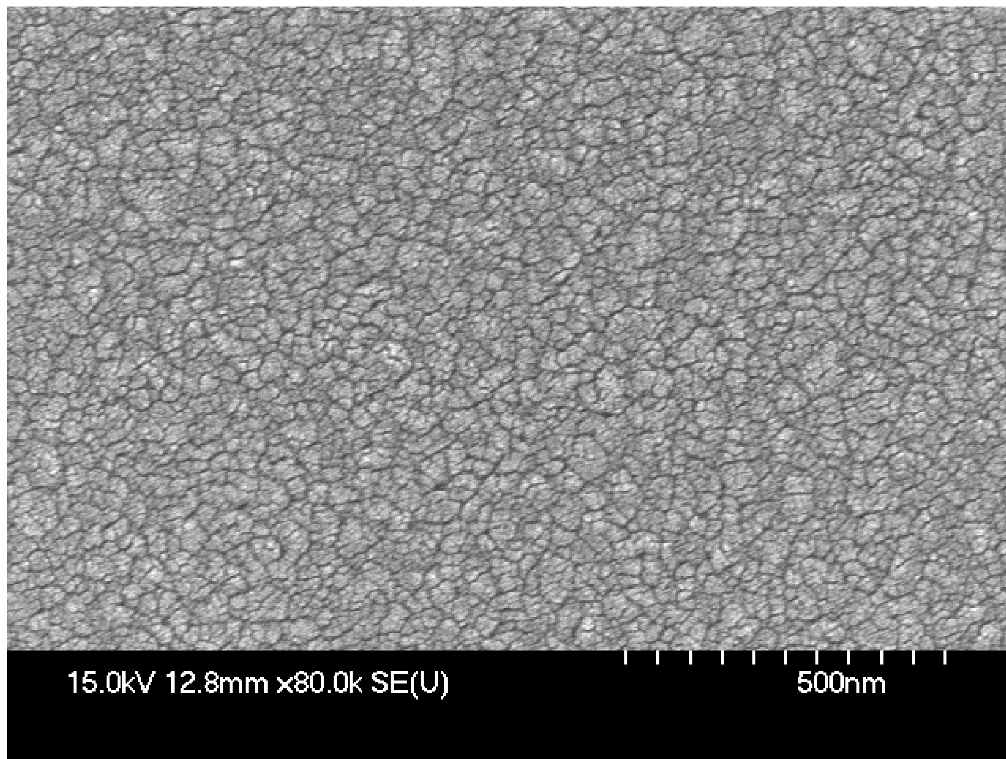

Fig. 4-11-1 SEM image of the 1wt% grown AZO film at Ts = R.T..

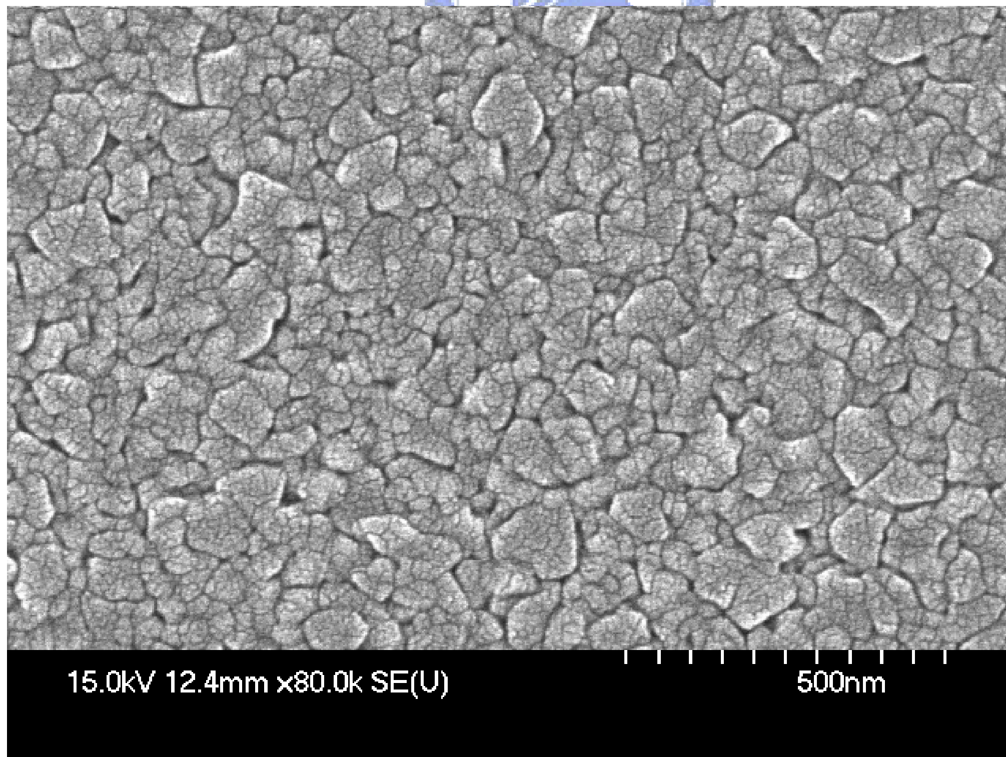

Fig. 4-11-2 SEM image of the 1wt% grown AZO film at Ts = 150℃.