

Supplementary material

Ultrasmooth organic films via efficient aggregation suppression by a low-vacuum physical vapor deposition

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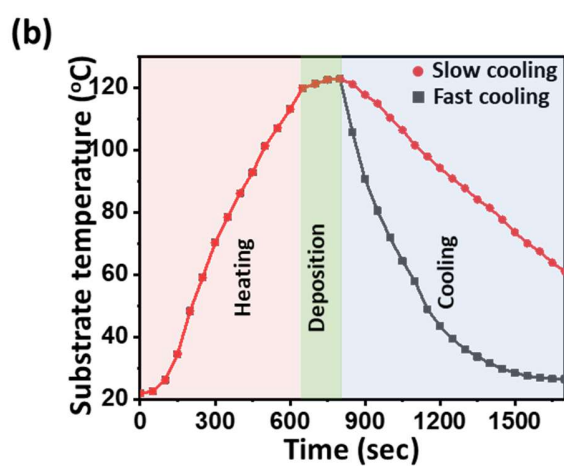
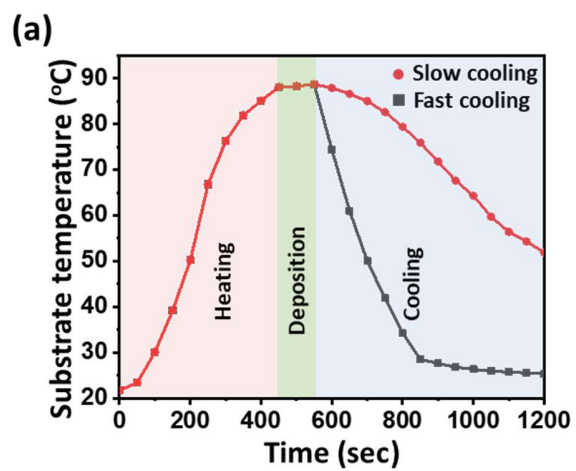


Figure S1. Substrate temperature profiles of (a) Alq₃, NPD, and (b) PCBM depending on SCPVD method (red) and FCPVD method (grey).

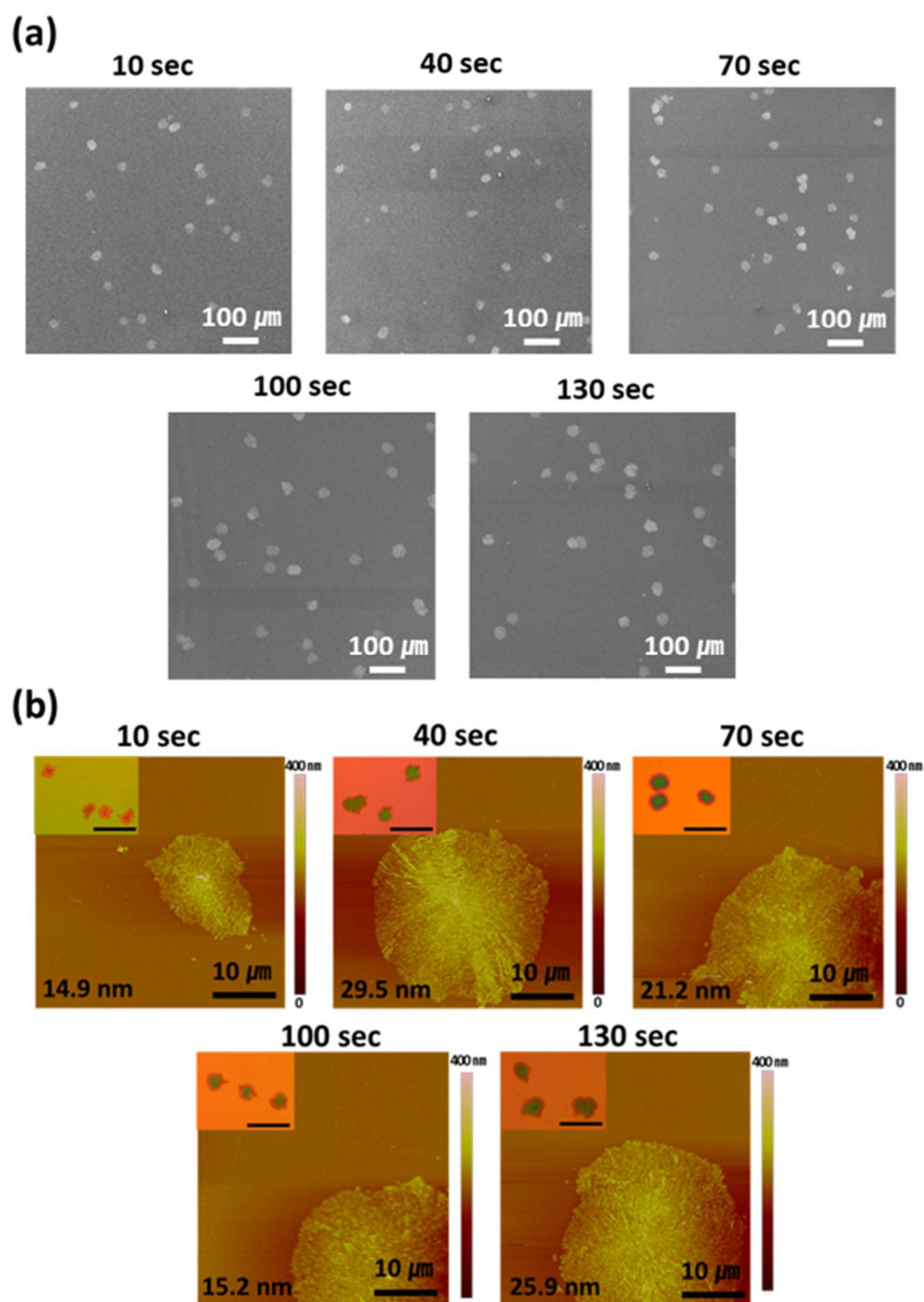


Figure S2. (a) SEM and (b) AFM images of rubrene films on Si/SiO₂ substrate obtained by SCPVD method depending on various deposition times.

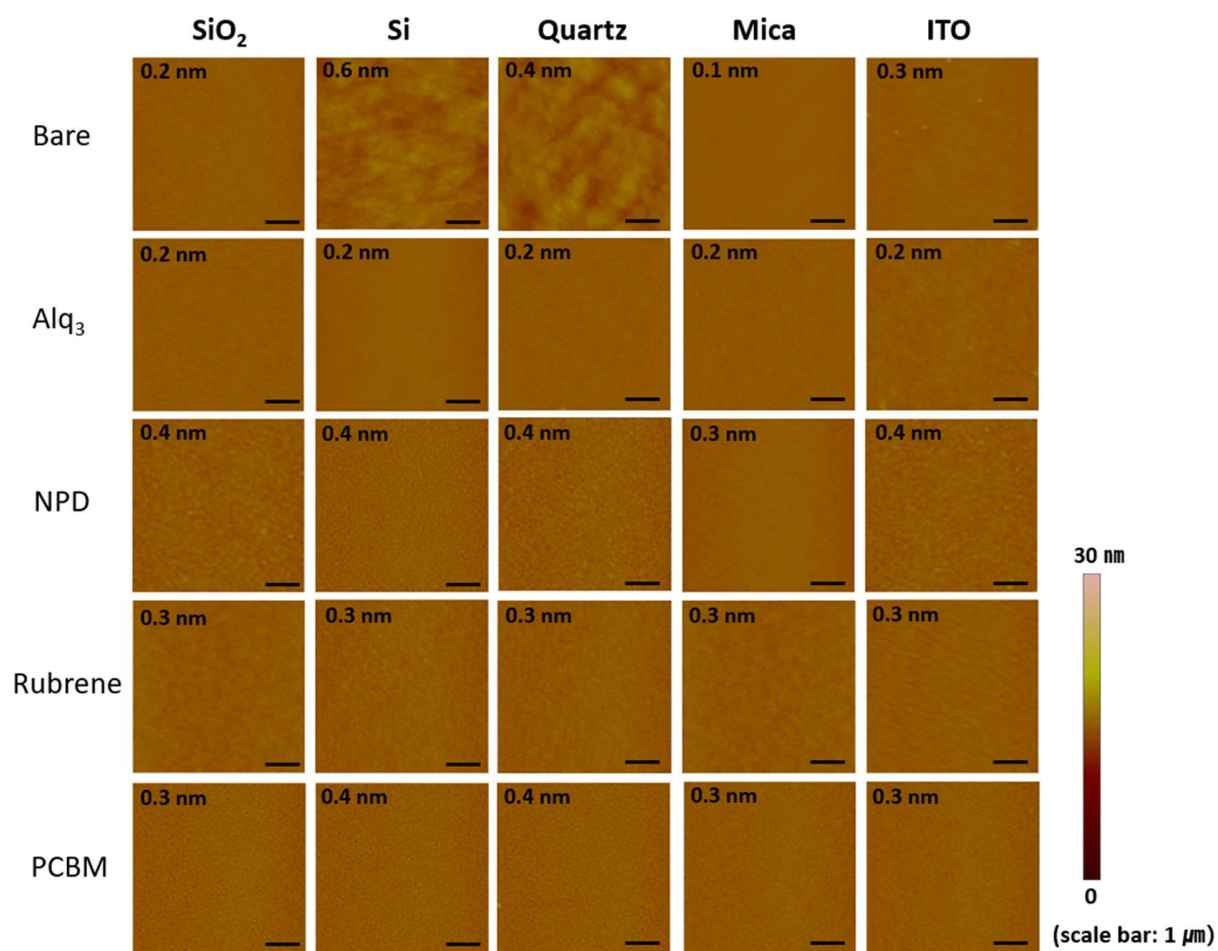


Figure S3. AFM images of rubrene, Alq₃, NPD, and PCBM films on Si/SiO₂, Si, quartz, mica, and ITO substrates obtained by FCPVD method.

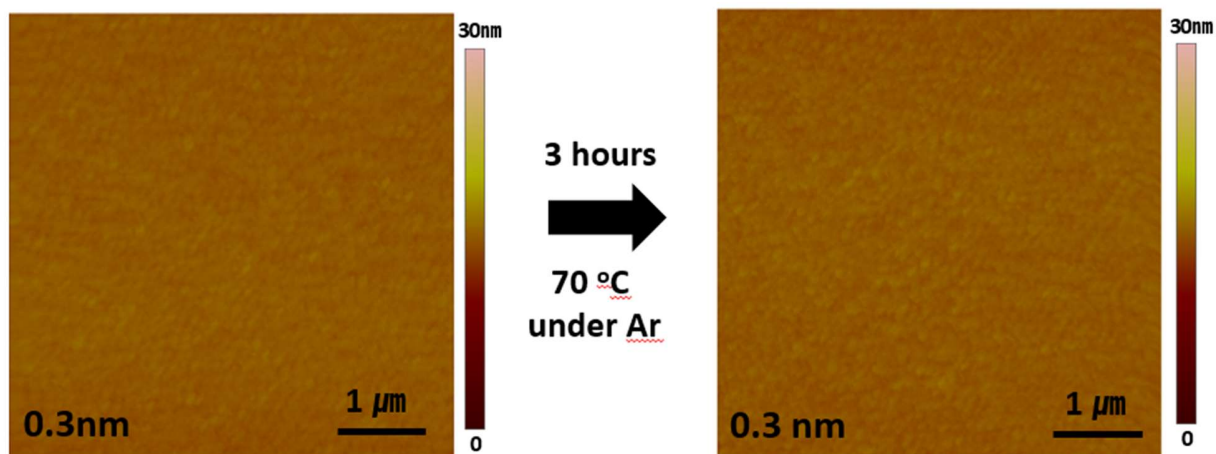


Figure S4. AFM images of rubrene film by FCPVD. The left image is as deposited rubrene film and the right image is the rubrene film annealed at 70 °C under Ar condition for 3 hours.

Rubrene - substrate temperature: 40 °C

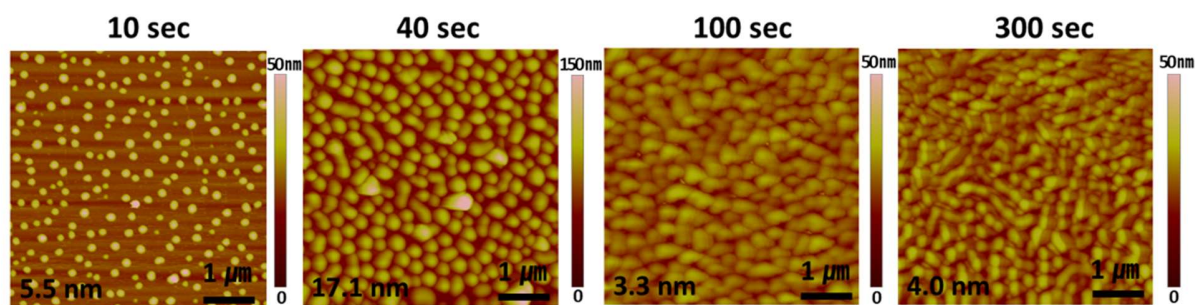


Figure S5. AFM images of rubrene films on the Si/SiO₂ substrate obtained at low substrate temperature (40 °C) condition depending on deposition time.

Rubrene - substrate temperature: 85 °C

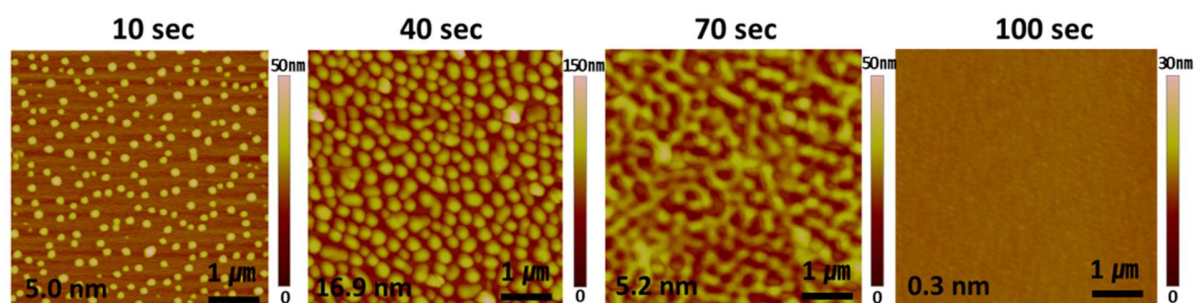


Figure S6. Surface morphologies of rubrene films on the Si/SiO₂ substrate obtained by FCPVD method depending on deposition time.

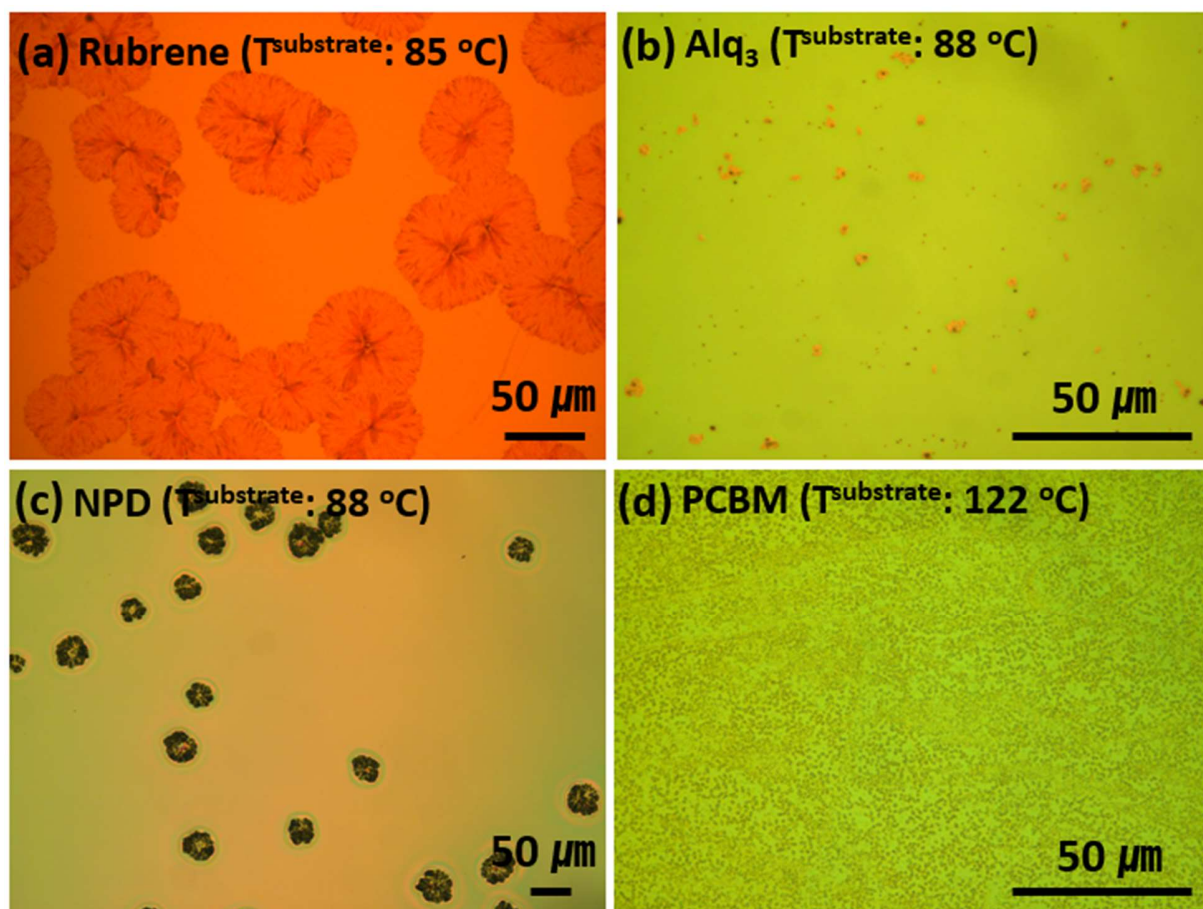


Figure S7. Optical microscope images of (a) rubrene, (b) Alq_3 , (c) NPD, and (d) PCBM films on Si/SiO₂ substrates by the high-vacuum method.

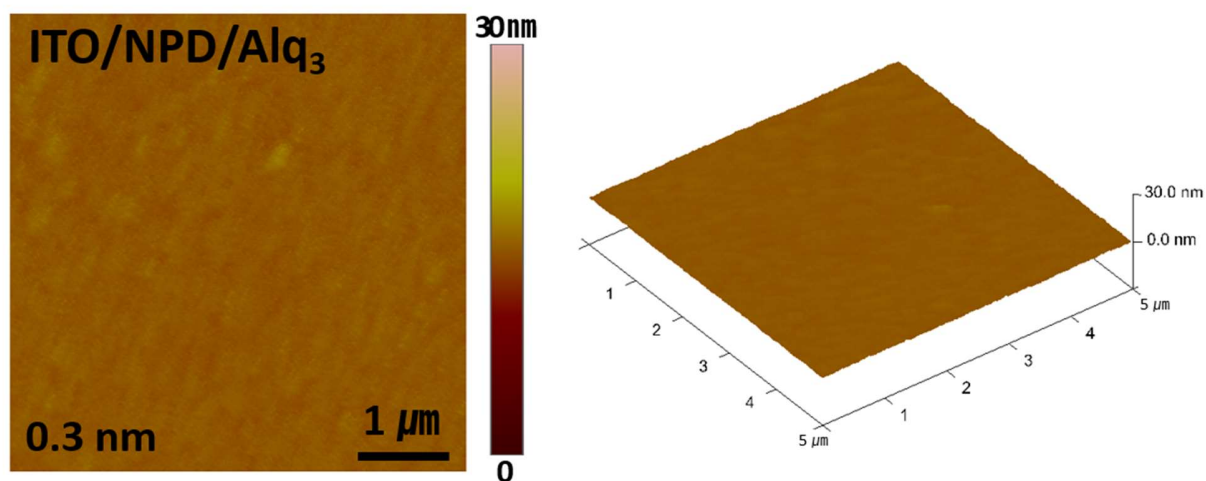


Figure S8. AFM images of heterojunction film in which NPD and Alq_3 thin films were sequentially deposited on an ITO substrate by FCPVD

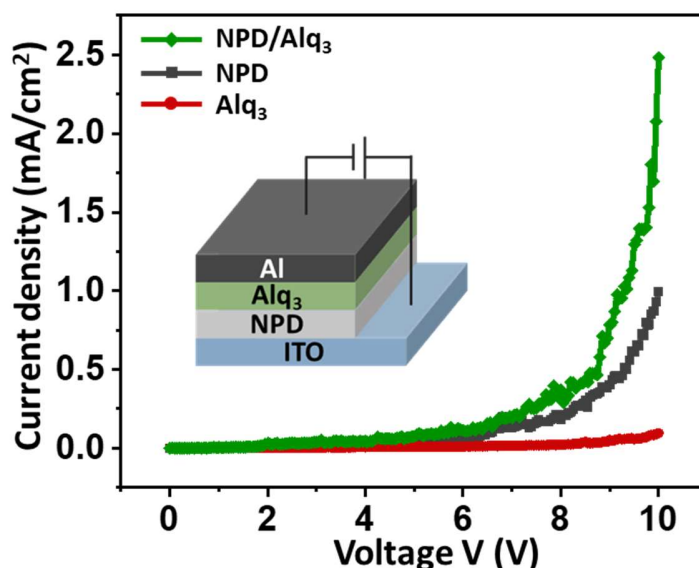


Figure S9. The current density-voltage characteristics of the devices prepared with ultrasmooth films obtained by FCPVD method. Heterojunction device (ITO/NPD/Alq₃/Al), HOD (ITO/NPD/Al), and EOD (ITO/Alq₃/Al) are represented as green, grey, and red lines respectively. The inset shows the device structure.

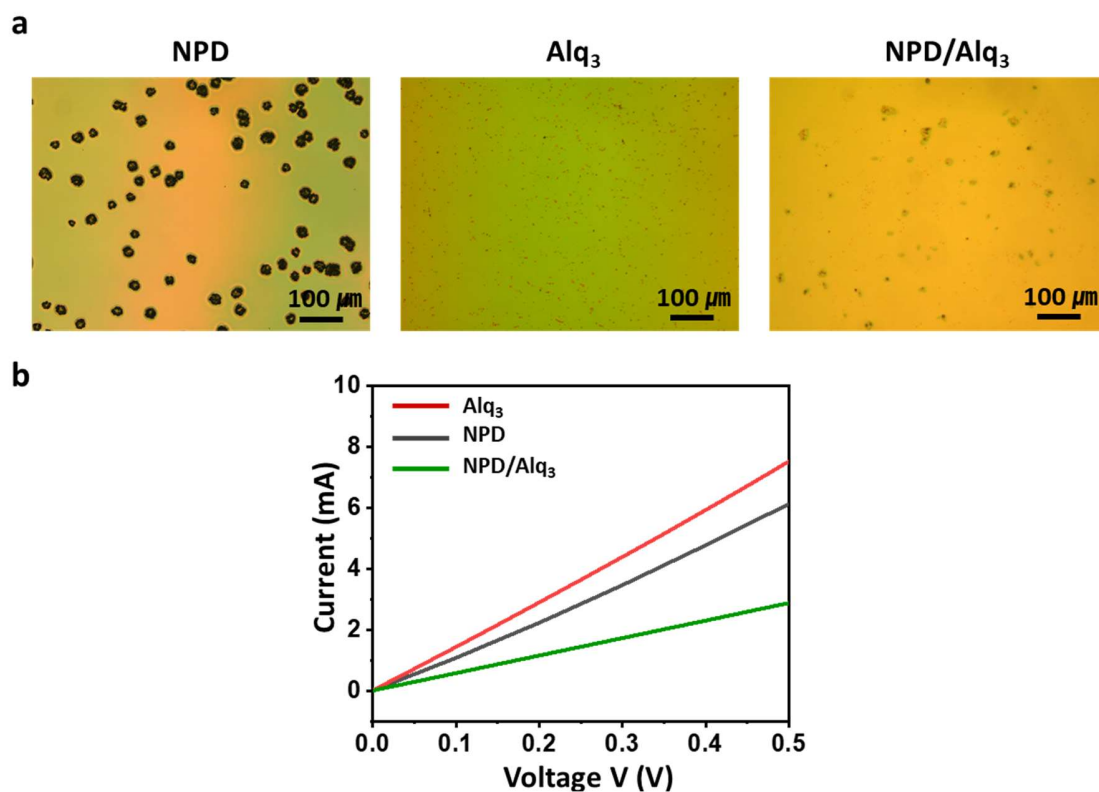


Figure S10. (a) Optical microscope images of NPD, Alq₃, and NPD/Alq₃ films on ITO substrates. (b) Current-voltage characteristics of the devices prepared with rough films obtained by SCPVD method. EOD (ITO/Alq₃/Al), HOD (ITO/NPD/Al), and heterojunction device (ITO/NPD/Alq₃/Al) are represented as red, grey, and green lines respectively.

Table S1. The target temperature conditions and deposition time for ultrasmooth films.

	T^{source}	$T^{\text{substrate}}$	Deposition time for ultrasmooth films
Rubrene	250 °C	85 °C	100 sec
Alq ₃	260 °C	88 °C	110 sec
NPD	260 °C	88 °C	110 sec
PCBM	310 °C	122 °C	150 sec