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Supporting Information

Electrical properties of amorphous Zn-Sn-O thin films depending on composition and post-deposition annealing temperature near crystallization temperature

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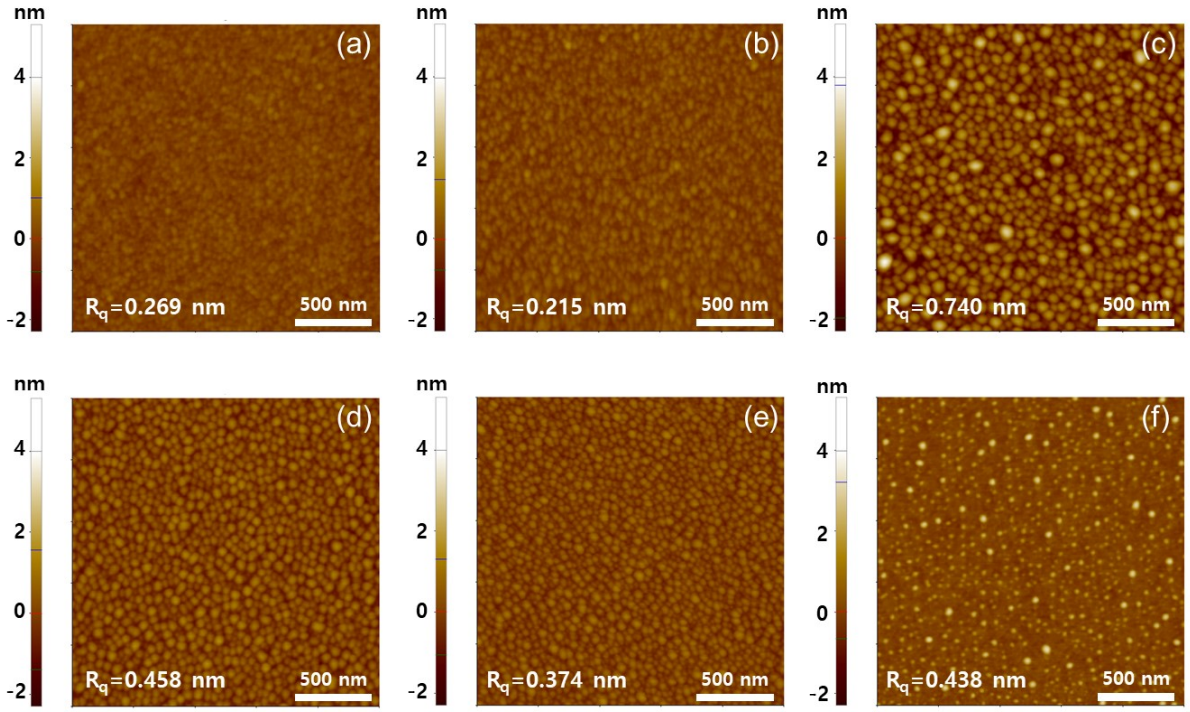

Figure S1. AFM images and root-mean-square roughness (R_q) value of ZTO thin films with (a) Sn 16 at%, (b) Sn 26 at%, (c) Sn 42 at%, (d) Sn 53 at%, (e) Sn 66 at%, (f) 76 at%

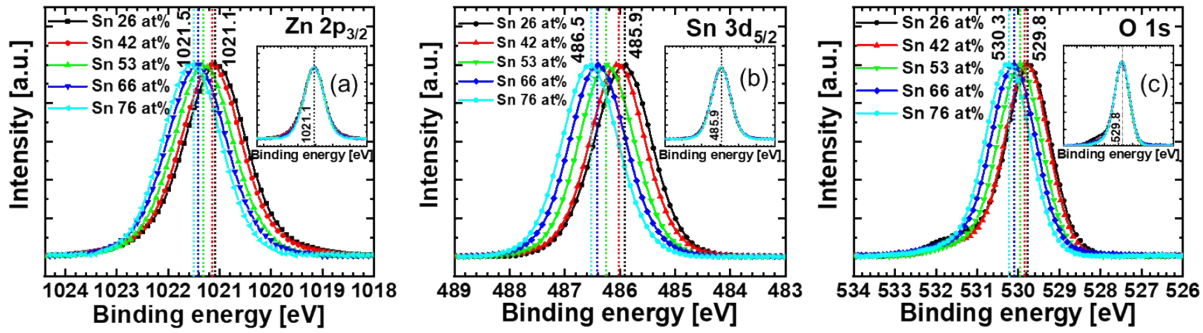

Figure S2. XPS spectra of (a) Zn $2p_{3/2}$, (b) Sn $3d_{5/2}$, (c) O 1s orbital of the ZTO films with Sn 26 ~ 76 at%. The inset in each panel shows the parallelly aligned peaks of each orbital.

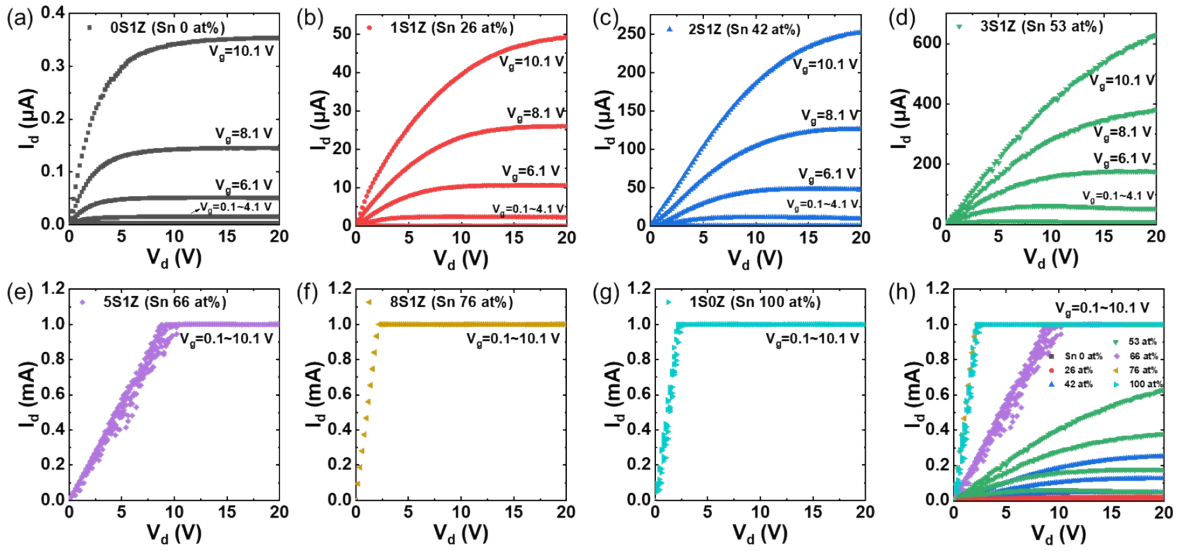

Figure S3. Output curves of ZTO thin films with (a) Sn 0 at% (b) Sn 26 at%, (c) Sn 42 at%, (d) Sn 53 at%, (e) Sn 66 at%, (f) 76 at%, (g) 100 at%, (h) summary of all

Table S1. Electrical parameters of the subgap density of state used in technology computer-aided design(TCAD) for Sn 42at% ZTO TFT.

Parameter	Sn 42at% ZTO	Description
E_g (eV)	3.2	Bandgap energy
NTA ($cm^{-3}eV^{-1}$)	$1.8*10^{20}$	Density of acceptor-like states in the tail distribution at the conduction band edge
NTD ($cm^{-3}eV^{-1}$)	$1.55*10^{20}$	Density of donor-like states in the tail distribution at the valence band edge
WTA (eV)	0.028	Characteristic decay energy for the tail distribution of acceptor-like states
WTD (eV)	0.11	Characteristic decay energy for the tail distribution of donor-like states
NGA ($cm^{-3}eV^{-1}$)	$1.2*10^{17}$	Total density of acceptor-like states in a Gaussian distribution
NGD ($cm^{-3}eV^{-1}$)	$8*10^{17}$	Total density of donor-like states in a Gaussian distribution
WGA (eV)	0.1	Characteristic decay energy for a Gaussian distribution of acceptor-like states
WGD (eV)	0.08	Characteristic decay energy for a Gaussian distribution of donor-like states
EGA (eV)	2.0	Energy that corresponds to the Gaussian distribution peak for acceptor-like states
EGD (eV)	2.95	Energy that corresponds to the Gaussian distribution peak for donor-like states

Table S2. Functions and formulas used to distribute the density of states in TCAD simulation

function	formula	Description
g(E)	$g_{TA}(E)+g_{TD}(E)+g_{GA}(E)+g_{GD}(E)$	Total density of states of the material
$g_{TA}(E)$	$NTA\times\exp(\frac{E-Ec}{WTA})$	Density of acceptor-like tail states
$g_{TD}(E)$	$NTD\times\exp(\frac{E_v-E}{WTD})$	Density of donor-like tail states
$g_{GA}(E)$	$NGA\times\exp(-\left[\frac{EGA-E}{WGA}\right]^2)$	Density of gaussian-distributed acceptor-like states
$g_{GD}(E)$	$NGD\times\exp(-\left[\frac{E-EGD}{WGD}\right]^2)$	Density of gaussian-distributed donor-like states