Supporting Information

Polymer Bulk-heterojunction Synaptic Field-Effect Transistors with Tunable Decay Constant

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1. Experimental Section

Preparation of Materials: The p-type highly π-extended organic D-A copolymer poly[2,5-bis(alkyl)pyrrolo[3,4-c]pyrrolo-1,4(2H,5H)-dione-alt-5,5-di(thiophene-2-yl)-2,2-(E)-2-(2-(thiophen-2-yl)- vinyl)thiophene] (PDVT-10) (M_W =183 kg mol^{-1}) was purchased from 1- Materials with a concentration 5 mg/mL and [6,6]-phenyl C61 butyric acid methyl ester ($PC_{61}BM$) was acquired from Solenne BV. The mixture of PDVT-10/$PC_{61}BM$ (at a weight ratio of 20:3) was dissolved in a mixture solvent of chloroform (CF)/chlorobenzene (CB). The weight ratio of $PC_{61}BM$ was optimized by comparison of different ratios of blend composition, and optimum synaptic performance was obtained for blends containing 15 wt % PCBM in all cases. In this work, the mixture solvent was mixed with CF and CB at various volume ratios 10:0, 9:1, 8:2, 7:3, 6:4, and 5:5, respectively. The solution of PDVT-10/$PC_{61}BM$ was heated at 60 °C for 1 day.

Synaptic Transistors Fabrication: OFET devices were fabricated in a bottom-gate top-contact (BGTC) configuration. Heavily n-type doped Si wafers with thermally grown 100-nm-thick SiO_2 as dielectric layers were used as substrates, which were fully cleaned by sequential ultrasonication in acetone, isopropanol, and deionized H_2O, respectively, and dried with a nitrogen blower. The SiO_2 layer was modified by OTS at 60 °C for 20 min to form an OTS self-assembled monolayer. Subsequently, PDVT-10/$PC_{61}BM$ solutions with various CF and CB ratios were spin-coated on the dielectric layer at 1000 rpm for 1 min as semiconductor layers and were annealed at 30 °C for 30 min in the air as followed. Finally, 50-nm-thick source and drain electrodes made of

gold were deposited on the film by vacuum-evaporation.

Electric measurement: The electric properties and basic synaptic behaviors were measured by the semiconductor parameter analyzer (Keithley B2902A) in an ambient environment. Atomic force microscopy (AFM) was performed using a Veeco Nanoscope IV in the tapping mode. Small-angle neutron scattering (SANS) was performed in China Spallation Neutron Source (CSNS).

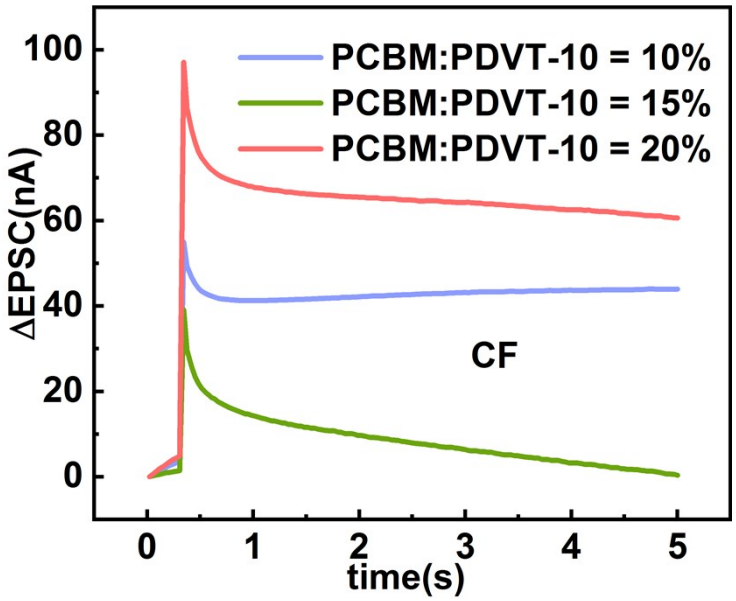

Figure S1 Comparison of EPSC of synaptic device in 10%, 15%, and 20% CB respectively. EPSC of PDVT-10/$PC_{61}BM$ synaptic transistors triggered by a presynaptic spike with V_{pre}= -35 V, t_d= 60 ms and V_{ds}= -10 V.

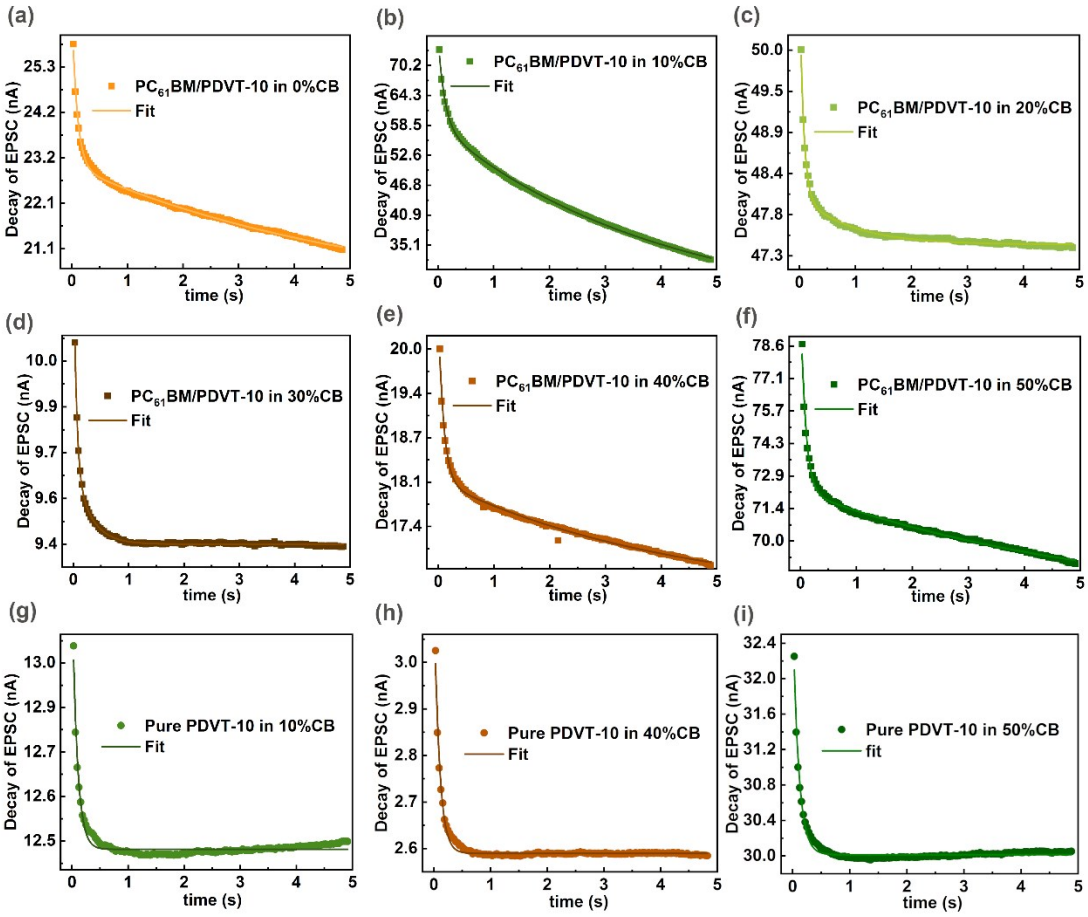

Figure S2 For the synaptic device with PDVT-10/$PC_{61}BM$ a) in CF, b) in 10%CB, c) in 20%CB, d) in 30%CB, e) in 40%CB, f) in 50%CB, the decay part of postsynaptic current can be fitted using a double-exponential function. For the synaptic device with pure PDVT-10 g) in 10%CB, h) in 40%CB, i) in 50%CB, the decay part of postsynaptic current can be fitted using a single-exponential function.

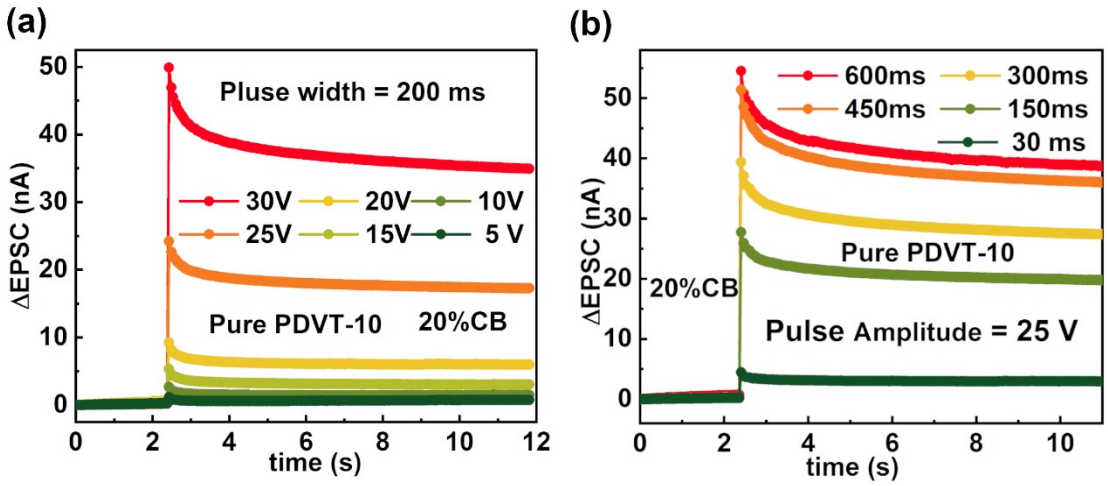

Figure S3 a) The EPSC of synaptic device triggered by a single spike with the same time of duration 200 ms and different presynaptic spike voltages from 5 to 30 V. b) The EPSC of synaptic device triggered by a single spike with the same spike amplitude 25V and different presynaptic times of duration from 30 to 600 ms.

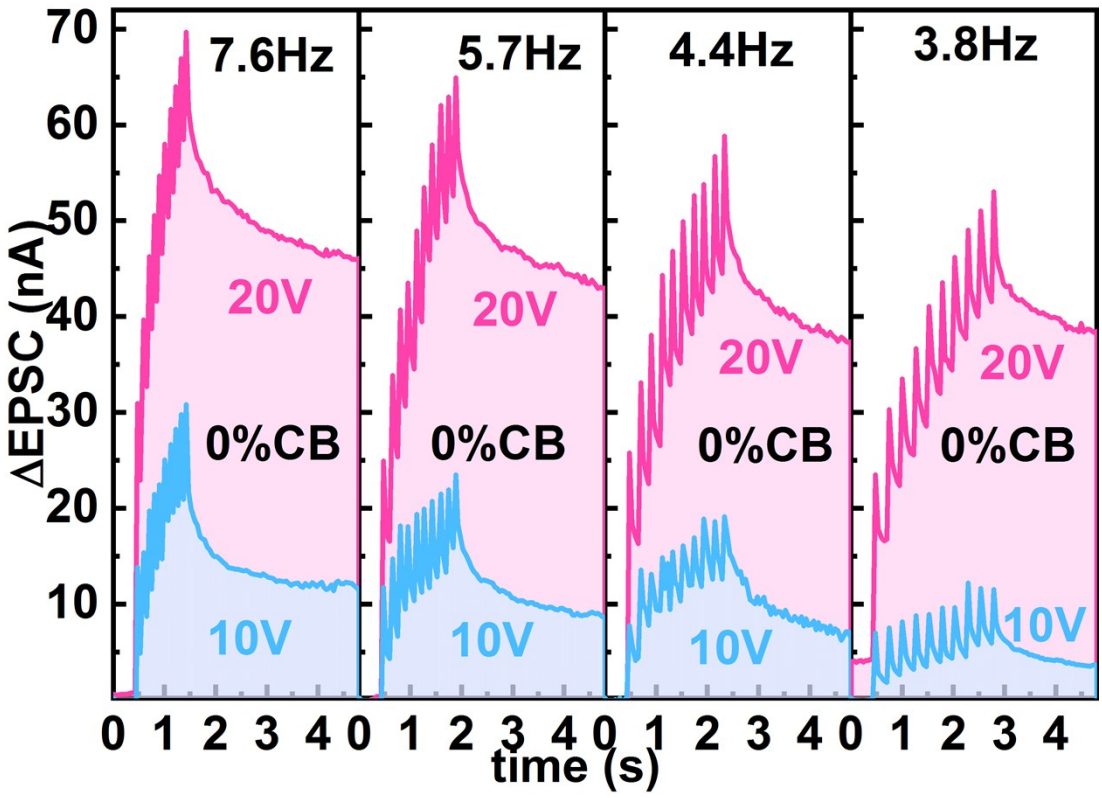

Figure S4 The EPSC of PDVT-10/$PC_{61}BM$ synaptic device in CF in the frequency of the stimulus spikes rises from 3.8 to 7.6 Hz and the presynaptic voltage rises from 10 V to 20V.

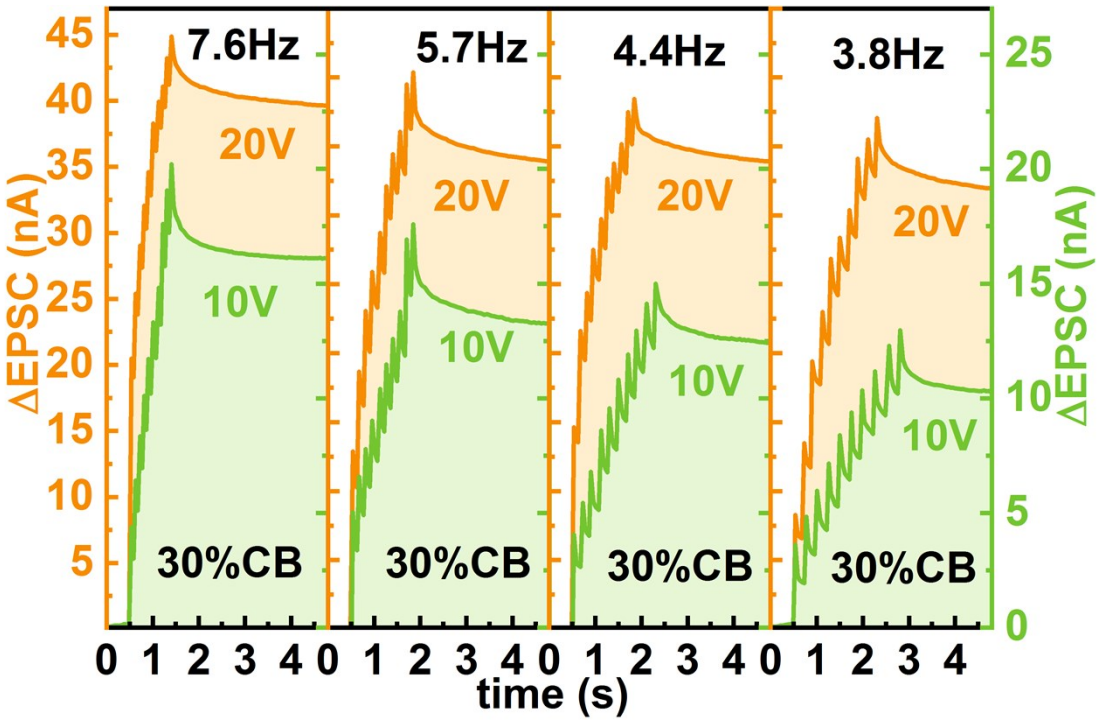

Figure S5 The EPSC of PDVT-10/$PC_{61}BM$ synaptic device in 30%CB in the frequency of the stimulus spikes rises from 3.8 to 7.6 Hz and the presynaptic voltage rises from 10 V to 20V.

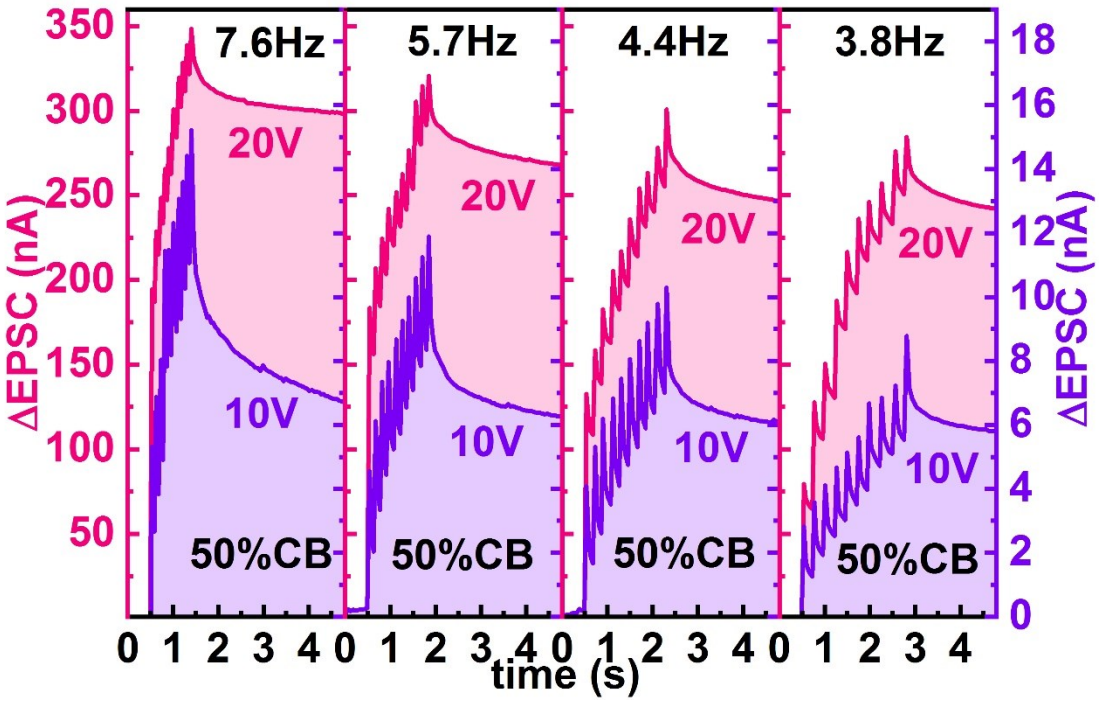

Figure S6 The EPSC of PDVT-10/$PC_{61}BM$ synaptic device in 50%CB in the frequency of the stimulus spikes rises from 3.8 to 7.6 Hz and the presynaptic voltage rises from 10 V to 20V.

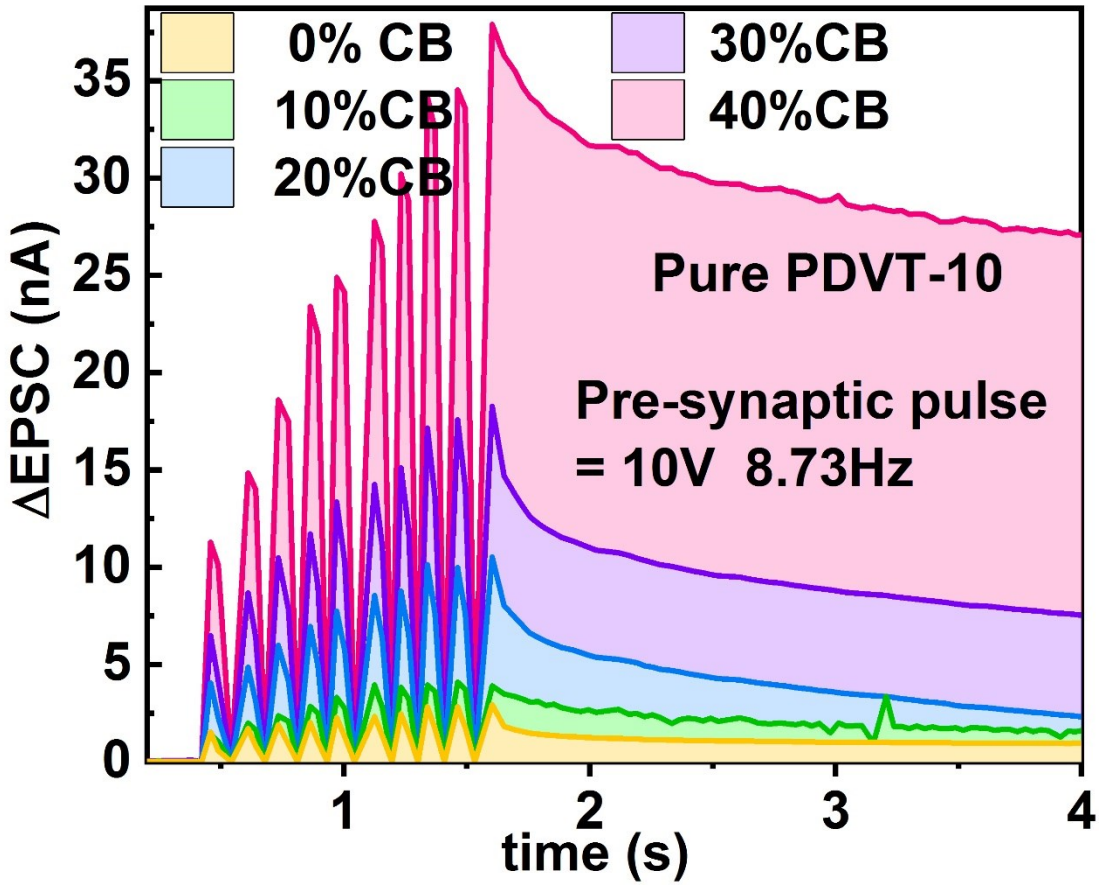

Figure S7 The EPSC of pure PDVT-10 synaptic device in vary ratios of CB from 0% to 50% . The frequency of repeated synaptic spikes was 8.73 Hz and 10V.

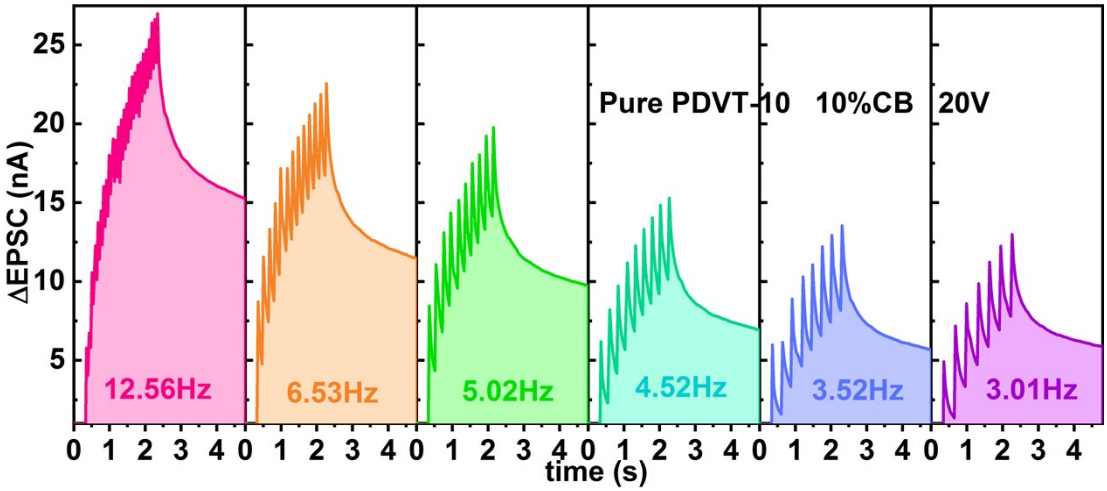

Figure S8 The EPSC of pure PDVT-10 synaptic device in 10%CB in the frequency of the stimulus spikes rises from 3.01 to 12.56 Hz.

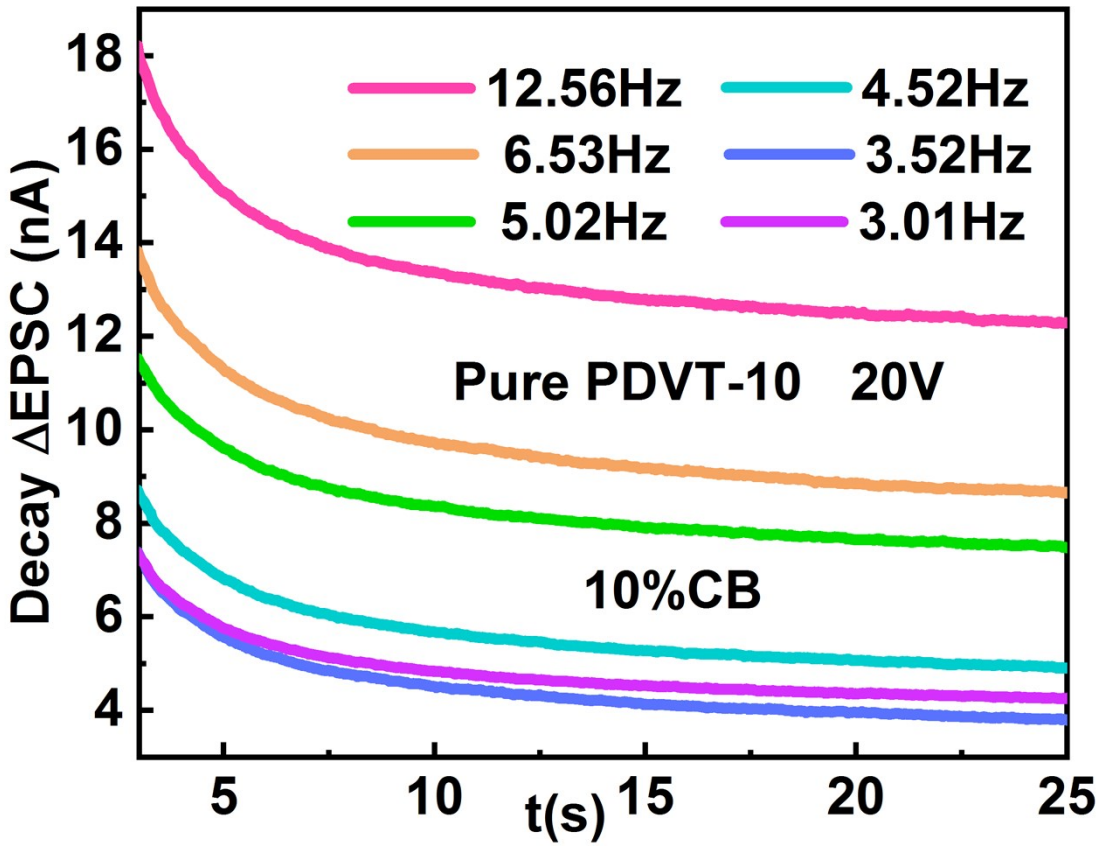

Figure S9 The decay part of EPSC of pure PDVT-10 synaptic device in 10% CB in the frequency of the stimulus spikes rises from 3.01 to 12.56 Hz.

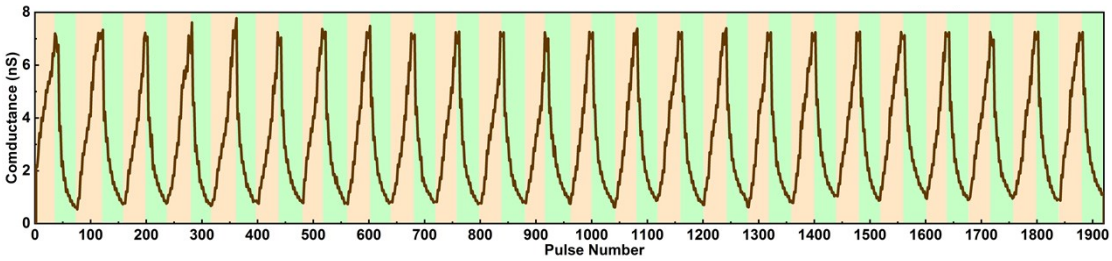

Figure S10 The reproducibility of PDVT-10/$PC_{61}BM$ SFET for 24 cycles (10 pulses positive pulse and 10 negative pulses with duration of 200 ms and interval of 200 ms).

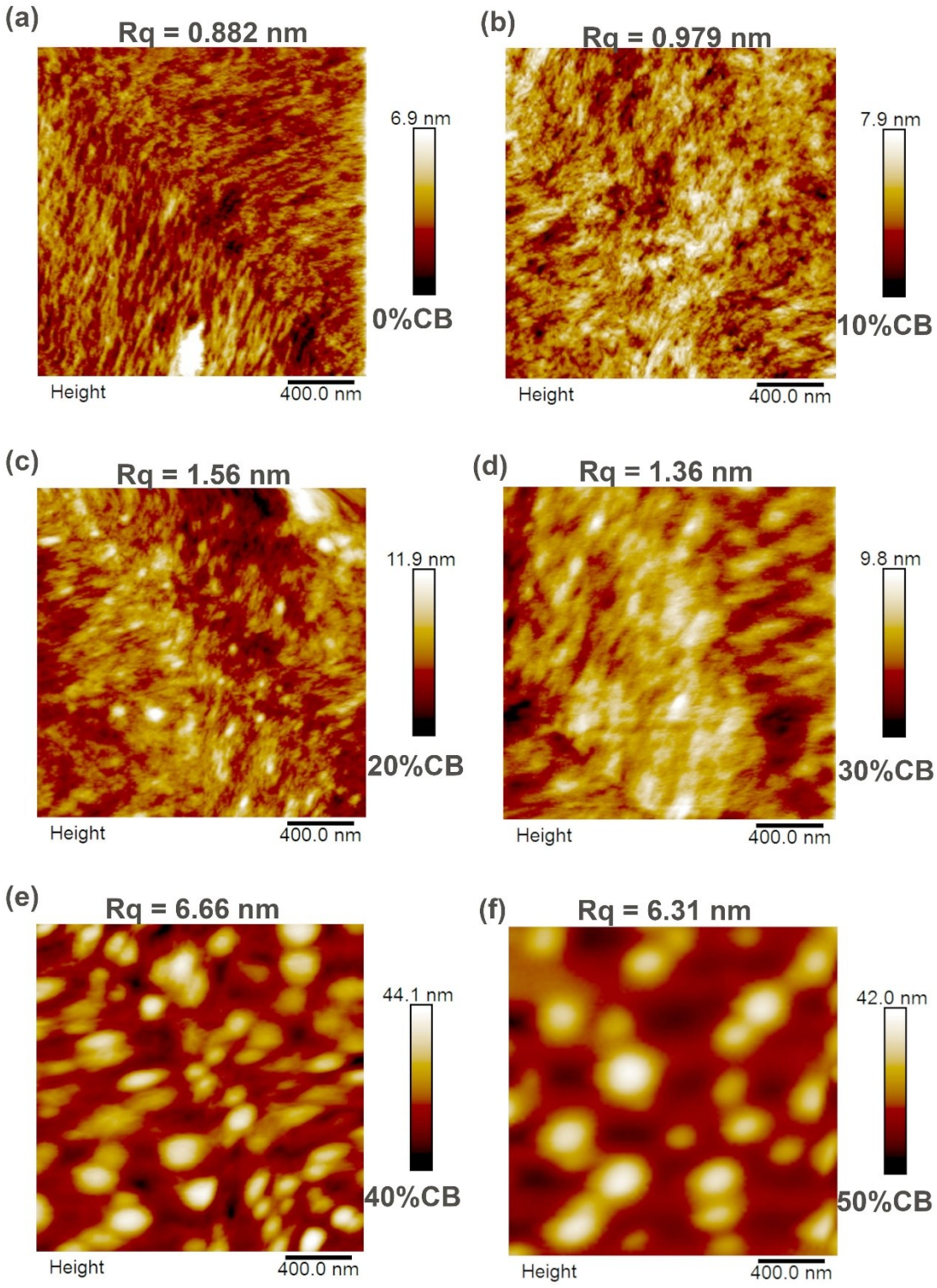

Figure S11 AFM tapping mode topographies of the surfaces of PDVT-10/$PC_{61}BM$ blends in (a) 0 % CB, (b) 10 % CB, (c) 20 % CB, (d) 30 % CB, (e) 40 % CB, and (f) 50 % CB.