TCI Product Feature

High-Performance Small-Molecule Semiconductors for Solution-Processed and/or Vacuum-Evaporated n-Channel Organic Transistors: TU-1, TU-3

The organic semiconductors TU-1 and TU-3 have been developed by Tokito's group at the Research Center for Organic Electronics in Yamagata University. TU-1 and TU-3 can be used in vacuum-evaporated and/or solution-processed high-performance organic field-effect transistors (OFETs) with electron mobilities of over 1 cm^2/Vs.[1~8] TU-1 and TU-3 (product number: T3922 and T3924) are evaluated through in-house device assessments to ensure the semiconductor performance of OFET devices for the reliable use of these materials.

Advantages of TU-1 and TU-3

- Electron mobility >1 cm^2/Vs
- Solution-processable and/or vacuum-evaporable
- Applicable to complementary circuits[2~8]
- Quality specification by electron mobility of OFET devices

Example: Application to complementary circuits

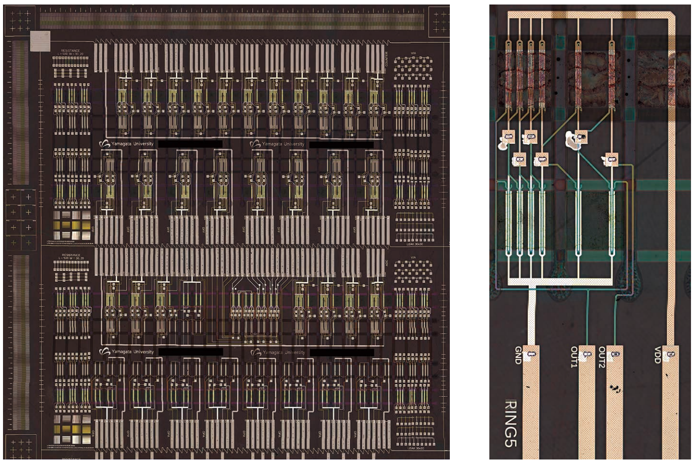
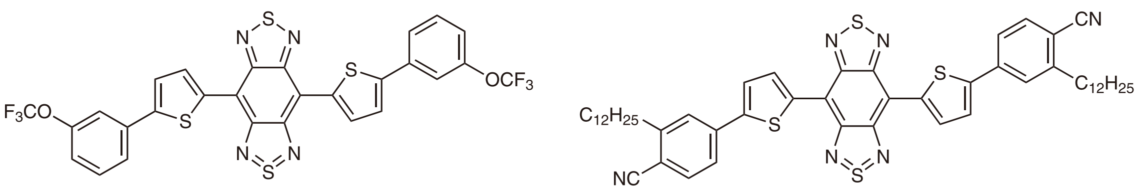


Figure 1. Photographs of complementary organic circuit using TU-3. (Pictures provided by Asst. Prof. Yasunori Takeda.)

Characteristics of TU-1 and TU-3



TU-1 TU-3

Figure 2. Structures of TU-1 and TU-3

Table 1. Optoelectronic and thermogravimetric characteristics of TU-1 and TU-3

Compound	HOMO [a] (eV)	LUMO [a] (eV)	HOMO [b] (eV)	LUMO [b] (eV)	$\lambda_{abs.\ peak}$ [c] (nm)	Td [d] (ºC)
TU-1	-5.44	-4.15	-5.58	-4.05	375, 707	422
TU-3	-5.56	-4.24	–	-4.12	385, 722	393

a) Calculated by DFT at Gaussian09 B3LYP/6-311++G(d,p), b) determined by cyclic voltammetry measurement, c) thin film, d) 5% weight loss.

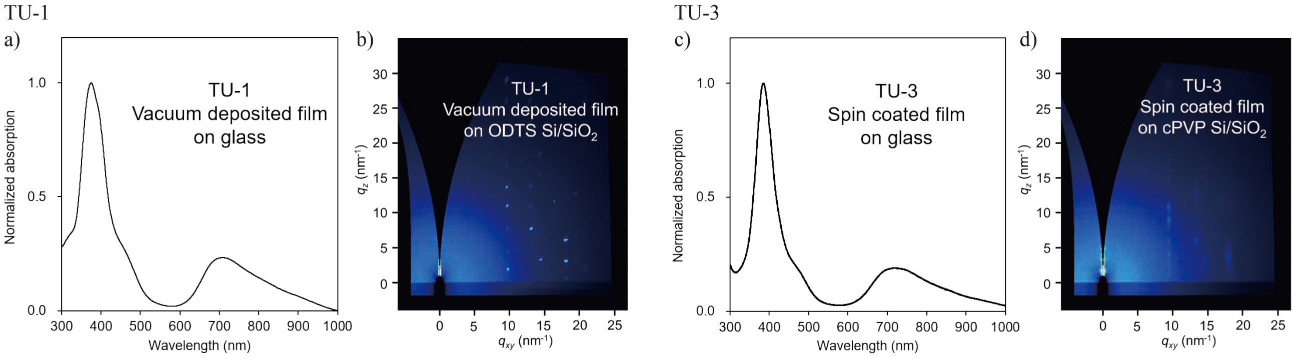


Figure 3. Thin-film UV-vis spectra (a, c) and 2D-GIXD patterns (b, d) of TU-1 and TU-3.

Table 2. Solubility of TU-1

Solvent	Temperature (ºC)	Concentration 0.03 wt%	0.05 wt%	0.1 wt%	0.3 wt%
Toluene	100	○	○	○	
Mesitylene	130	○	○	○	○
Chlorobenzene	130	○	○	○	
o-Dichlorobenzene	130	○	○		

Table 3. Solubility of TU-3

Solvent	Temperature (ºC)	Concentration 0.1 wt%	0.2 wt%	0.3 wt%
Xylene	100	○	○	○
Anisole	100	○	○	
Chloroform	60	○	○	
Chlorobenzene	80	○	○	○
o-Dichlorobenzene	60	○	○	○

Performance evaluation of TU-1 and TU-3

TU-1-based device (fabricated by vacuum deposition method)

1. ODTS SAM layer was formed on n^+-Si / SiO_2 (200 nm) substrate.
2. Vacuum deposition of TU-1 (substrate temperature: 60 ºC, deposition rate: 0.1 Å/sec, film thickness: 40 nm).
3. Vacuum deposition of Au electrode (thickness, 40 nm; channel length, 50 µm; channel width, 1.5 mm).
4. Annealing treatment at 150 ºC for 30 min in nitrogen glove box.
5. Device performance evaluation in nitrogen glove box.

TU-3-based device (fabricated by spin coating method)

1. Cross-linked poly vinyl phenol insulator was formed on n^+-Si / SiO_2 (200 nm) substrate.
2. TU-3 was dissolved in chloroform at concentration of 0.1wt%.
3. Spin-casting of TU-3 in nitrogen glove box (rotation speed: 1000 RPM, film thickness 20 nm).
4. Annealing treatment at 180 ºC for 30 min in nitrogen glove box.
5. Vacuum deposition of Au electrode (thickness: 40 nm, channel length: 50 µm, channel width 1.5 mm).
6. Device performance evaluation in nitrogen glove box.

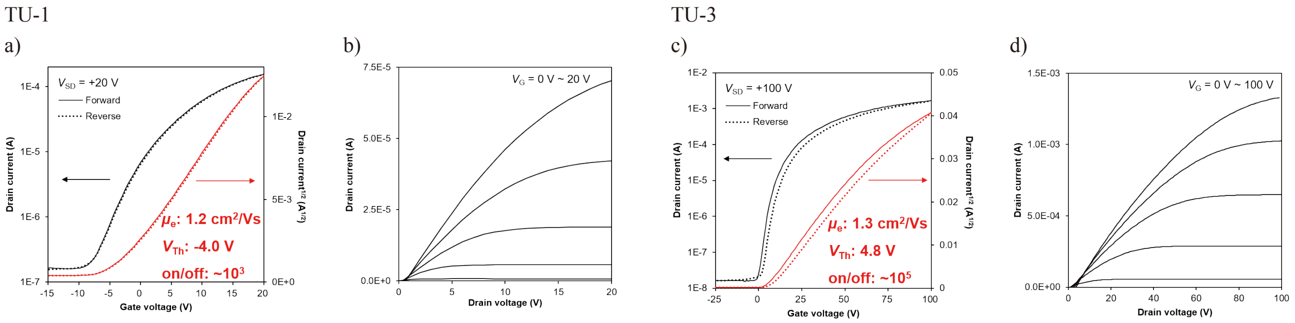


Figure 4. Transfer curves (a, c) and output curves (b, d) for TU-1- and TU-3-based OFETs.

Table 4. OFET characteristics of TU-1, TU-3-based devices

Solvent	Insulator	V_{SD} [V]	$\mu_{ave.}$ [cm^2/Vs]	μ_{max} [cm^2/Vs]	V_{Th} [V]	on/off
TU-1 (vacuum deposition)	SiO_2	20	0.31 (0.01)	0.33	6.5 (0.2)	~10^6
	SiO_2	40	0.45 (0.01)	0.46	9.6 (0.1)	~10^7
	SiO_2 / ODTS	20	0.88 (0.18)	1.18	-1.1 (2.6)	~10^3
TU-3 (spin coating)	SiO_2	20	0.21 (0.03)	0.26	11.9 (0.4)	~10^5
	SiO_2 / cPVP	20	0.51 (0.03)	0.55	5.0 (0.1)	~10^3
	SiO_2 / cPVP	100	1.03 (0.14)	1.25	5.3 (1.3)	~10^5

The product specifications of TU-1 and TU-3 are the electron mobilities of >0.50 cm²/Vs in OFET devices.

References

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TU-1 and TU-3 were developed by Tokito-Kumaki-Sekine laboratory in Yamagata University and commercialized with the cooperation of Future Ink Corporation.
The pictures and part of physical property data were provided by Tokito-Kumaki-Sekine laboratory in Yamagata University and Future Ink Corporation.

Products

TU-1		100mg	250mg	T3922
TU-3		100mg	250mg	T3924

High Quality p-Type Semiconductor

Ph-BTBT-10		100mg	250mg	D5491

Surface Treatment Regents

Octadecyltrichlorosilane (ODTS) (>99.0%)			1g	T3815
n-Octyltrichlorosilane (OTS)		25g	250g	O0168
1,1,1,3,3,3-Hexamethyldisilazane (HMDS)	25mL	100mL	500mL	H0089

Organic Solvents

Toluene		100mL	T0260
p-Xylene	25mL	500mL	X0014
Mesitylene	25mL	500mL	T0470
Anisole	25g	500g	A0492
Chloroform (stabilized with Ethanol)		100mL	C0175
Chlorobenzene		500g	C1948
o-Dichlorobenzene	25mL	500mL	D1116