Room-temperature processed, air-stable and highly-efficient graphene/silicon solar cells with organic interlayers

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Supporting information

Extraction the values of series resistances of solar cells

The current density and voltage (*J-V*) under dark circumstance follow **Equation S1** when series resistance (R_s) is taken into account, [1,2]

$$J = J_0 \left(\exp\left(\frac{q(V - JR_s)}{nkT} \right) - 1 \right) \tag{S1}$$

where J_s is the reversed saturation current density, *T* the absolute temperature (298 K) and *V-JR*$_s$ the voltage applied across the Schottky solar cells. When $V - JR_s > 3kT/q$, the term of minors 1 can be ignored, then the *J-V* relation becomes as follows,

$$J = J_0 \exp\left[\frac{q(V - JR_s)}{nkT} \right] \tag{S2}$$

Equation S2 is differentiated and rearranged into **Equation S3**.

$$\frac{dV}{d(\ln J)} = R_s A_{eff} J + \frac{nkT}{q} \tag{S1.3}$$

Where A_{eff} is the effective area of Schottky solar cell. The value of R_s is obtained from the slope of d*V*/dln*J vs. J* curves.
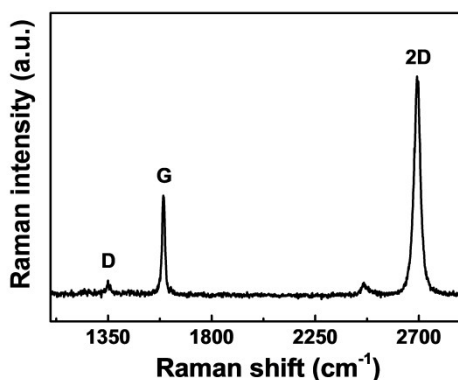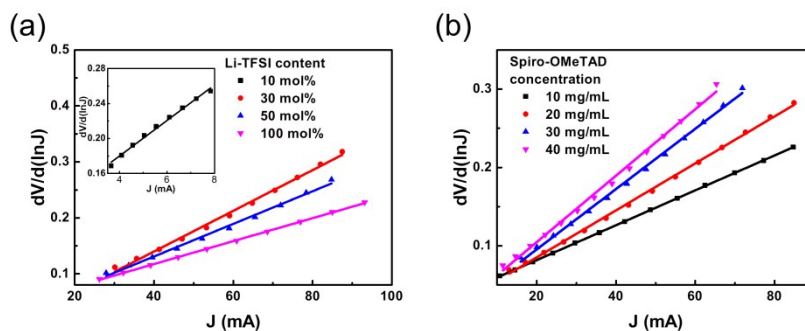

Figure S1. Raman spectrum of a Gr film.

Figure S2. The dV/dln$J$ vs. J curves of Gr/HTL/Si solar cells varying with (a) Li-TFSI contents and (b) concentration of spiro-OMeTAD solutions to extract the series resistances.
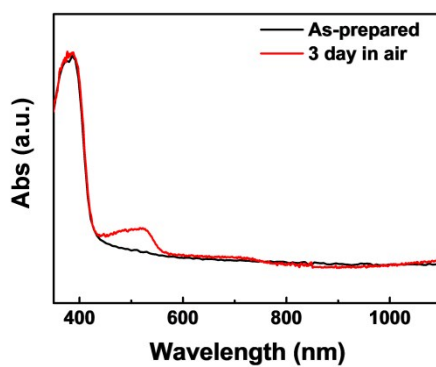

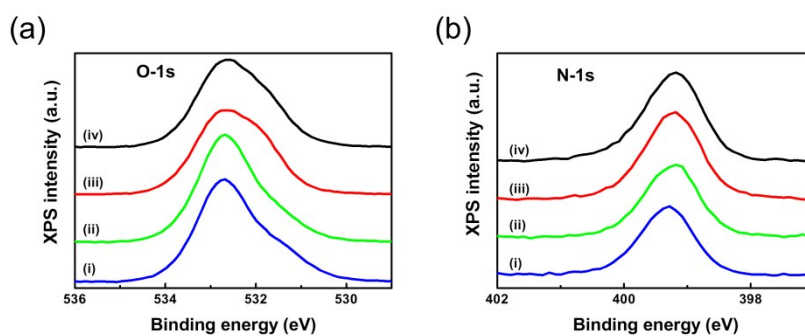Figure S3. Absorption spectrum of spiro-OMeTAD thin film on glass.

Figure S4. XPS spectra corresponding to (a) O-1s and (b) N-1s core levels of (i) as-prepared spiro-OMeTAD thin films, (ii) Gr protected sample and bare spiro-OMeTAD thin films after (iii) 1 day and 3 days air exposure.

Table S1. Summarized photovoltaic parameters of Gr/Si solar cells with increasing the LiTFSI content of the spiro-OMeTAD solutions.

LiTFSI content (mol%)	V_{OC} (mV)	J_{SC} (mA/cm^2)	FF (%)	PCE (%)	R_s (Ωcm^2)
0	240.8	0.16	33.41	0.01	
10	433.8	29.41	31.80	4.06	20.30
30	444.2	30.51	56.28	7.63	3.63
50	536.4	32.50	70.32	12.25	2.91
100	518.3	32.76	68.32	11.60	2.05

Table S2. Summarized photovoltaic parameters of Gr/Si solar cells with increasing the concentration of the spiro-OMeTAD solutions.

Concentration of spiro-OMeTAD (mg/mL)	V_{OC} (mV)	J_{SC} (mA/cm^2)	FF (%)	PCE (%)	R_s (Ωcm^2)
10	530.1	31.54	56.42	9.43	2.22
20	544.7	33.20	71.20	12.88	3.00
30	552.2	32.84	64.08	11.39	3.85
40	558.2	31.44	62.15	9.91	4.24

References

1   A. Tataroğluand Ş. Altındal, *Microelectron. Eng.*, 2008, **85**, 233-237.

2   D. Pysch, A. Metteand S. W. Glunz, *Sol. Energ. Mat. Sol. C.*, 2007, **91**, 1698-1706.