Electronic Supplementary Material (ESI) for Energy & Environmental Science.

Supporting Information

Textile-based washable polymer solar cells for optoelectronic modules: Toward self-powered smart clothing

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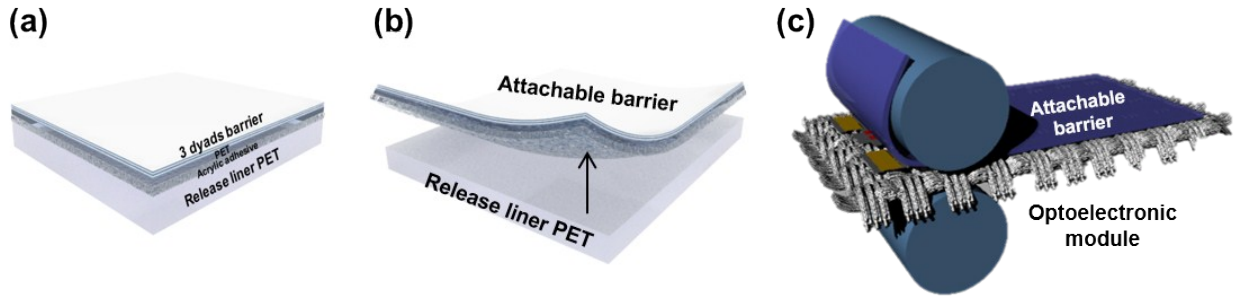

Figure S1. Image of the attachable encapsulation process: (a) Structure of attachable encapsulation, (b) Attachable barrier separated by release liner PET and (c) Attached to the optoelectronic module without additional curing process.

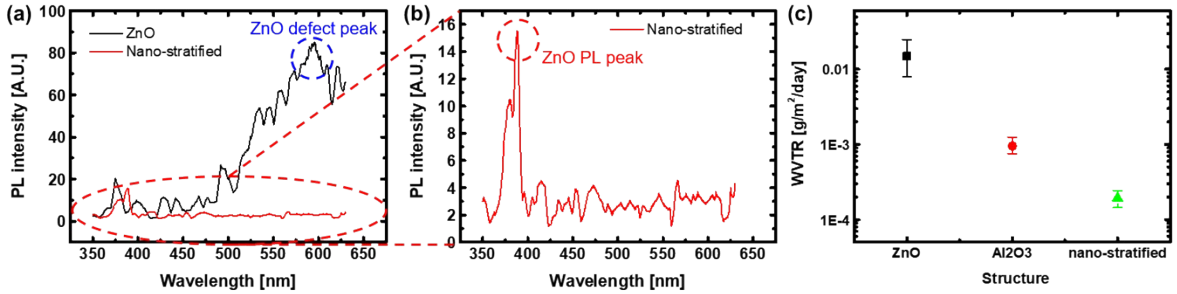

Figure S2. PL characteristic of ALD-oxides: (a) ZnO and nano-stratified, and (b) enlarged view of nano-stratified; (c) estimated WVTR of ZnO, Al_2O_3, and nano-stratified layer.

Table S1. Estimated WVTR of the ZnO, Al_2O_3, and the nano-stratified layer.

Structure	ZnO	Al_2O_3	Nano-stratified
WVTR [g/m^2/day]	1.49×10^{-2}	9.54×10^{-4}	1.94×10^{-4}

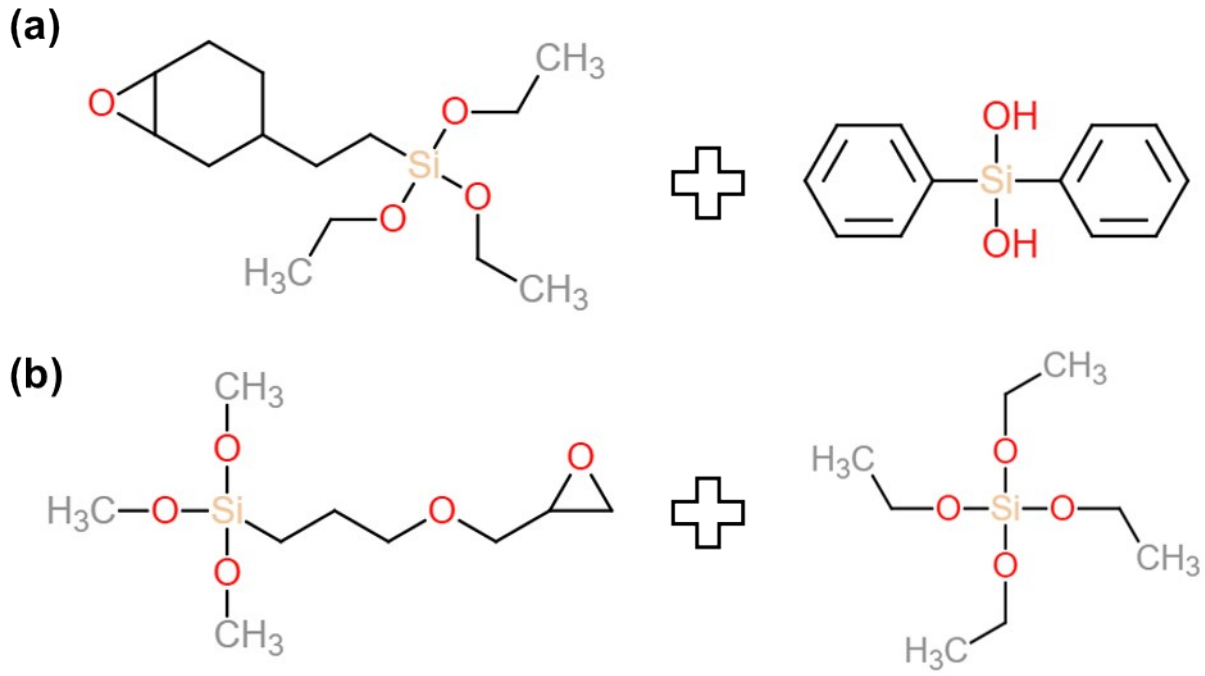

Figure S3. Candidates polymer of capping layer: (a) $P_{low,SiO2}$, a cyclo-aliphatic epoxy oligosiloxane resin, synthesized by ECTS and DPSD, and (b) $P_{high,SiO2}$, SiO_2-composite polymer, synthesized by Si:GPTMS and TEOS.

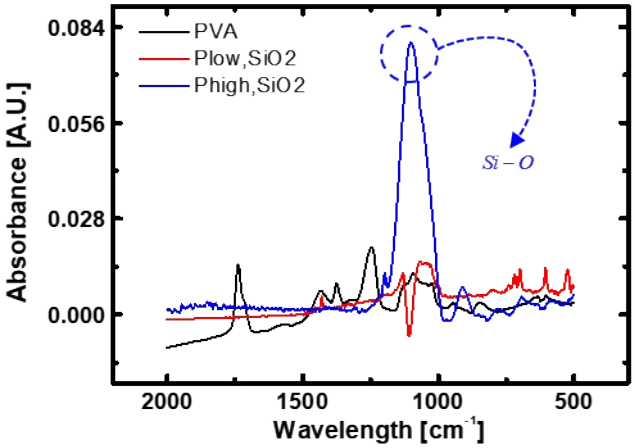

Figure S4. FT-IR measurements of PVA, $P_{low,SiO2}$, and $P_{high,SiO2}$.

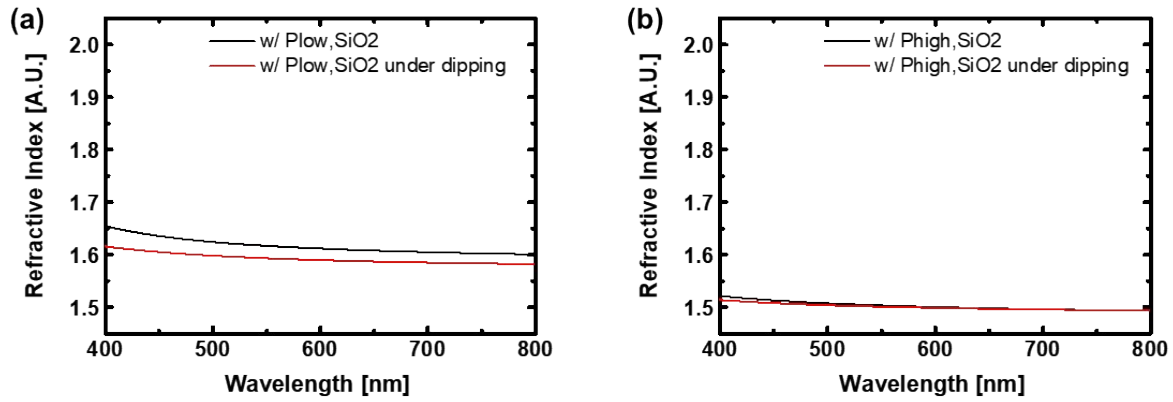

Figure S5. Ellipsometric analysis of optical constant before and after dipping: (a) $P_{low,SiO2}$, and (b) $P_{high,SiO2}$.

Table S2. Refractive index and peak to valley roughness of a unit dyad of functional encapsulation barrier with various polymers.

Storage condition		w/o polymer	w/ $P_{low,SiO2}$	w/ $P_{high,SiO2}$
Refractive index	Before dipping	1.71991	1.61622	1.50241
	After dipping	1.43519	1.59248	1.50016
Peak to valley roughness	Before dipping	5.392 nm	4.627 nm	2.820 nm
	After dipping	61.526 nm	25.522 nm	6.970 nm

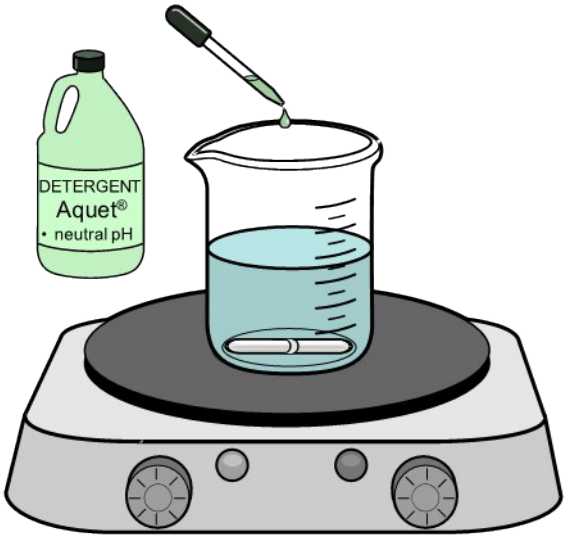

Figure S6. Schematic diagram of the washing test.

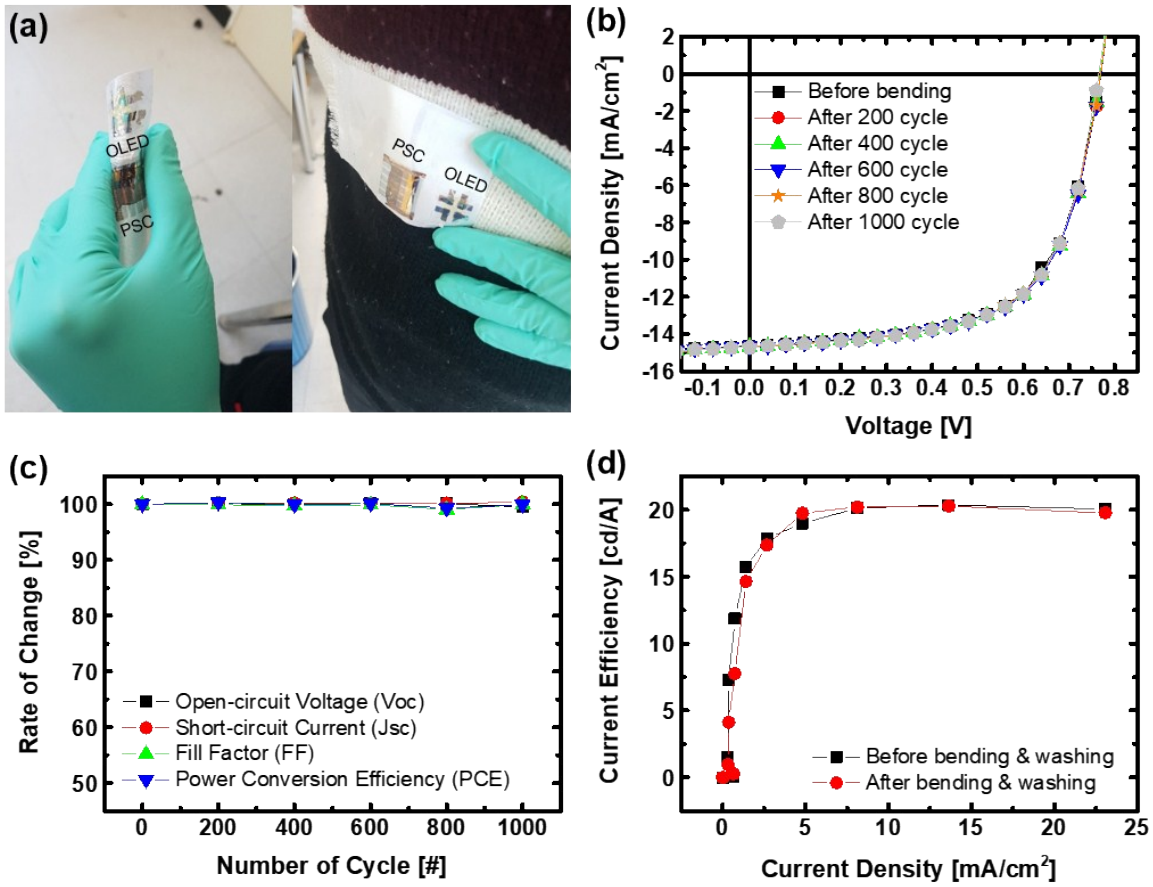

Figure S7. Prototype of textile-based washable optoelectronic modules with functional encapsulation barrier: (a) picture of optoelectronic module, (b) electrical characteristics of PSCs with bending cycle, (c) ROC of performance factors according to bending cycles, and (d) electrical characteristics of OLEDs with bending and washing.

Table S3. The change in performance factors according to bending cycles.

Parameter	before bending	after 200 cycle	after 400 cycle	after 600 cycle	after 800 cycle	after 1000 cycle
V_{OC} [V]	0.77 (0.769±0.003)[a]	0.77 (0.769±0.003)	0.77 (0.768±0.003)	0.77 (0.767±0.003)	0.77 (0.766±0.004)	0.77 (0.767±0.003)
J_{SC} [mA/cm^2]	14.66 (14.84±0.15)	14.69 (14.81±0.11)	14.69 (14.81±0.13)	14.67 (14.86±0.18)	14.67 (14.81±0.13)	14.72 (14.81±0.13)
FF [%]	63.21 (62.91±0.36)	63.16 (63.01±0.23)	63.04 (62.82±0.42)	63.14 (62.60±0.65)	62.60 (62.98±0.48)	63.18 (62.91±0.48)
PCE [%]	7.12 (7.19±0.06)	7.15 (7.18±0.07)	7.12 (7.15±0.07)	7.13 (7.14±0.08)	7.07 (7.15±0.04)	7.12 (7.15±0.07)

[a] These are statistical values of average and standard deviation obtained from 8 PSC samples.