Supplementary Information

UV-enhanced atomic layer deposition of Al_2O_3 thin films at low temperature for gas-diffusion barrier

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Table S1. WVTRs of various Al_2O_3 barrier thin films with TFE performance

Process	Deposition condition	Substrate	Film thickness [nm]	WVTR measurement	WVTR [$g\ m^{-2}\ day^{-1}$]	Ref.
UV-ALD	TMA, H_2O at 40 °C	Glass	100	Electrical Ca test (at 70 °C, 90% RH and 85 °C, 85% RH)	9.20×10^{-7} (24 °C)	This work
		PET	20-100	MOCON test (at 37.8 °C, 100% RH)	$< 1.00\times10^{-3}$ (37.8 °C)	
ALD	TMA, H_2O at 100-175 °C	PEN, Kapton®	26	Tritiated water (HTO) test (at RT, 100% RH)	1.00×10^{-3} (24 °C)	[1]
ALD	TMA, H_2O at 120 °C	PEN	25	Optical Ca test (at 38 or 60 °C, 85% RH)	$< 1.00\times10^{-5}$ (23 °C)	[2]
ALD	TMA, H_2O at 80 °C	Glass	60	Electrical Ca test (at 20 °C, 60% RH)	4.90×10^{-4} (20 °C)	[3]
	TMA, O_3 at 80 °C				8.70×10^{-6} (20 °C)	
PE-ALD	TMA, O_2 plasma at RT	PEN	20	Optical Ca test (at 21 °C, 60% RH)	5.00×10^{-3} (25 °C)	[4]
PE-ALD	TMA, O_2 plasma at 120 °C	PES	11.8	MOCON test (at 37.8 °C, 100% RH)	$< 4.00\times10^{-3}$ (37.8 °C)	[5]
PE-ALD	TMA, O_2 plasma at 120 °C	PEN	50	MOCON test (at 38 °C, 100% RH)	8.85×10^{-4} (20 °C)	[6]
RP-ALD	TMA, O_2 plasma at 100 °C	PES	100	Electrical Ca test (at 50 °C, 50% RH)	2.60×10^{-4} (50 °C)	[7]

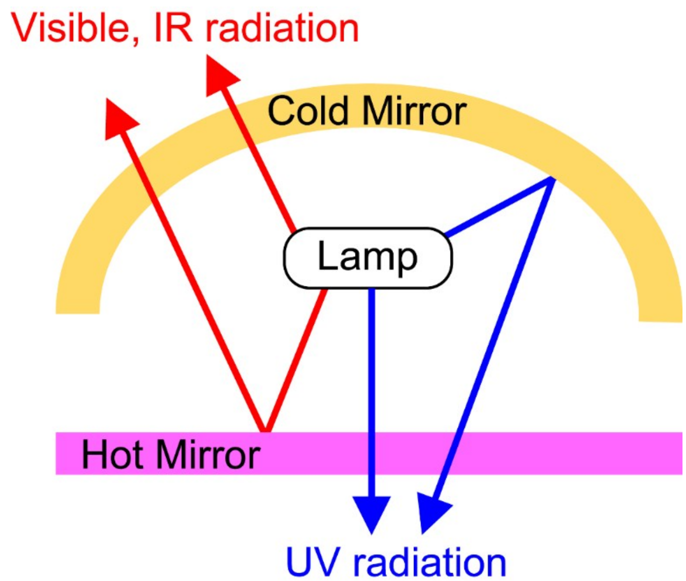

Fig. S1. Schematic diagram showing the arrangement of hot and cold mirrors in UV-ALD process to filter out IR and visible lights from the UV source.

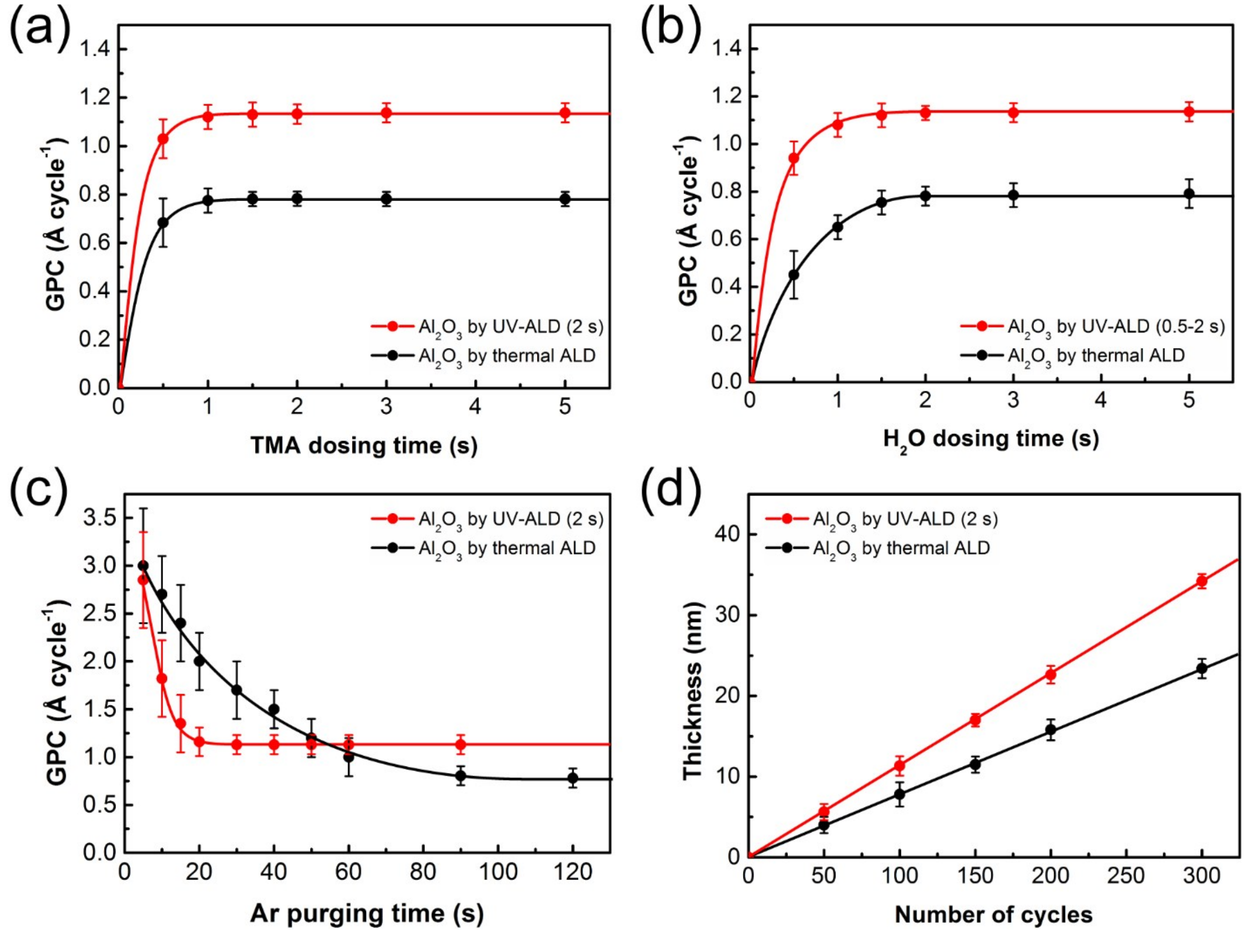

Fig. S2. Influence of various ALD parameters on the growth of Al_2O_3 film under thermal ALD and UV-ALD processes at 40 °C. Growth per cycle (GPC) of Al_2O_3 film depending on (a) TMA dosing time, (b) H_2O dosing time, and (c) Ar gas purging time after H_2O dosing. For each GPC measurement in (a), (b) and (c), 500 cycles of ALD were performed. (d) Growth measured in terms of thickness of Al_2O_3 film with respect to number of ALD cycles, showing the linear trend of film growth.

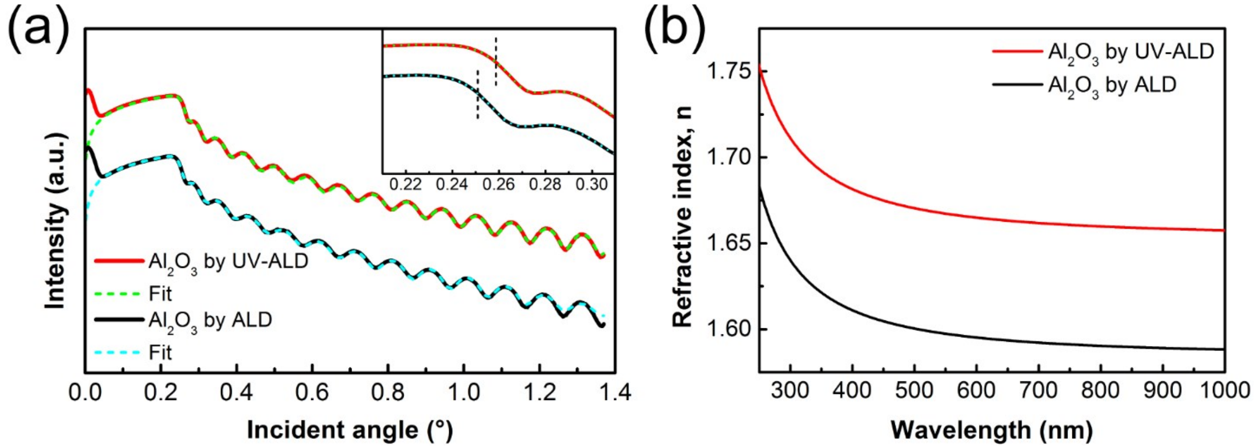

Fig. S3. (a) XRR spectra of Al_2O_3 films grown under thermal ALD and UV-ALD processes at 40 °C. Solid lines are experimentally obtained spectra, while dotted lines represent the fitted spectra. Inset shows the critical angles of the XRR spectra for estimation of the film densities. (b) Ellipsometry spectra of the Al_2O_3 thin films grown under thermal ALD and UV-ALD processes at 40 °C. Refractive indices of the films were obtained at 633 nm.

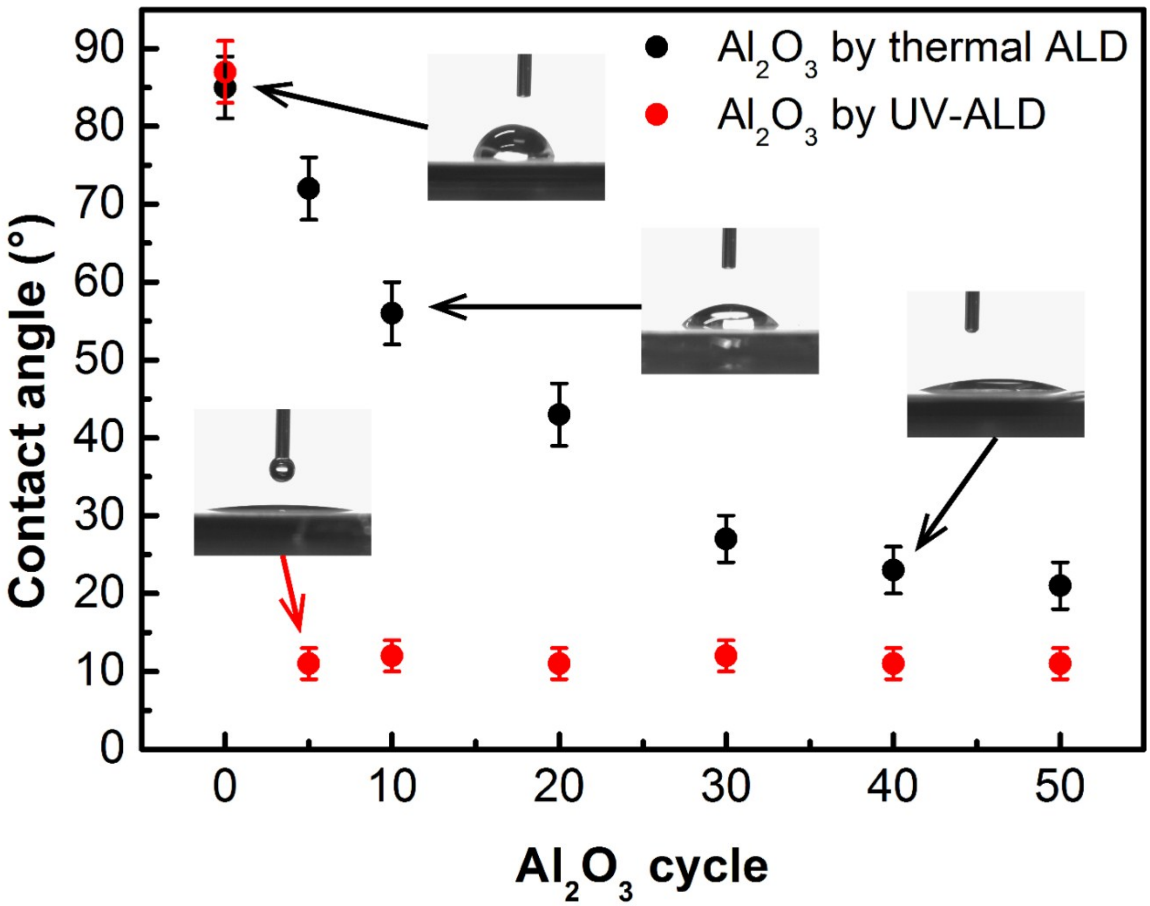

Fig. S4. Contact angle of water on the surface of Al_2O_3 thin films deposited on PET substrates by thermal ALD and UV-ALD processes at 40 °C.

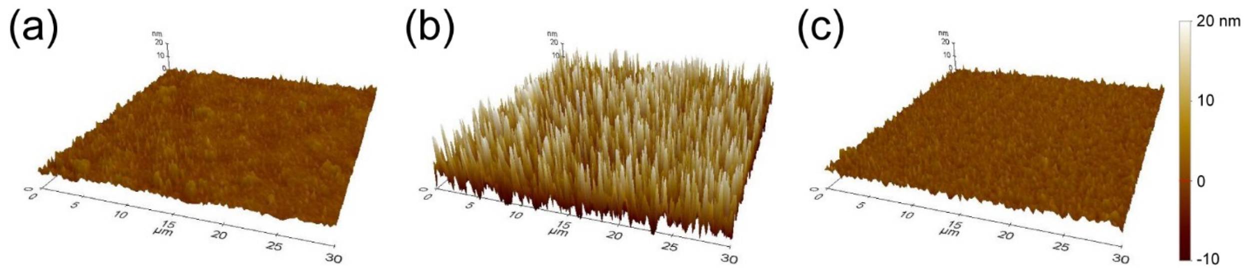

Fig. S5. AFM surface images. (a) Bare PET substrate. Al_2O_3 thin films deposited on PET substrates for 100 cycles by (b) thermal ALD, and (c) UV-ALD at 40 °C. RMS surface roughness are 3.12, 6.38, and 3.34 nm, respectively, in the films shown in (a), (b), and (c).

References

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