Supporting Information

Organic Field-Effect Transistors Integrated with Ti_2CT_x Electrodes

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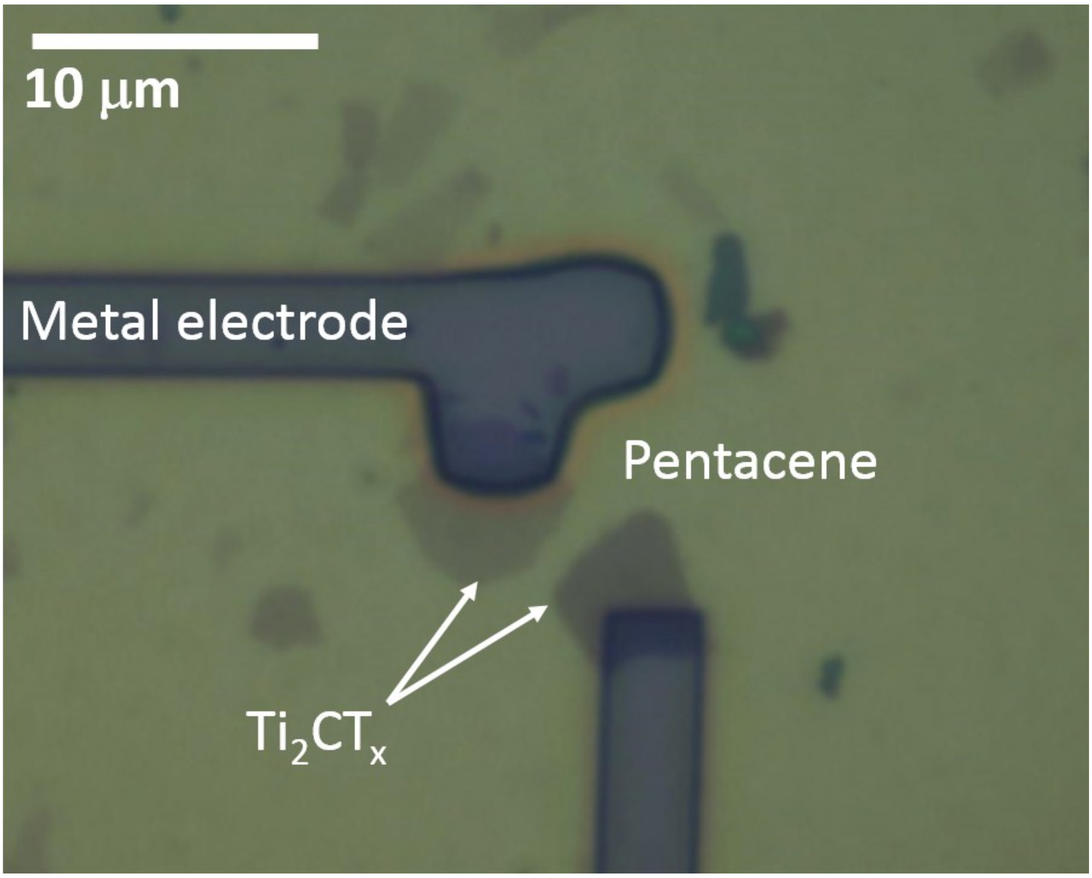

Figure S1. Optical microscopy (OM) image of organic field-effect transistor (OFET) device structure.

Proper Ti_2CT_x flakes are identified and metal electrodes are then formed. After pentacene is deposited, the source/drain contacts were formed between pentacene and Ti_2CT_x as shown in the above OM image.

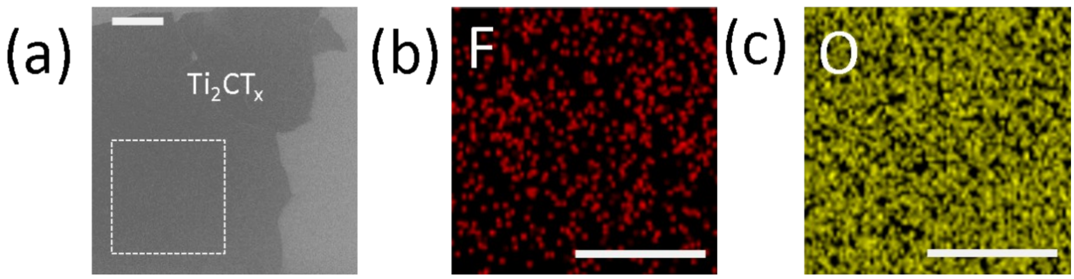

Figure S2. Energy-dispersive spectrometry (EDS) analysis of a Ti_2CT_x flake. Scale bars, 1μm.

Figure S2a shows a scanning electron microscopy (SEM) image of a Ti_2CT_x flake on SiO_2 substrate. Figure S2b and c show EDS mapping of the white dashed square in Figure S2a, for fluorine (F) and oxygen (O), respectively. Full coverage and uniform distribution of F and O are observed, which indicates that the Ti_2CT_x surface is fully terminated with surface groups (–F, –OH and/or –O).[S1] This is consistent with the X-ray photoelectron spectroscopy (XPS) results in Figure 1 in main text.

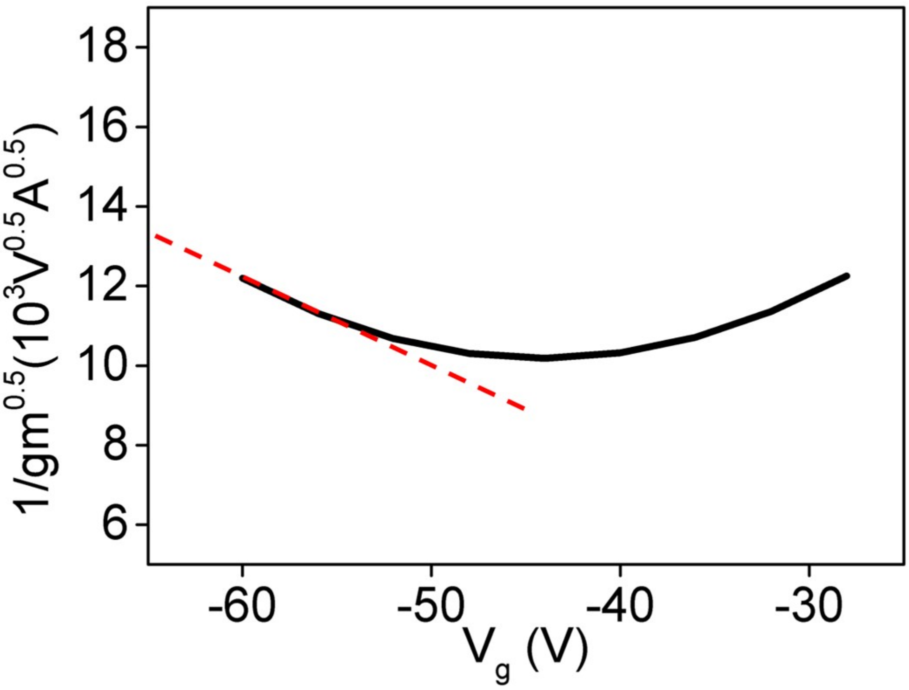

Figure S3. Evaluation of the mobility attenuation factor θ. Note that θ is extracted at the high gate field (strong accumulation region) where the Y function method is valid.

The transfer characteristics (I_{ds} versus V_g) in the linear region can be expressed as:

$I_{ds} = G_m V_{ds}(V_g - V_{th})/[1 + \theta(V_g - V_{th})]$.[S2]

Here, $G_m = (W/L)\mu_0 C_i$ is the transconductance parameter in which μ_0 is low-field mobility; V_{th} is the threshold voltage; and θ is the mobility attenuation factor.

The Y-function is defined as $Y = I_{ds}/g_m^{0.5}$,[S3] so

$Y = (G_m V_{ds})^{0.5}(V_g - V_{th}) = [(W/L)\mu_0 C_i V_{ds})]^{0.5}(V_g - V_{th})$, then

$dY = [(W/L)\mu_0 C_i V_{ds})]^{0.5} dV_g$

Thus, μ_0 can be extracted from the slope of Y versus V_g. (see Figure 3d in main text)

Once μ_0 is known, G_m can be extracted as $G_m = (W/L)\mu_0 C_i$

The transconductance, g_m, can be obtained:

$g_m = dI_{ds}/dV_g = G_m V_{ds}/[1 + \theta(V_g - V_{th})]^2$, so

$g_m^{0.5} = (G_m V_{ds})^{0.5}/[1 + \theta(V_g - V_{th})]$, and

$1/g_m^{0.5} = [1 + \theta(V_g - V_{th})]/(G_m V_{ds})^{0.5}$, then

$d(1/g_m^{0.5}) = [\theta/(G_m V_{ds})^{0.5}]dV_g$

So θ can be extracted from the slope of $1/ g_m^{0.5}$ versus V_g. (see Figure S3)

After G_m and θ are both known, Rc can be calculated from $\theta = G_m \times Rc$.[S3]

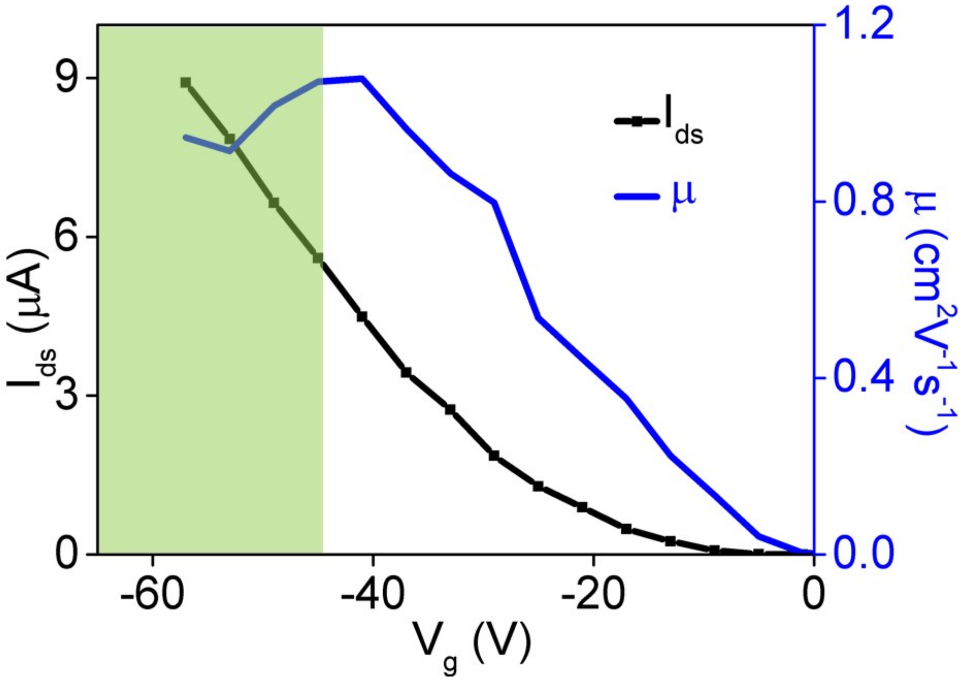

Figure S4. Part of the transfer curve in Figure 3a and V_g dependence of mobility.

Figure S4 shows the transfer curve in Figure 3a on a linear scale, with the mobility values in Figure S4 all extracted by the linear-regime equation: $\mu = (dI_{ds}/dV_g) \times [L/(WC_i V_{ds})]$. The linear-regime equation is valid when: $|V_{ds}|<|V_g - V_{th}|$.[S4] V_{ds} was -20V and V_{th} was extracted as -25V, so the linear-regime equation is valid when V_g<-45 V, shown as the green region in Figure S4. The extracted mobility values are valid in this region, and are located in a very narrow range (0.9-1.1 $cm^2V^{-1}s^{-1}$) where the V_g dependence of the mobility can barely be observed.

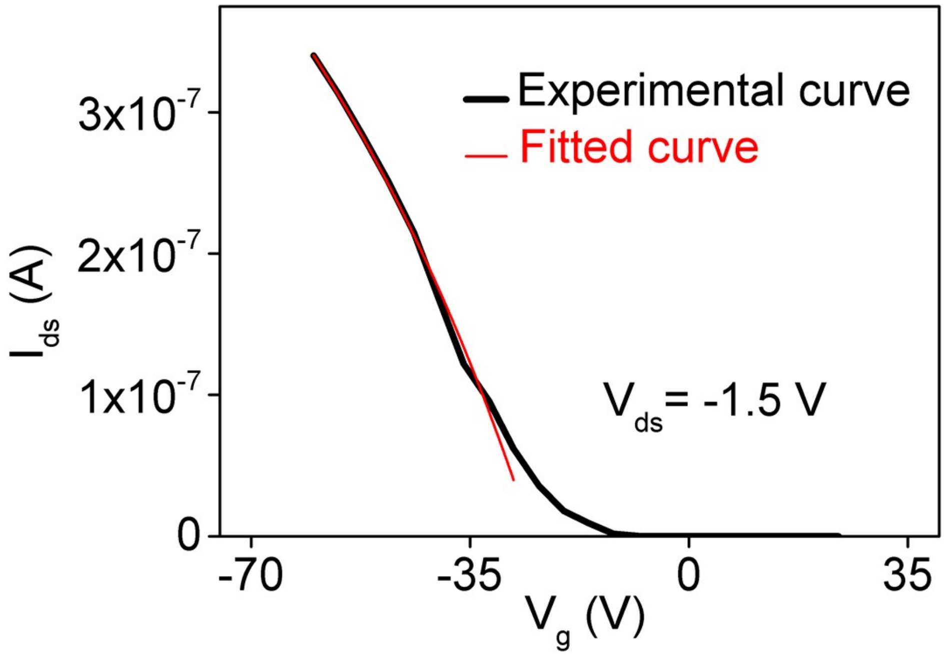

Figure S5. I_{ds} vs. V_g curve in Figure 3d in liner scale.

We used the constant-Rc mode to fit the experimental curve with the equation: $I_{ds}=V_{ds}/\{Rc+1/[(V_g-V_{th})\mu_0C_iW/L]\}$,[S5, 6] where μ_0 is the contact-free mobility. As shown in Figure S5, the shape of the experimental curve could be well-described by the constant-Rc mode. The extracted Rc was 2.3 kΩ cm, which is consistent with the Rc value extracted by the Y-function method (3 kΩ cm).

References

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