Electronic Supplementary Information

A Simple Approach to the Fabrication of Fluorine-Doped Zinc Oxide Thin Films by Atomic Layer Deposition at Low Temperatures and an Investigation into the Growth Mode

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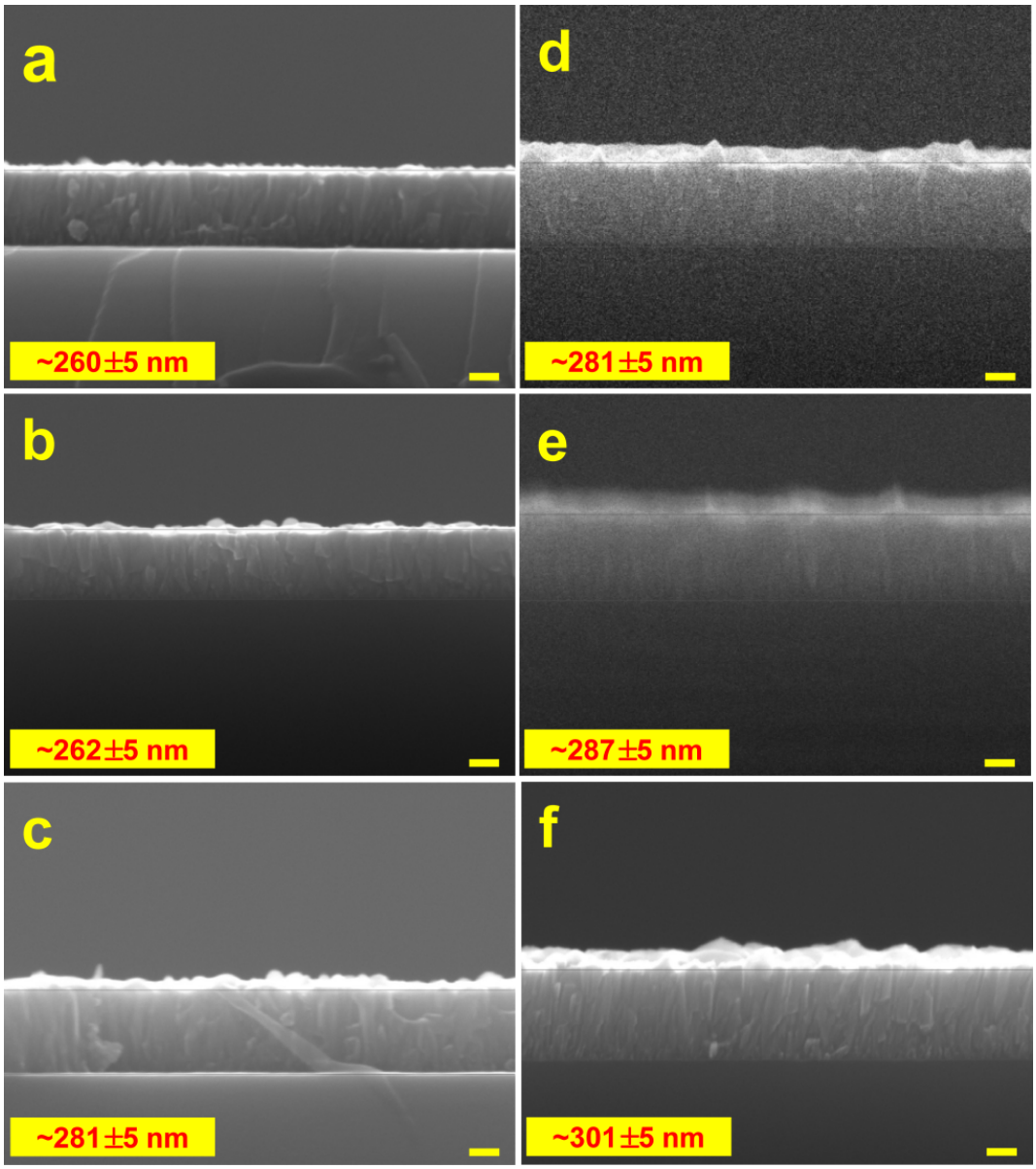
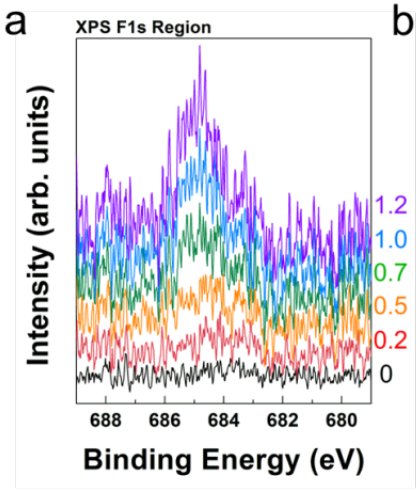


Figure S1. Cross-sectional field emission scanning electron microscopy (FE-SEM) images of (a) undoped ZnO, (b) ZnO:F{0.2}, (c) ZnO:F(0.5), (d) ZnO:F(0.7), (e) ZnO:F(1.0), and (f) ZnO:F(1.2) films grown at 140°C on Si substrates (All scale bars represent 100 nm).



b

ZnO:F{0.2}	Zn $2p_{3/2}$	O 1s	F 1s
BE (eV)	1021.77	530.9	684.5
FWHM (eV)	2.52	2.47	0.58
Area	2784235	559399	2913
A.S.F.	3.354	0.711	1.000
At.%	**51.25**	**48.57**	**0.18**
ZnO:F(1.2)	**Zn $2p_{3/2}$**	**O 1s**	**F 1s**
BE (eV)	1021.77	530.9	684.5
FWHM (eV)	2.47	2.51	0.52
Area	3084872	581590	20534
A.S.F.	3.354	0.711	1.000
At.%	**52.31**	**46.52**	**1.17**

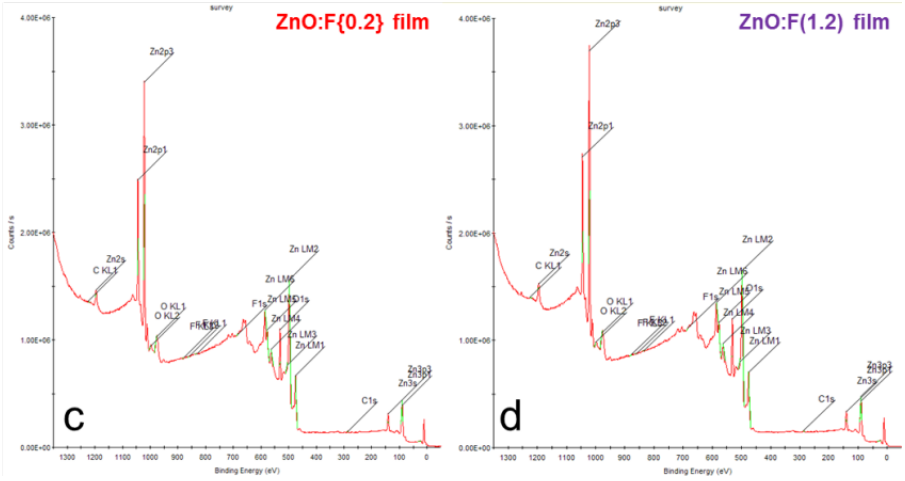


Figure S2. (a) The overlay of XPS spectra for undoped ZnO and various contents of ZnO:F films in F 1s region and (b) the peak-fit results (FWHM; full-width at half-maximum and A.S.F.; atomic sensitivity factor for X-ray sources at 90°) of Zn $2p_{3/2}$, O1s, and F1s peaks for ZnO:F{0.2} and ZnO:F(1.2) samples. The XPS spectra of wide scan for (c) ZnO:F{0.2} and (d) ZnO:F(1.2) films are used for the elemental analysis by using the peak fitting program (Thermo Avantage v3.25).

Table S1. Average crystallite sizes of the samples calculated by using the full-width at half-maximum of (100) and (002) peaks, Hall effect measurement parameters (carrier concentration (***n***), mobility (***μ***), resistivity (***ρ***), and conductivity (***σ***)).

Sample I.D.	(100) Crystallite Size (nm)	(002) Crystallite Size (nm)	n (cm^{-3})	μ (cm^2/Vs)	ρ at RT (Ωcm)	σ at RT $(\Omega cm)^{-1}$
ZnO	**20.77**	**21.79**	1.713×10^{19}	**17.73**	2.055×10^{-2}	**48.66**
ZnO:F{0.2}	**19.32**	**22.32**	3.589×10^{19}	**43.66**	3.983×10^{-3}	**251.1**
ZnO:F(0.5)	**22.90**	**23.99**	5.467×10^{19}	**32.49**	3.514×10^{-3}	**284.6**
ZnO:F(0.7)	**21.93**	**22.14**	1.243×10^{20}	**25.04**	2.181×10^{-3}	**458.6**
ZnO:F(1.0)	**22.84**	**23.71**	1.375×10^{20}	**24.20**	1.876×10^{-3}	**533.1**
ZnO:F(1.2)	**21.81**	**23.51**	1.462×10^{20}	**19.49**	2.190×10^{-3}	**456.5**