Supporting Information for Publication

Effects of the Wrinkle Structure and Flat Structure Formed During Static Low-Temperature Annealing of ZnO on the Performance of Inverted Polymer Solar Cells

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Table S1. Summary of the previous works for ZnO wrinkle and flat structure by dynamic annealing (DA) and static annealing (SA). The mean value means the average value of the height of wrinkle or flat structure.

	Wrinkle or Flat	Dynamic or Static Annealing	Target Temperature (From RT to ~°C in case of DA) on hotplate	The Concentration of Solution (M)	Ramping Rate (°C/min)	The Height of Wrinkle or Flat (nm) / mean value (nm)	RMS (nm)
Ref 26	Wrinkle	DA	350	0.75	22	~150 /	~47.3
Ref 30	Wrinkle	DA	250	0.7	10, 20, 30,	320, 290, 150,	67, 44, 24,
Ref 24	Wrinkle	DA	275	0.75	50	~120	~4
Ref 29	Wrinkle	DA	350	0.75, 0.75, 0.75 (+0.25mg) 0.75 (+1mg) 0.75 (+3mg) 0.75 (+5mg) 0.75 (+10mg)	11 23 23 23 23 23 23	~180 / (150) ~130 / (100) ~100 / (70) ~ ~ ~ 70 / < (30)	- - - - - - -
Ref 27	Wrinkle Flat	DA, SA,	200 200	0.44~0.54	Unknown (maybe slower than SA and 68.75) // Unknown (maybe so fast)	38 (4000rpm) ~ 70 (2000rpm)	8.8 ~ 12.8
Ref 28	Wrinkle Flat	DA, SA,	200	0.45	68.75 // Unknown (maybe higher than DA)	~15	2~3.6
Ref 25	Wrinkle	SA	200 (at Oven)	0.5	Unknown (maybe low, lower than 68.75)	~85	~13.6
Our Work	Wrinkle Flat	SA	150, 200,	0.75	From 40 to 0 // From 56 to 0	~116.9, ~5	~21.5, ~1.7

Figure S1. AFM surface morphology results of the transformation from ZnO wrinkle structure at 150°C annealing temperature to ZnO flat structure over 170°C annealing temperature.

ZnO (150℃)   ZnO (160℃)   ZnO (170℃)

ZnO (180℃)   ZnO (190℃)   ZnO (200℃)
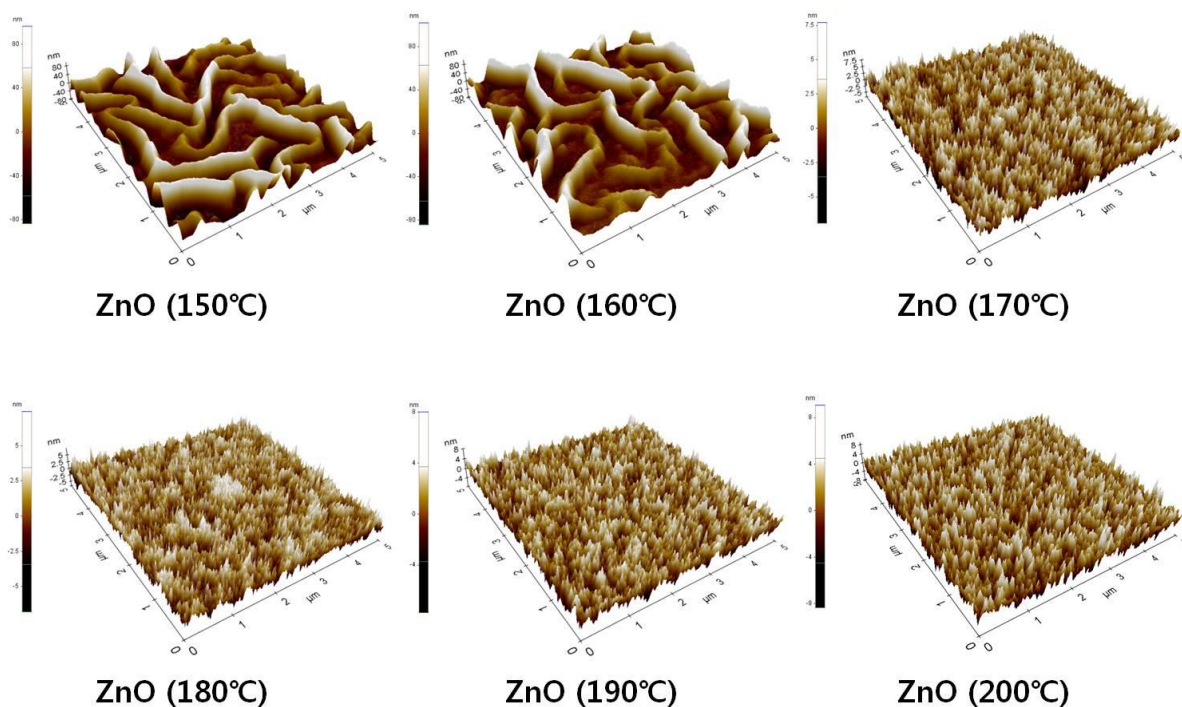
The surface morphology of the deposited ZnO layer at 150°C shows the formation of wrinkle structures. This wrinkle surface morphology was formed because the solvent was not completely vaporized at low temperature which disturbed the specific orientation of ZnO crystal growth. With an increase in the annealing temperature, the wrinkle structure starts to disappear and transform into a more homogeneous flat structure which can be seen at 170°C. Though the flat structures were formed at this temperature, the annealing temperature was raised to 200°C in order to make sure a complete vaporization of any solvent present.
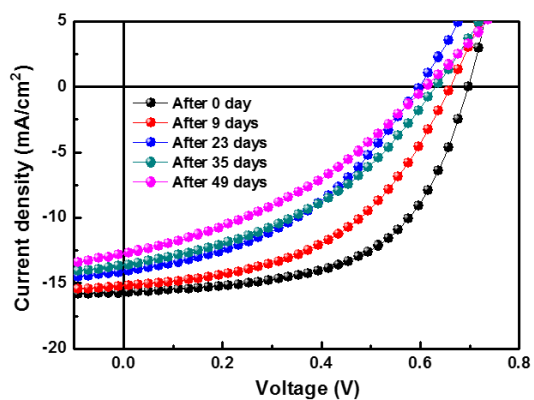
Figure S2. AFM analysis of the device with (a) ZnO wrinkle structure (b) ZnO flat structure after Ag deposition on PTB7-F20:PC$_{71}$ layer.
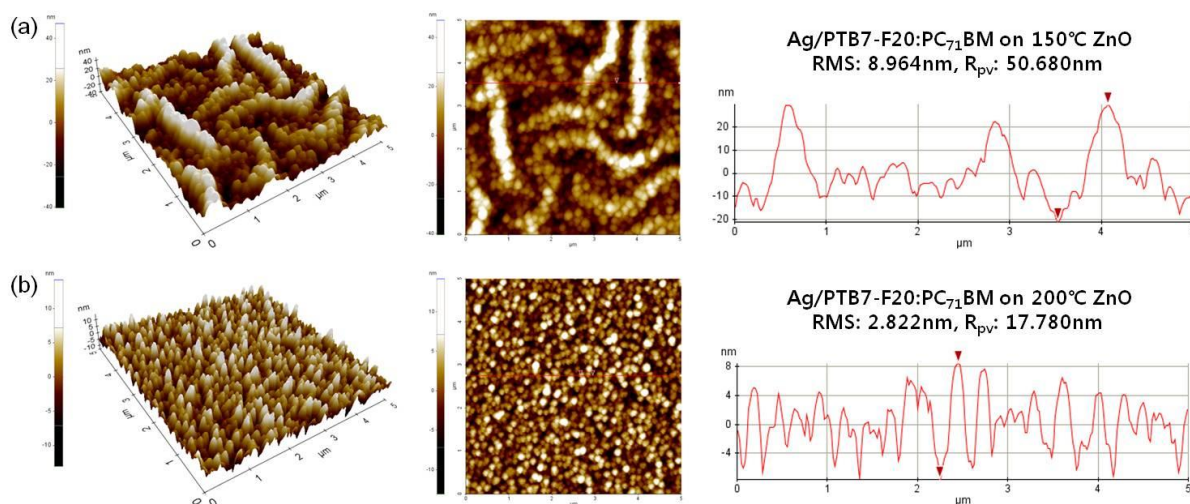
The surface analysis of the device structure after deposition of Ag electrode on ZnO wrinkle structure and flat structure with PTB7-F20:PCBM$_{71}$ shows a negligible change in the surface morphology at 200°C annealing temperature. However, a wide reduction in surface roughness was observed even though the wrinkle structures persist. This reduction in surface roughness is probably due to the filling of the valleys in between the ridge structures with Ag.

Figure S3. *J-V* characteristics comparison of devices fabricated using ZnO wrinkle structure at 150°C and ZnO flat structure at 200°C over a period of time.