Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.
This journal is © The Royal Society of Chemistry 2019

Top Dielectric Induced Ambipolarity in an n-channel dual-gated Organic Field Effect Transistor

Kaushik Bairagi [a,], Elisabetta Zuccatti [a], Francesco Calavalle [a], Sara Catalano [a], Subir Parui [a †], Roger Llopis [a], Frank Ortmann [b], Fèlix Casanova [a,c], Luis E. Hueso[a,c,*]*

[a] CIC nanoGUNE, 20018 San Sebastian, Spain

[b]Center for Advancing Electronics Dresden and Dresden Center for Computational Materials Science, Technische Universität Dresden, 01062, Dresden, Germany

[c]IKERBASQUE, Basque Foundation for Science, 48013 Bilbao, Spain

† Present address: IMEC and K. U. Leuven, Leuven 3001, Belgium

*E-mail: k.bairagi@nanogune.eu; l.hueso@nanogune.eu

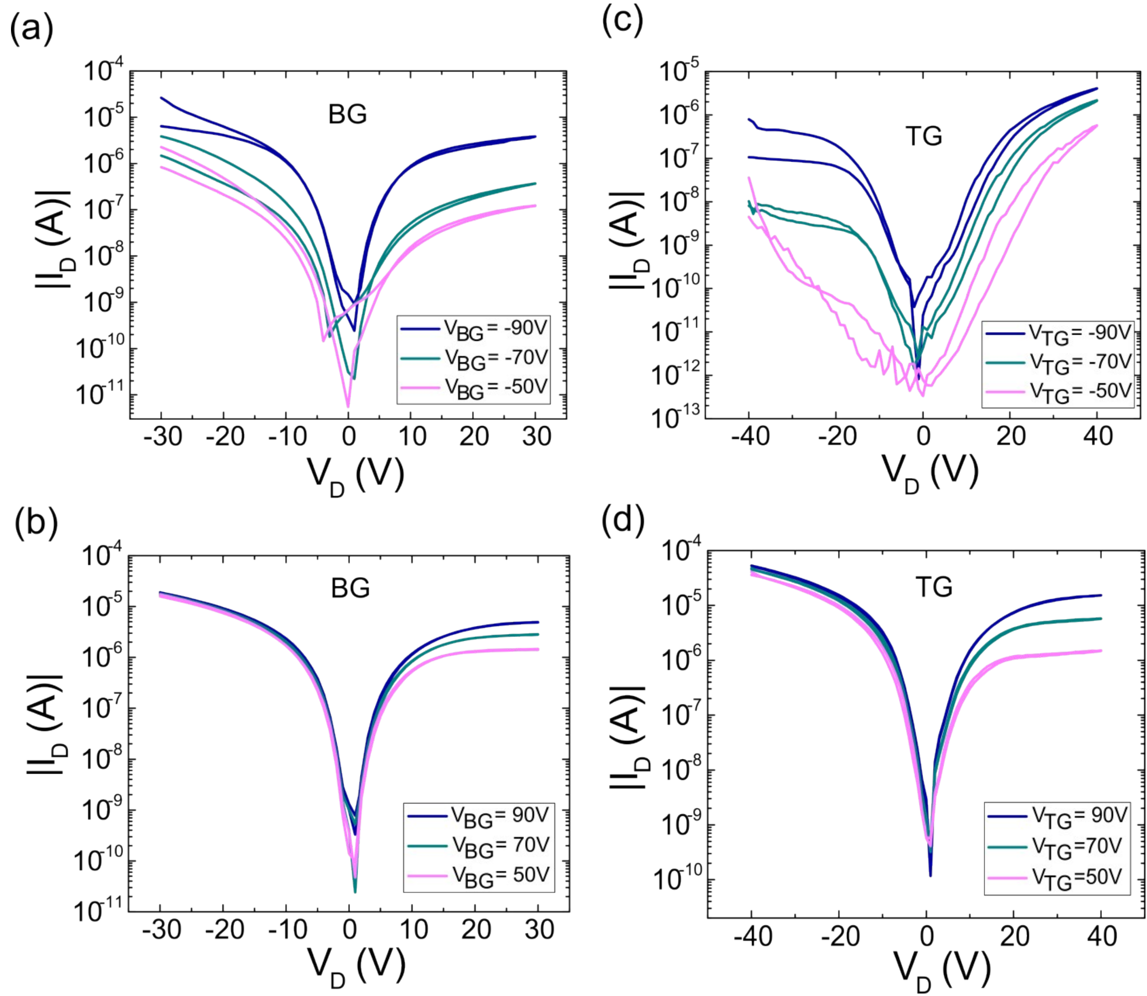

Figure S1. Trace-retrace drain characteristics (I_D - V_D) of N2200 (36 nm) transistor when probed with respect to bottom gate (a) for p-type operation (b) for n-type operation and when probed with respect to top gate (c) for p-type operation (d) for n-type operation.

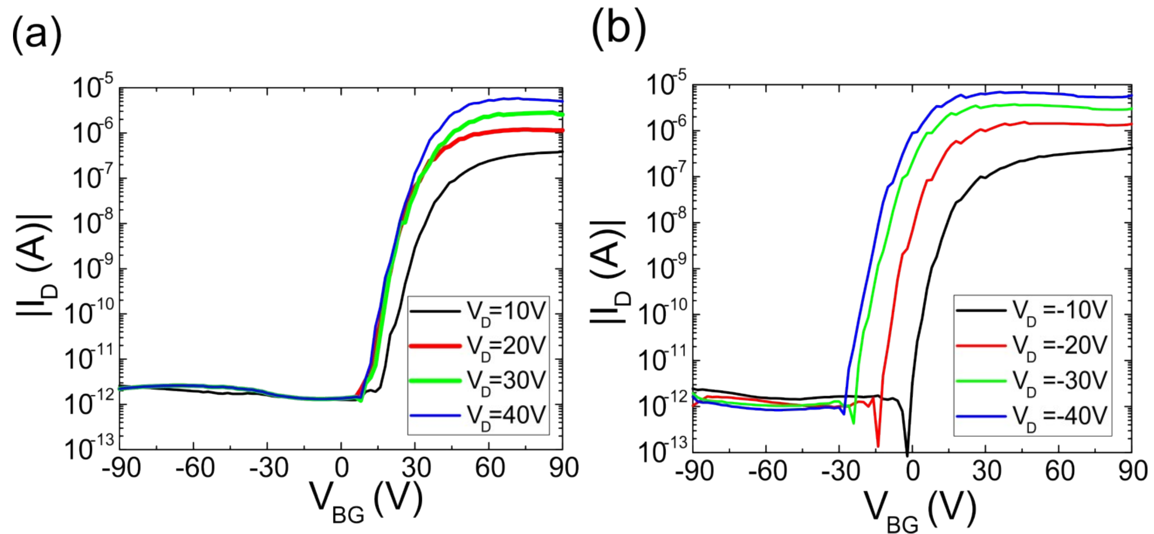

Figure S2. Transfer characteristics of N2200 (115 nm) (baked at 130˚C for 1h 30 min) transistor (L=10 µm, W = 10 mm) probed with respect to bottom gate (a) positive V_D (b) negative $V_{D.}$

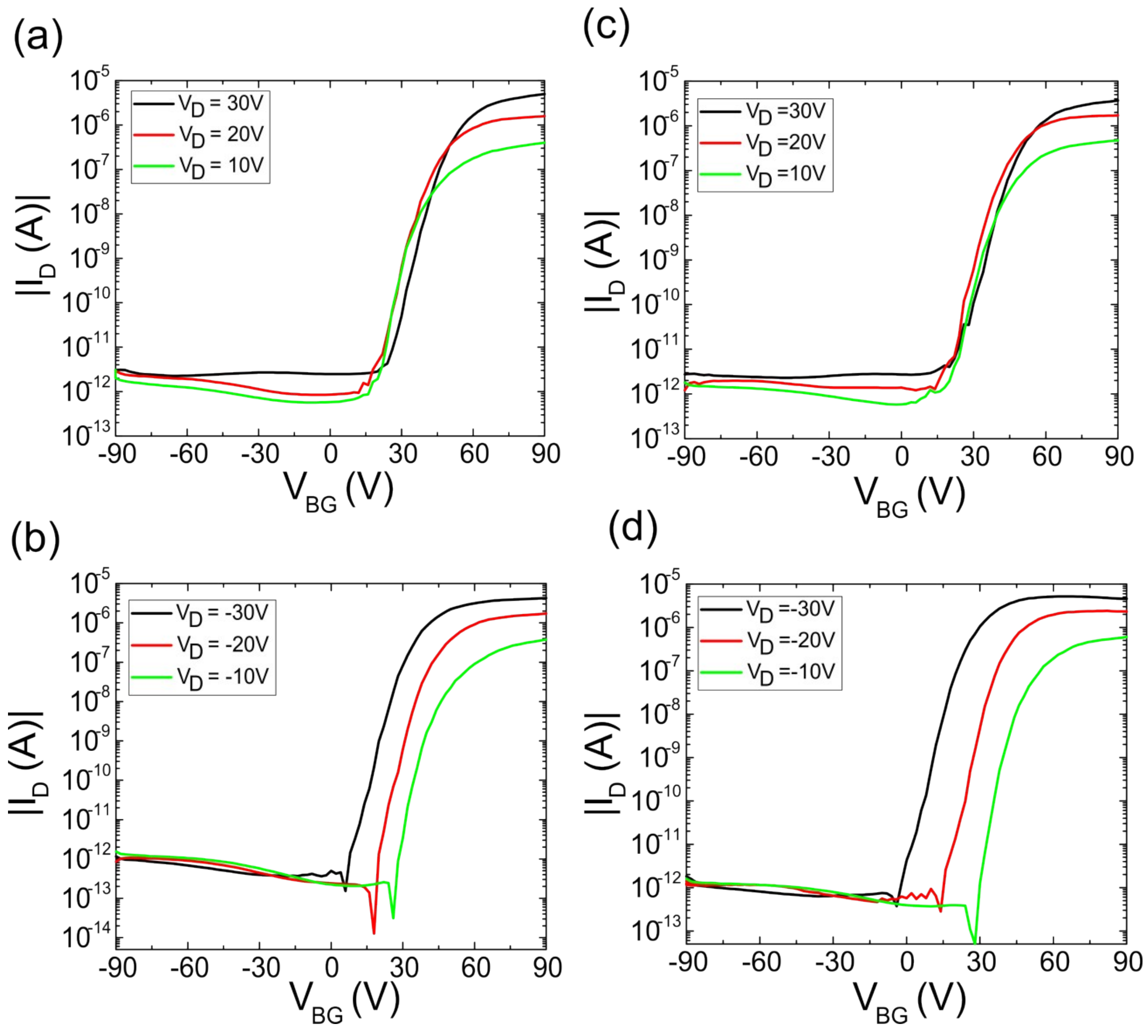

Figure S3. Transfer characteristics of anisole solvent (solvent for PMMA) coated N2200 (115 nm) transistor (L=10 μm, W = 10 mm) probed with respect to bottom gate (a)-(b) as spun anisole, (c)-(d) baking at 180˚C for 2 min. after spin-coating of anisole.

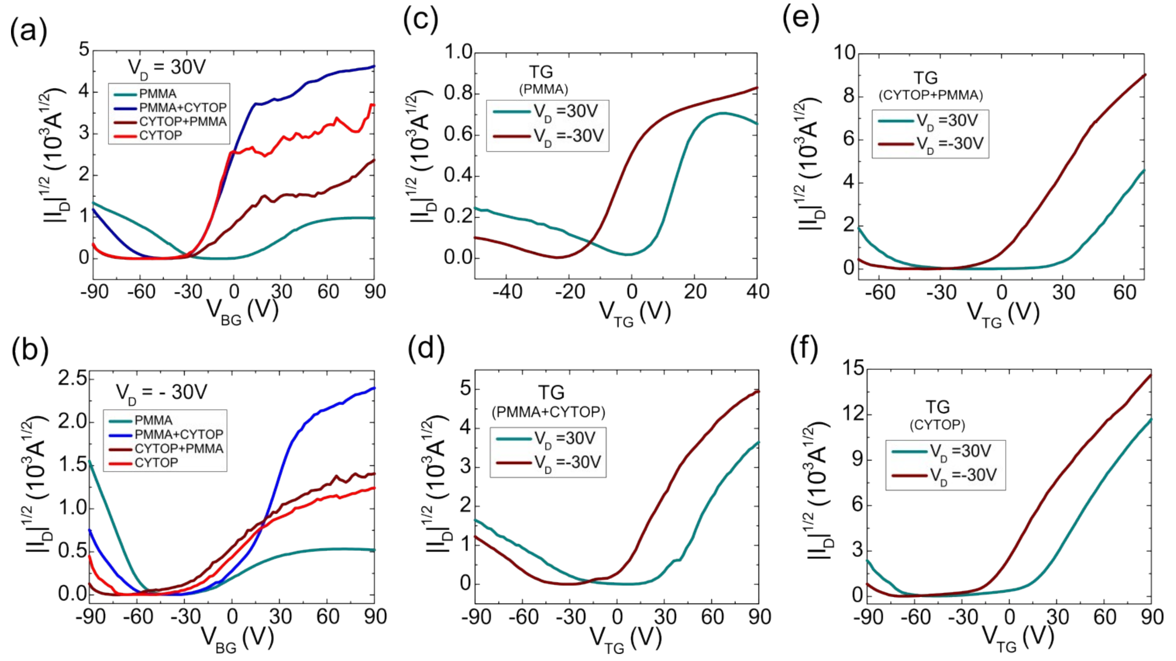

Figure S4. $\sqrt{I_D}$ vs. V_G of N2200 (36 nm) transistor (L=10 μm, W = 10 mm) probed with respect to bottom gate having different top gate dielectrics with a drain bias V_D = 30V (a), with V_D = -30V (b). The same with respect to top gate with different top dielectrics, (c) PMMA, (d) PMMA+CYTOP, (e) CYTOP+PMMA and (f) CYTOP.

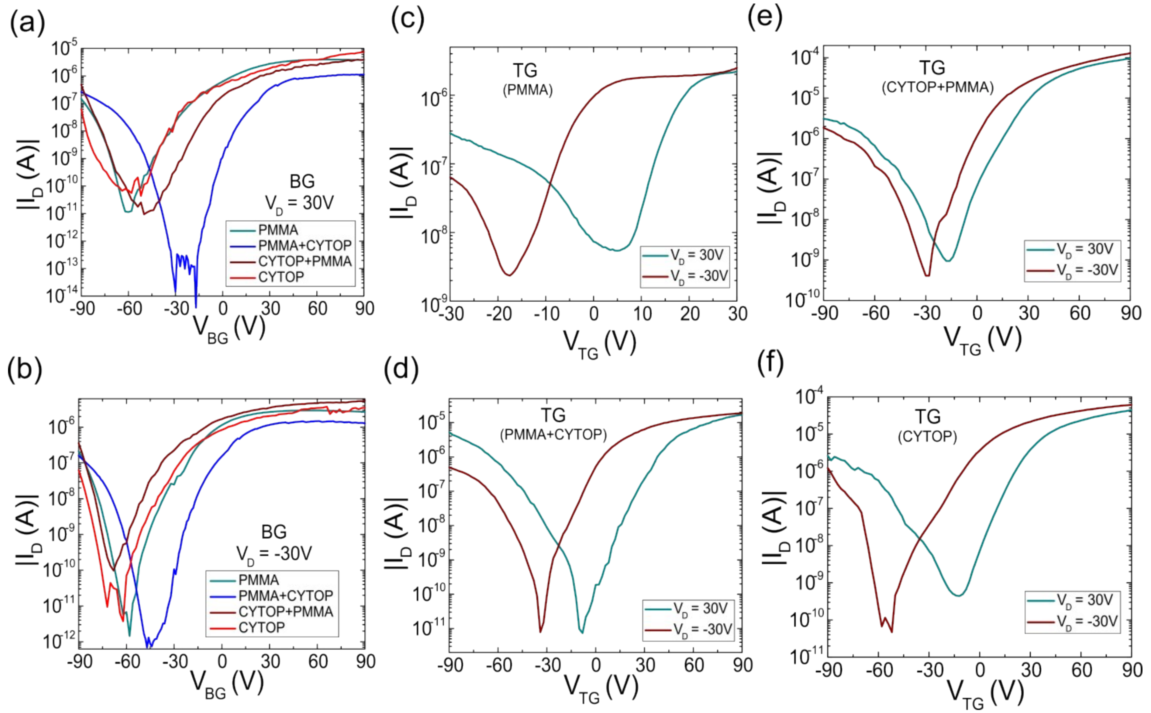

Figure S5. Transfer characteristics of N2200 (55 nm) transistor (L=10 μm, W = 10 mm) probed with respect to bottom gate having different top gate dielectrics with a drain bias V_D = 30V (a), with V_D = -30V (b). Transfer characteristics of the same transistors measured with respect to top gate with different top dielectrics, (c) PMMA, (d) PMMA+CYTOP, (e) CYTOP+PMMA and (f) CYTOP.

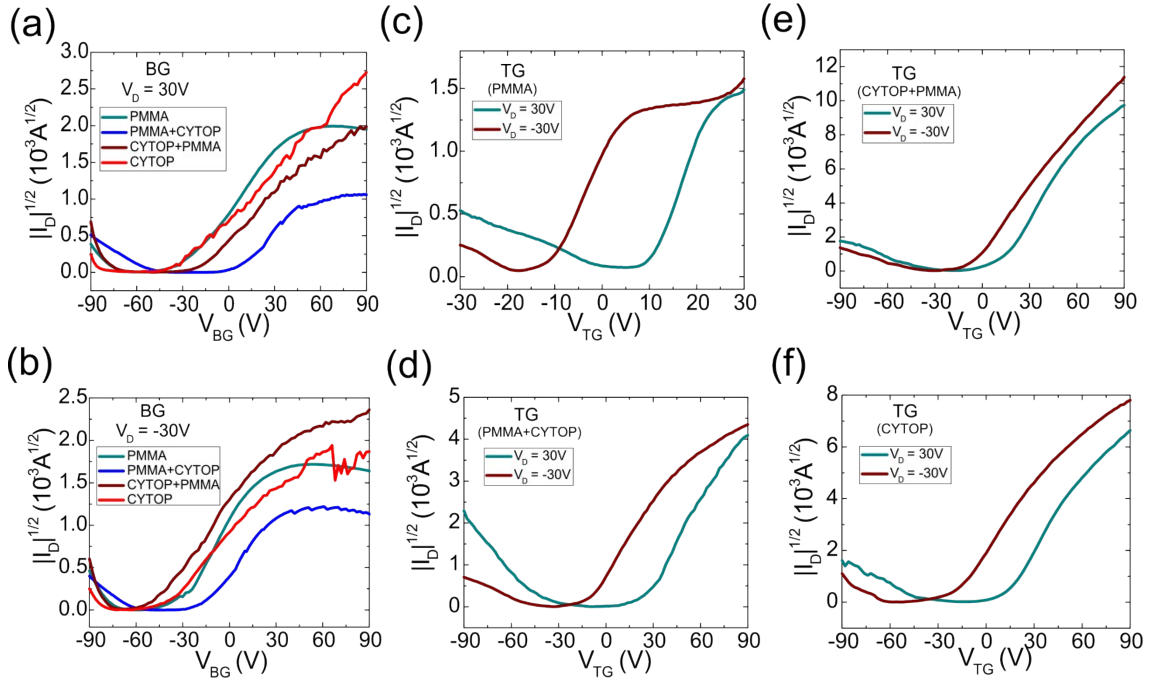

Figure S6. $\sqrt{I_D}$ vs. V_G of N2200 (55 nm) transistor (L=10 µm, W = 10 mm) probed with respect to bottom gate having different top gate dielectrics with a drain bias V_D = 30V (a), with V_D = -30V (b). The same with respect to top gate with different top dielectrics, (c) PMMA, (d) PMMA+CYTOP, (e) CYTOP+PMMA and (f) CYTOP.

Table S1a. Mobilities and turn on voltages while OFET operating in BGBC mode (with 55 nm N2200)) (L=10 µm, W = 10 mm)

Top dielectrics	p-channel		n-channel	
	$\mu_{h,BG}$ (× 10^{-3} cm^2 V^{-1} s^{-1})	V_{on} (V)	$\mu_{e,BG}$ (× 10^{-3} cm^2 V^{-1} s^{-1})	V_{on} (V)
PMMA	0. 11	-61.5	0. 17	-59.6
PMMA+CYTOP	0. 02	-49.2	0. 18	-18.2
CYTOP+PMMA	0. 41	-68.8	0. 10	-48.4
CYTOP	0. 08	-72.1	0. 11	-52.4

Table S1b. Mobilities and turn on voltages while OFET operating in TGBC mode (with 55 nm N2200) (L=10 µm, W = 10 mm)

Top dielectrics	p-channel		n-channel	
	$\mu_{h,TG}$ (× 10^{-3} cm^2 V^{-1} s^{-1})	V_{on} (V)	$\mu_{e,TG}$ (× 10^{-3} cm^2 V^{-1} s^{-1})	V_{on} (V)
PMMA	0. 05	-18.4	1.8	5.6
PMMA+CYTOP	0. 39	-34.3	5.36	-8.2
CYTOP+PMMA	0. 65	-29.5	14.40	-16.5
CYTOP	1.40	-58.1	5.52	-11.4

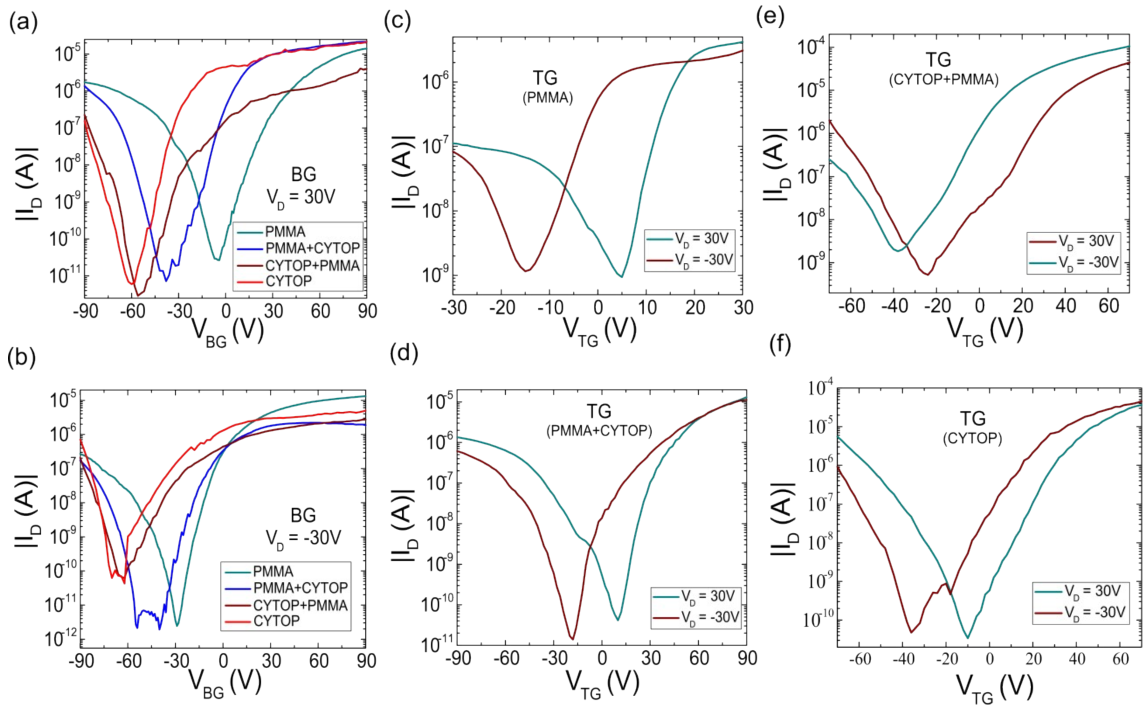

Figure S7. Transfer characteristics of N2200 (115 nm) transistor (L=10 µm, W = 10 mm) probed with respect to bottom gate having different top gate dielectrics with a drain bias V_D = 30V (a), with V_D = -30V (b). Transfer characteristics of the same transistors measured with respect to top gate with different top dielectrics, (c) PMMA, (d) PMMA+CYTOP, (e) CYTOP+PMMA and (f) CYTOP.

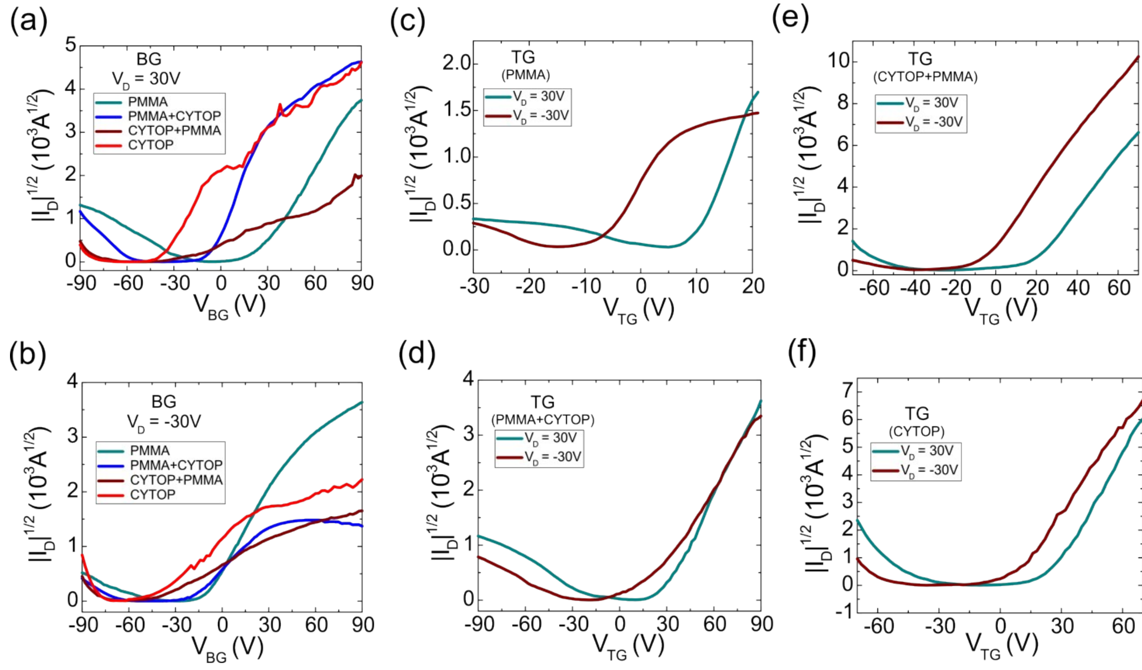

Figure S8. $\sqrt{I_D}$ vs. V_G of N2200 (115 nm) transistor (L=10 μm, W = 10 mm) probed with respect to bottom gate having different top gate dielectrics with a drain bias V_D = 30V (a), with V_D = -30V (b). The same with respect to top gate with different top dielectrics, (c) PMMA, (d) PMMA+CYTOP, (e) CYTOP+PMMA and (f) CYTOP.

Table S2a. Mobilities and turn on voltages while OFET operating in BGBC mode (with 115 nm N2200)) (L=10 μm, W = 10 mm)

Top dielectrics	p-channel		n-channel	
	$\mu_{h,BG}$ (× 10^{-3} cm^2 V^{-1} s^{-1})	V_{on} (V)	$\mu_{e,BG}$ (× 10^{-3} cm^2 V^{-1} s^{-1})	V_{on} (V)
PMMA	0.03	-28.7	0. 59	-4.8
PMMA+CYTOP	0. 03	-53.8	1. 15	-38.2
CYTOP+PMMA	0. 17	-64.3	0.04	-55.1
CYTOP	0. 79	-70.2	0. 58	-59.6

Table S2b. Mobilities and turn on voltages while OFET operating in TGBC mode (with 115 nm N2200) (L=10 μm, W = 10 mm)

Top dielectrics	p-channel		n-channel	
	$\mu_{h,TG}$ (× 10^{-3} cm^2 V^{-1} s^{-1})	V_{on} (V)	$\mu_{e,TG}$ (× 10^{-3} cm^2 V^{-1} s^{-1})	V_{on} (V)
PMMA	0. 02	-15.5	3.13	4.8
PMMA+CYTOP	0. 10	-18.5	2.44	10.2
CYTOP+PMMA	0. 21	-38.3	10.75	-24.2
CYTOP	1.87	-36.4	8.11	-10.2

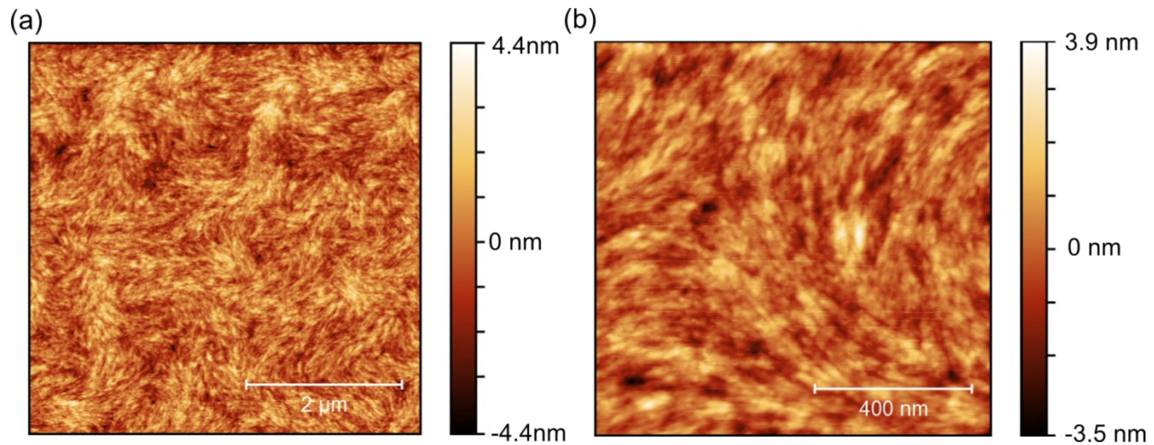

Figure S9. AFM images of N2200 film on Si^{n++}/SiO_2. The nodular like morphology is observed which is the characteristic growth process of this type of polymer by spin-coating. The RMS roughnesses are 0.9 nm and 0.8 nm for (a) and (b) respectively.

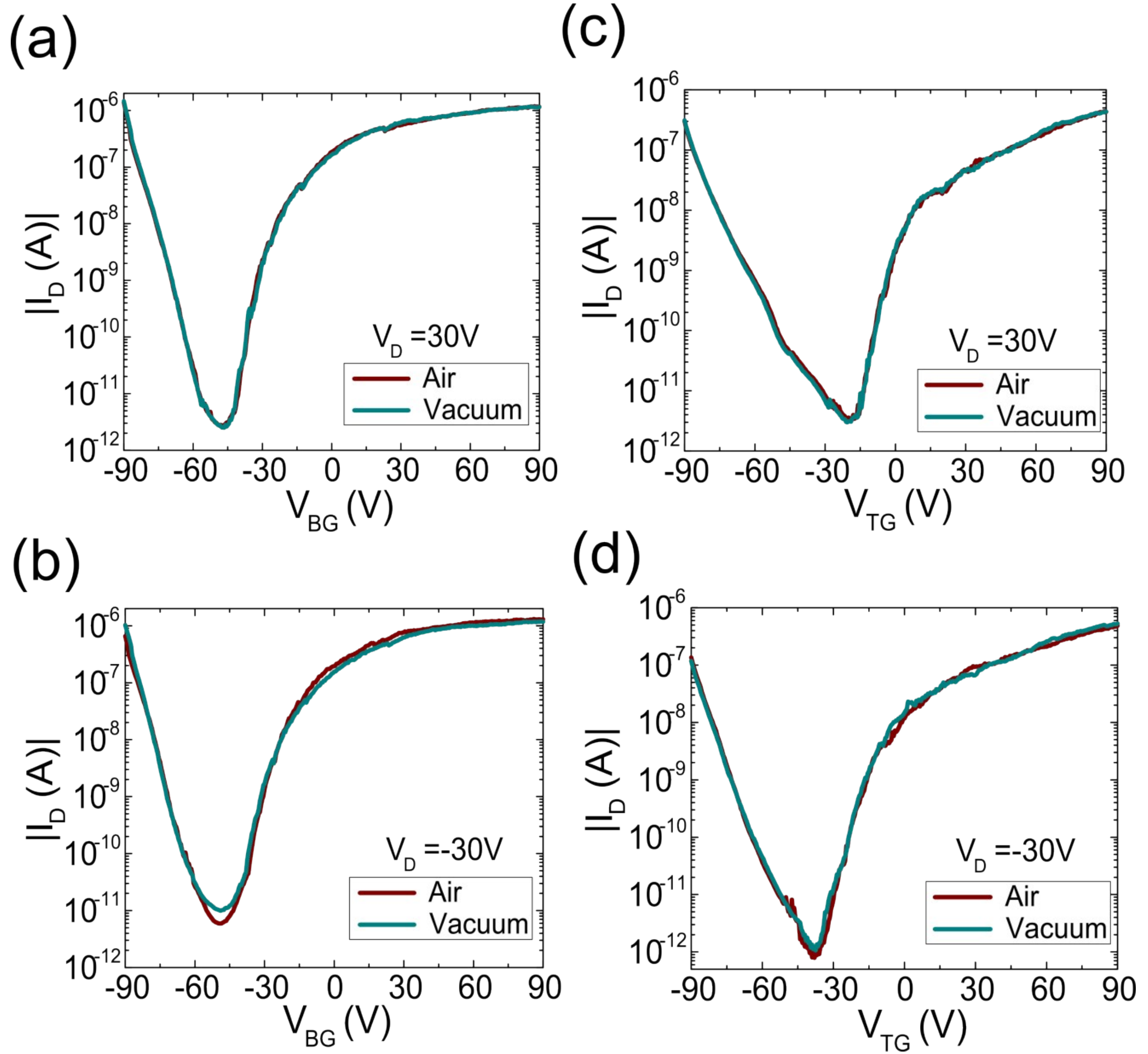

Figure S10. Air stability of dual gated N2200 transistor. Transfer characteristics of a N2200 (115 nm) transistor (L=10 μm, W = 10 mm) with PMMA+CYTOP as top gate dielectric measured in air and vacuum after 312 days of sample fabrication (sample was stored in a nitrogen filled box). Sample probed with respect to bottom gate (a) for V_D = 30V, (b) for V_D =-30V, probed with respect to top gate (c) for V_D = 30V, (d) for V_D =-30V.