

Supporting Information

Instantaneous Pulsed-Light Cross-linking of a Polymer Gate Dielectric for Flexible Organic Thin-Film Transistors

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Figure S1.

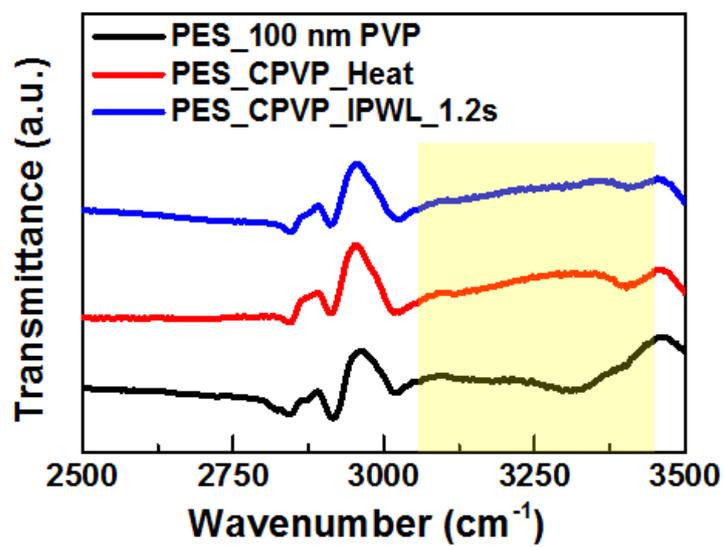


Figure S1. FT-IR spectra of 100 nm PVP:PMF films cross-linked by thermal heating and IPWL irradiation with 14 Jcm⁻².

Figure S2.

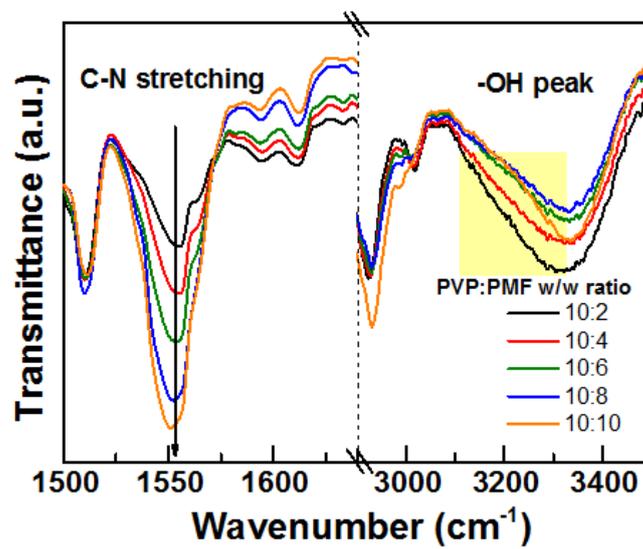


Figure S2. FT-IR spectra of PVP:PMF film with various weight ratio after exposure of IPWL irradiation.

Figure S3.

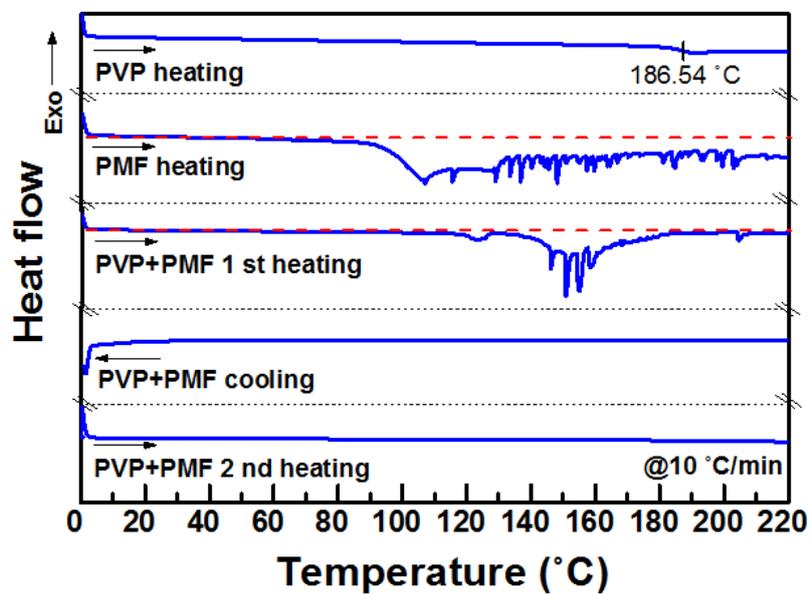


Figure S3. Differential scanning calorimetry (DSC) thermograms of PVP, PMF and PVP:PMF (10:8 w/w ratio) solution.

Figure S4.

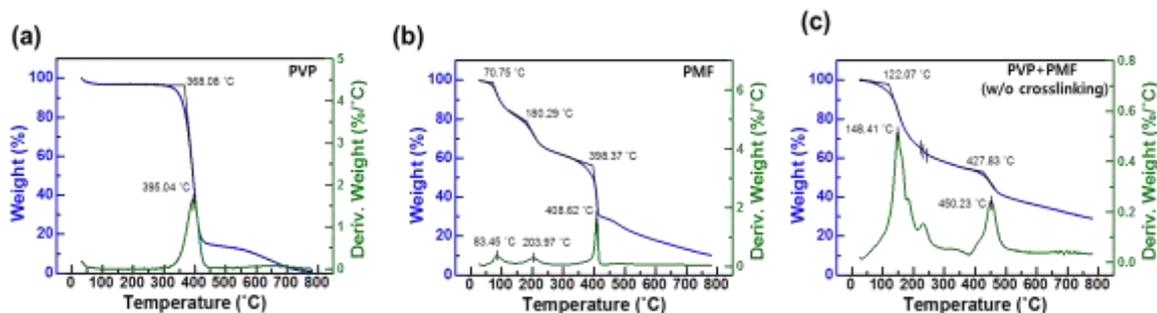


Figure S4. Thermal gravimetric analysis (TGA) of (a) PVP and (b) PMF, and (c) PVP:PMF mixture.

The thermal behavior of the PVP and PMF components and PVP:PMF mixtures was investigated by thermal gravimetric analysis (TGA) in N_2 atmosphere at a heating rate of 10 Kmin^{-1} . For preparation of PVP:PMF mixture sample, 10:8 w/w ratio PVP:PMF was mixed in PGMEA solvent and then the solvent was almost evaporated in the vacuum oven at RT. To crosslink PVP:PMF, the PVP:PMF mixture was thermally heated in the vacuum oven at $180\text{ }^\circ\text{C}$ for 1 hr. Thermal degradation of PVP occurs at the temperature above $368\text{ }^\circ\text{C}$ (Figure S4a). Thermal decomposition of PMF happens in four separate stages (Figure S4b). First 16% weight loss in the temperature ranging from $70\text{ }^\circ\text{C}$ to $120\text{ }^\circ\text{C}$ was originated from the evaporation of 1-butanol solvent (b.p $116\text{-}118\text{ }^\circ\text{C}$). Additional 20% mass loss between $120\text{ }^\circ\text{C}$ and $200\text{ }^\circ\text{C}$ was observed, which might be due to the evaporation of alcohols and moistures originated from the unknown reactions between melamine resin and alkyd functional groups of the molecules. This also attributed to the multiple endothermic peaks in DSC curve of PMF in Figure S3. Significant mass loss near $400\text{ }^\circ\text{C}$ might be due to the chemical bond scission in the PMF molecules. Thermal analysis of PVP:PMF before cross-linking exhibits two characteristic mass loss (Figure S4c); 40 % mass reduction between $120\text{ }^\circ\text{C}$ to $250\text{ }^\circ\text{C}$ might be due to the evaporation of residual PGMEA solvent (b.p $145\text{ }^\circ\text{C}$) and the by-products such as moisture and alcohols originated from the chemical reaction between the PVP and PMF molecules. Additional gradual reduction near $450\text{ }^\circ\text{C}$ might be due to the decomposition of unreacted PVP and PMF and thermal degradation of weakly bound functional groups. The displaced positions from the decomposition temperatures of pure components can be due to the mixing and interaction effect. Because of cross-linking reaction, 40% of original mass still remained at high temperature of $500\text{ }^\circ\text{C}$.

Figure S5.

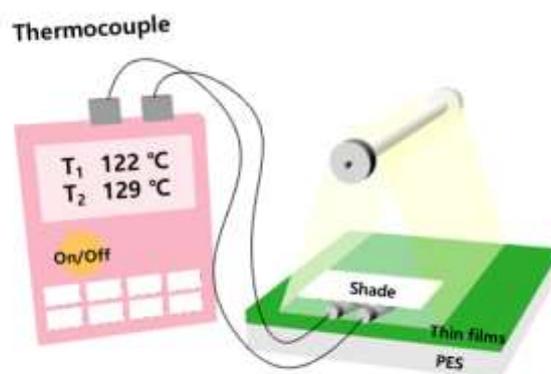


Figure S5. The in-situ measuring scheme of the surface temperature of a film during IPWL irradiation.

Figure S6.

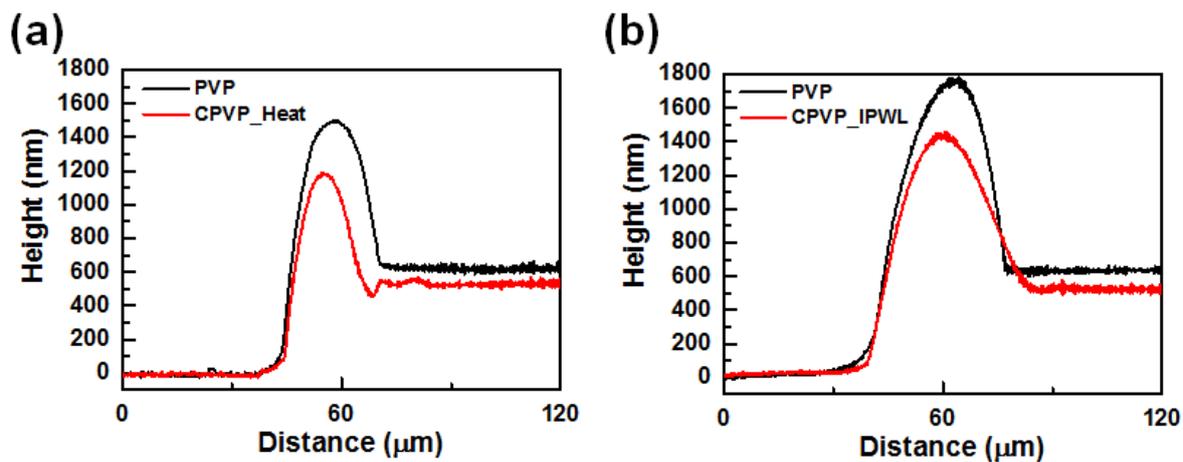
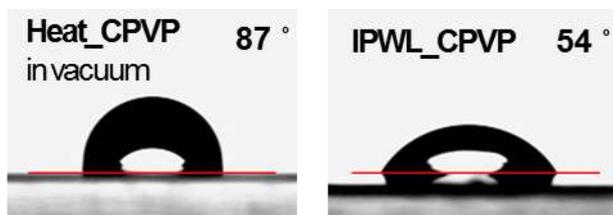


Figure S6. Height profiles showing the changes in the thickness of PVP films before and after cross-linking using (a) thermal annealing and (b) IPWL irradiation.

Figure S7.



Surface Energy (mJ/m ²)	γ_s^d	γ_s^p	γ_s
CPVP-Heat (@ 180°C in vacuum)	35.6	2.0	37.7
CPVP-IPWL	33.6	18.2	51.7

Figure S7. Photographs of water droplets on the CPVP_Heat and CPVP_IPWL dielectrics. Summary of the surface energies of the CPVP films, as determined from contact angle measurements with two probe liquids (water and diiodomethane) and by fitting the measured values to the following equation

$$1 + \cos\theta = \frac{2(\gamma_s^d)^{1/2}(\gamma_{lv}^d)^{1/2}}{\gamma_{lv}} + \frac{2(\gamma_s^p)^{1/2}(\gamma_{lv}^p)^{1/2}}{\gamma_{lv}}$$

where γ_{lv} is the surface energy of the probe liquid, and the superscripts *d* and *p* refer to the dispersive and polar interaction components, respectively.

Figure S8.

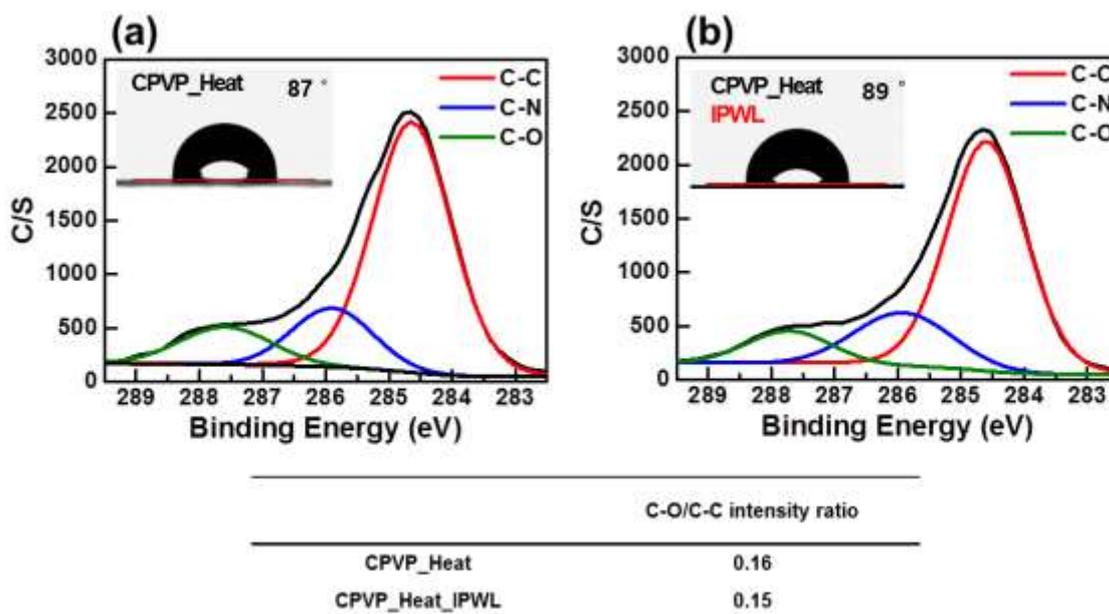


Figure S8. C1s X-ray photoemission spectroscopy (XPS) spectra obtained at the take-off angle of 15° for CPVP_Heat; (a) without and (b) with IPWL irradiation. Inset: Photographs of water contact angles on each dielectrics. The intensity ratio of C-O to C-C bond was showed below the XPS spectra.

Figure S9.

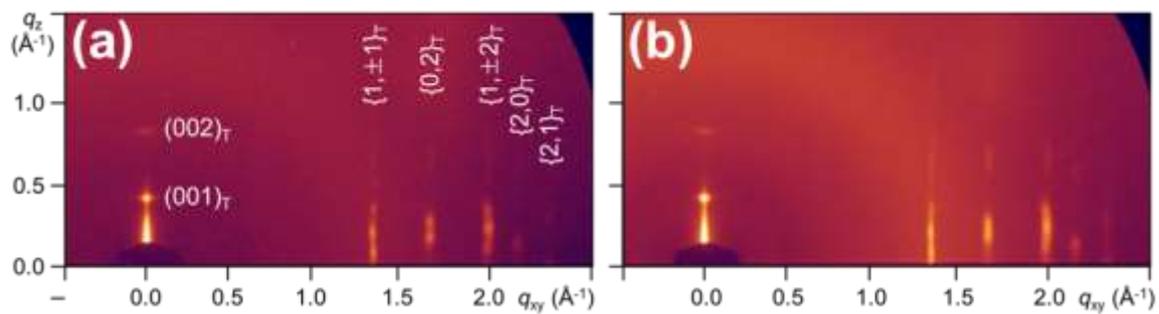
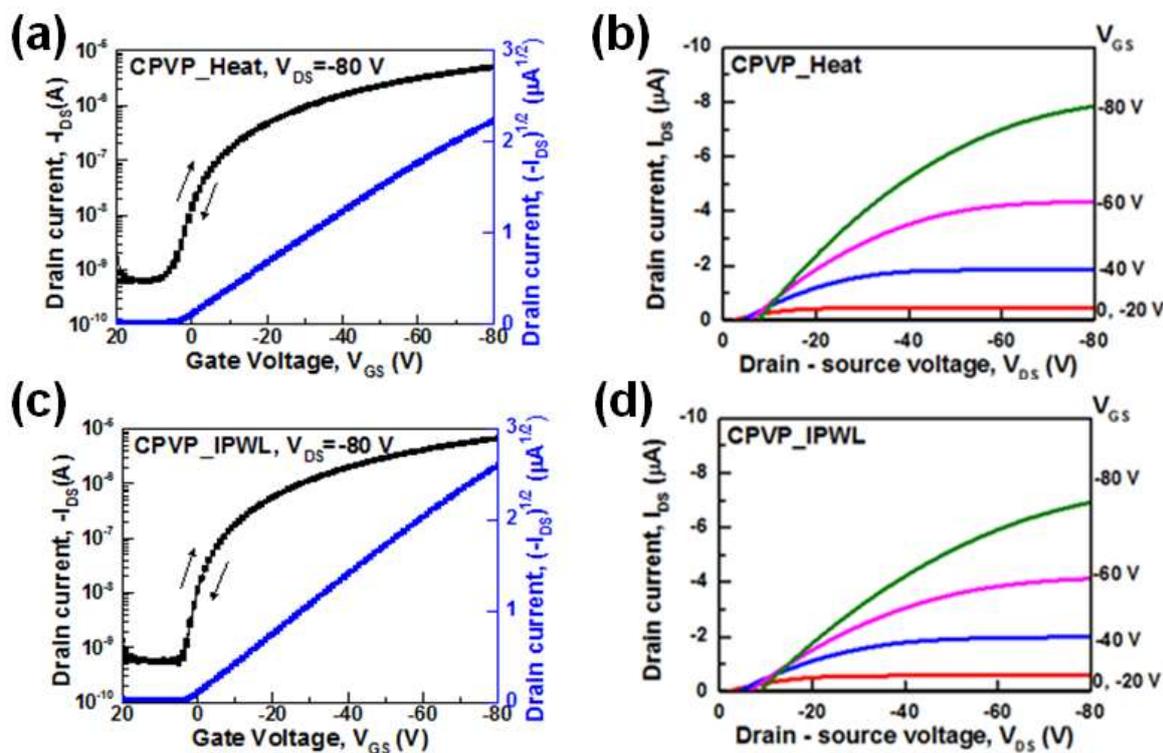


Figure S9. 2D GIXD patterns of 25 nm-thick pentacene films on (a) CPVP_Heat and (b) CPVP_IPWL.

Figure S10.



Gate dielectric	Electrical Properties			
	μ (cm ² V ⁻¹ S ⁻¹)	I_{on}/I_{off}	V_T (V)	SS (Vdec ⁻¹)
CPVP_Heat	0.022	8.1×10^3	3.2	4.9
CPVP_IPWL	0.030	1.0×10^4	2.5	2.8

Figure S10. Transfer characteristics (I_{DS} - V_{GS}) and output characteristics (I_{DS} - V_{DS}) of the P3HT-based transistors with differently cross-linked PVP dielectrics; (a)(b) CPVP_Heat and (c)(d) CPVP_IPWL. The electrical properties of the devices are summarized in a table below the transfer curves.

Figure S11.

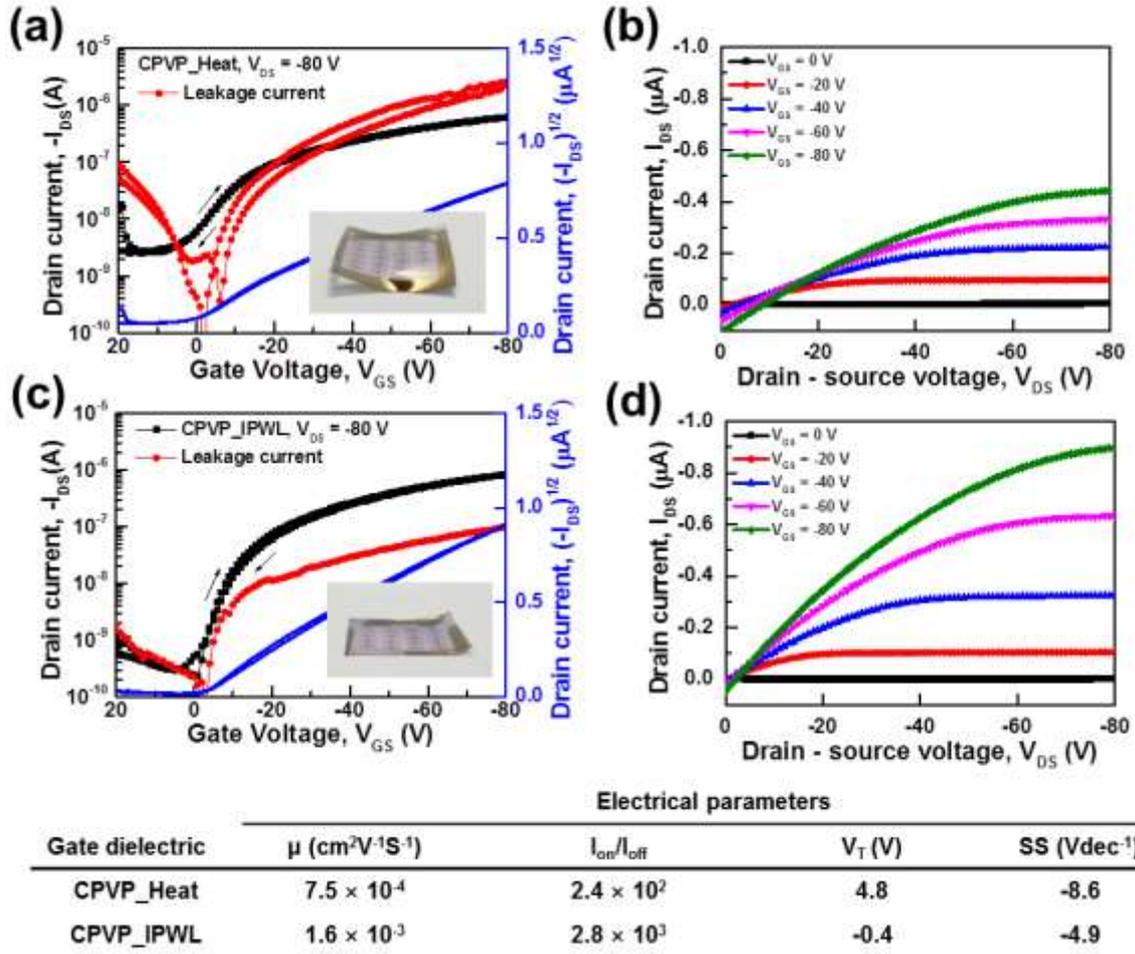


Figure S11. Transfer characteristics (I_{DS} - V_{GS}) and output characteristics (I_{DS} - V_{DS}) of the P3HT-based transistors using PET substrate coated with (a),(b) CPVP_Heat and (c),(d) CPVP_IPWL gate dielectrics. The electrical properties of the devices are summarized in a table below the transfer curves.