

Supplementary Information

High-efficiency robust organic solar cells using transfer-printed PEDOT:PSS electrodes through interface bonding engineering

Xi Fan,^a Wei Song,^a Tao Lei,^a Bingang Xu,^{*,b} Feng Yan,^{*,c} Naixiang Wang,^c Huiqin Cui,^a and Ziyi Ge^{*,a}

^aNingbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences, Ningbo, 315201, P.R. China. E-mail: geziyi@nimte.ac.cn

^bInstitute of Textiles and Clothing, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, 999077, P.R. China. E-mail: tcxubg@polyu.edu.hk

^cDepartment of Applied Physics, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, 999077, P.R. China. E-mail: apafyan@polyu.edu.hk

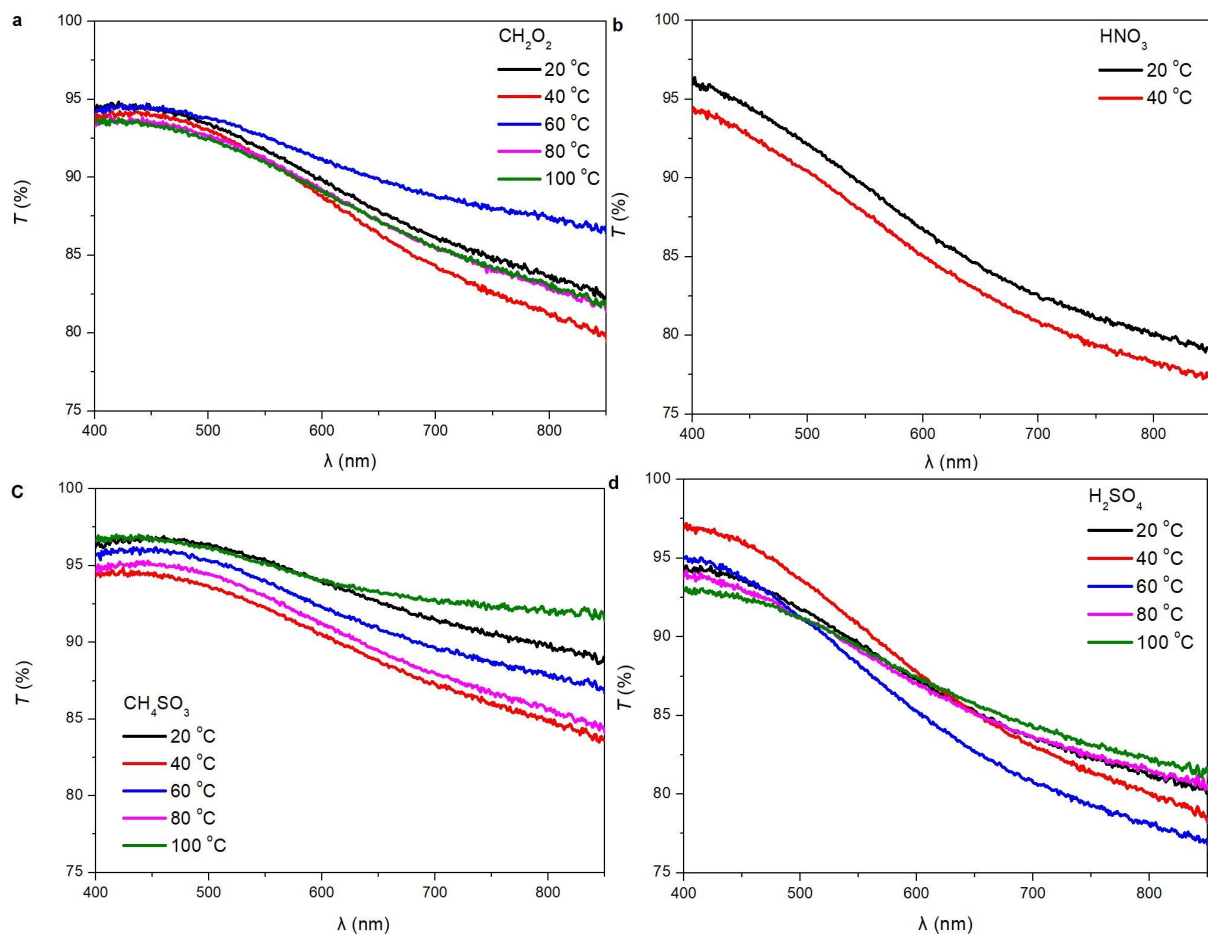


Fig. S1 Optical transparency of the PEDOT:PSS films with the four kinds of acid treatments at 20–40 °C.

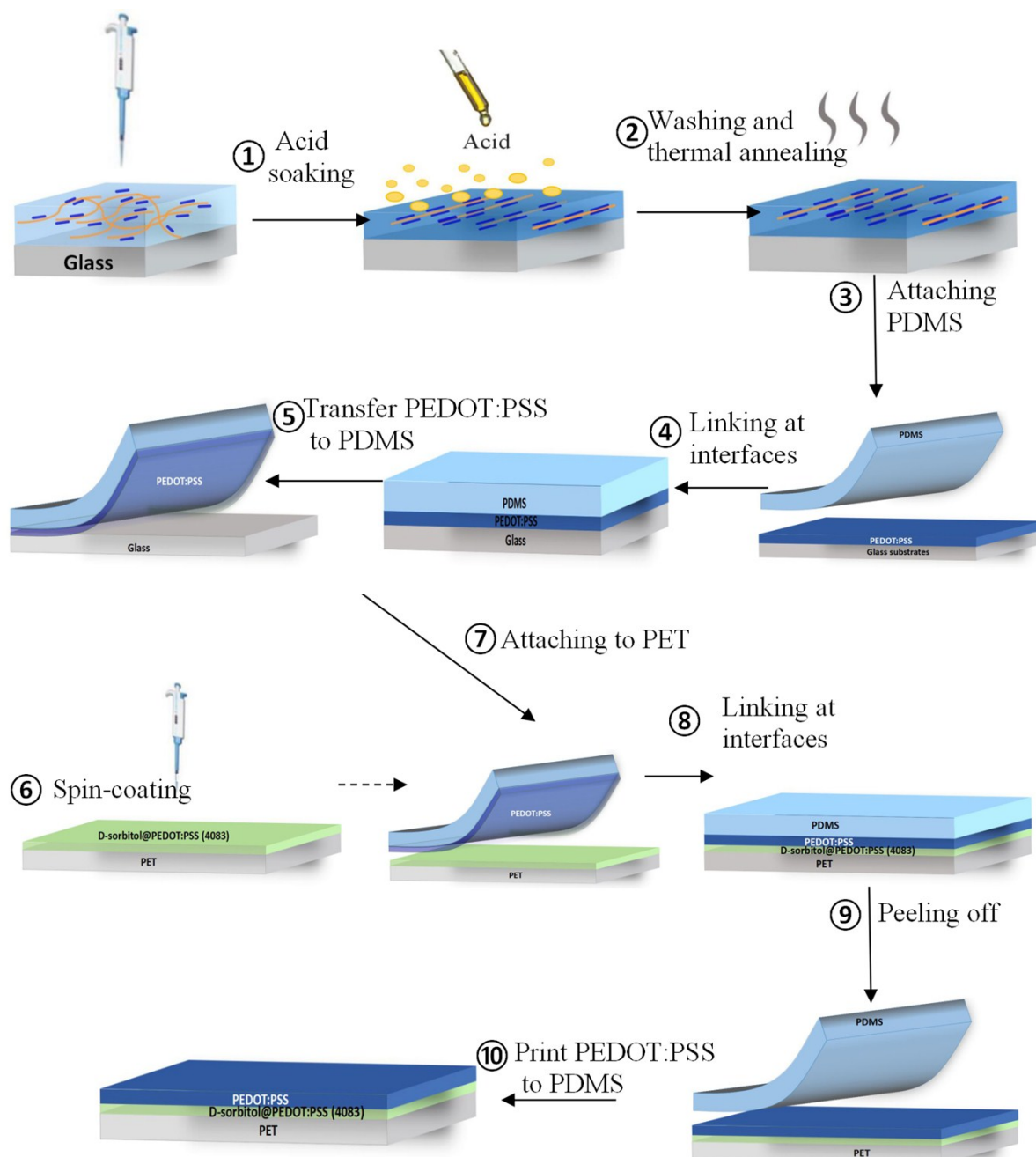


Fig. S2 Schematic diagram of the newly developed transfer-printing process.

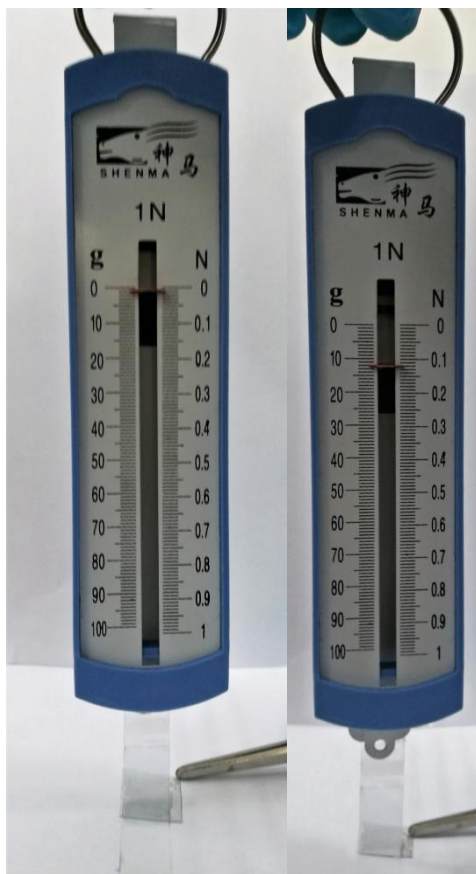


Fig. S3 Schematic diagram of adhesion test of PEDOT:PSS films on PET substrate.

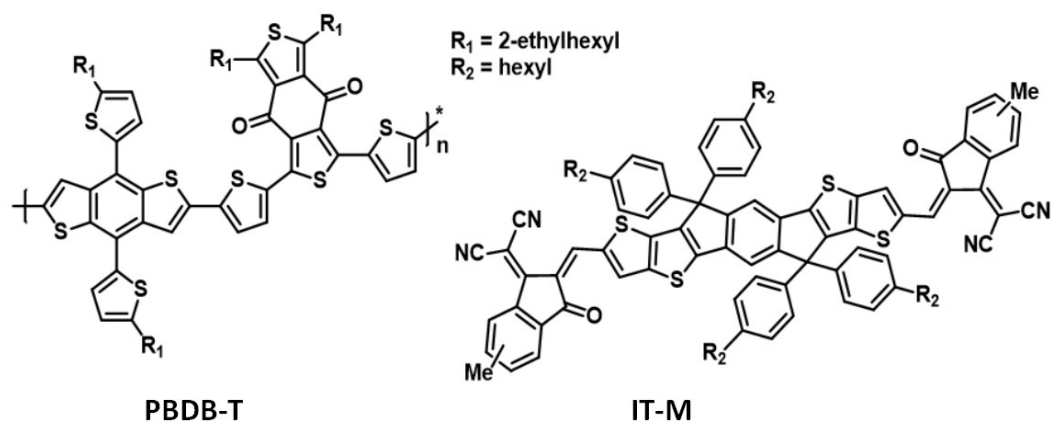


Fig. S4 Molecular structures of PBDB-T and IT-M.

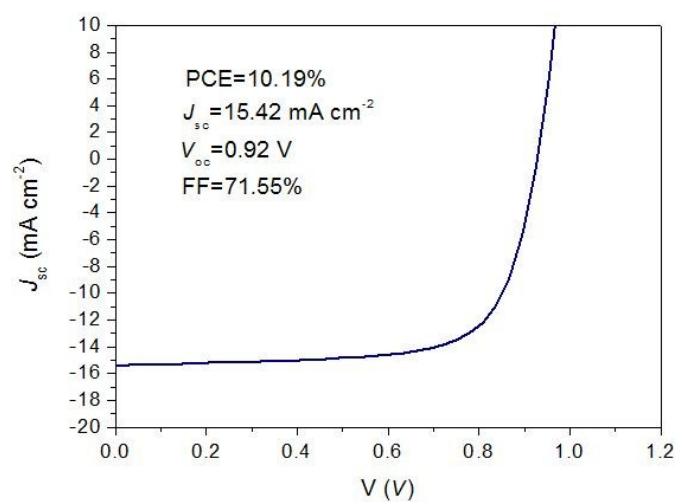


Fig. S5 J - V characteristic of the best flexible devices fabricated on PEDOT:PSS/SM/PET substrates.



Fig. S6 The picture of bend test station and cylindrical radius

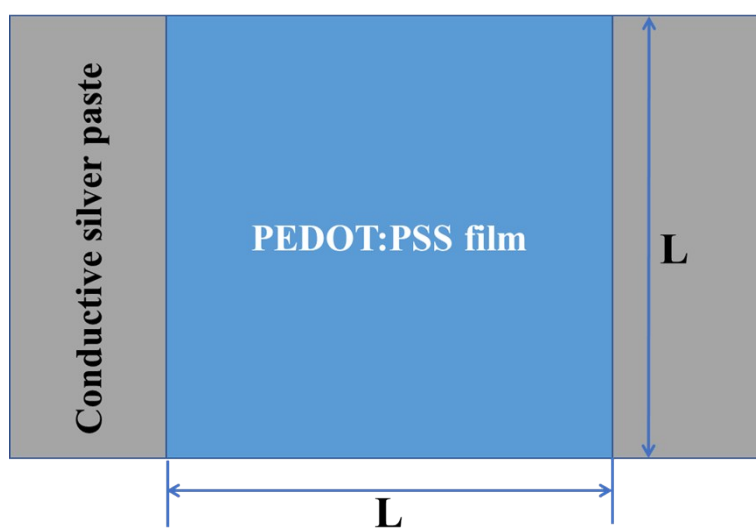


Fig. S7 Schematic diagram of square resistance test

Tab. S1 Comparison of PCE values of flexible organic solar cells with diverse flexible transparent electrodes

FTE categories	Active layer	Ave. PCE (%)	Refer.
ZnO			
ZnO/Cu(8.0 nm) on Cu(O)/ZnO	PTB7:PC ₇₁ BM	6.70	[1]
ZnO/Cu(9.5 nm) on Cu(O)/ZnO	PTB7:PC ₇₁ BM	7.7	[2]
TiO ₂ /ZnO/Ag(8.0 nm)/ZnO	PBDB-T:IT-M:PC ₇₁ BM	10.48	[3]
ZnO/Cu (O:5%)(7 nm)/ZnO	PTB7-Th:PC ₇₁ BM	7.65	[4]
ZnO/N-doped Cu(6.5 nm)/ZnO	PTB7:PC ₇₁ BM	7.10	[1]
ZnO/Ag(9.0 nm)/ZnO	PBDB-T:IT-M	9.57	Here
Printed PEDOT:PSS/ZnO/Ag(9.0 nm)/ZnO	PBDB-T:IT-M	10.55	
Nano-structures of metals			
PEDOT:PSS/Ag island	PTB7-Th:PC ₇₁ BM	9.8	[5]
PEDOT:PSS/Ag grid	PTB7-Th:PC ₇₁ BM	6.58	[6]
Ag grid	PTB7-Th:PC ₇₁ BM	6.43	[7]
PEDOT:PSS/Ag mesh	PTB7:PC ₇₁ BM	6.73	[8]
Ag NW	PTB7-Th:PC ₇₁ BM	8.75	[9]
Cu NW	PTB7-Th:PC ₇₁ BM	4.6	[10]
Ag NW	PBDB-T:IT-M	9.78	Here
Printed PEDOT:PSS/Ag NW	PBDB-T:IT-M	10.21	
PEDOT:PSS			
PEDOT:PSS	PTB7-Th:PC ₇₁ BM	7.7	[11]
PEDOT:PSS	PBDTT-S-TT:PC ₇₁ BM	6.42	[12]
PEDOT:PSS	P3HT:PCBM	2.87	[13]
PEDOT:PSS	P3HT:PCBM	4.2	[14]
Printed PEDOT:PSS	PBDB-T:IT-M	9.94	Here
Others			
Graphene	PTB7:PC ₇₁ BM	7.2	[15]
CNT	PTB7:PC ₇₁ BM	3.91	[16]

References

- [1] G. Zhao, S. M. Kim, S. Lee, T. Bae, C. Mun, S. Lee, H. Yu, G. Lee, H. Lee, M. Song, J. Yun, *Adv. Funct. Mater.* **2016**, 26, 4180.
- [2] G. Zhao, M. Song, H. Chung, S. M. Kim, S. Lee, J. Bae, T. Bae, D. Kim, G. Lee, S. Z. Han, H. Lee, E. Choi, J. Yun, *ACS Appl. Mater. Interfaces*, **2017**, 9, 38695.
- [3] Q. Liu, J. Toudert, L. Ciammaruchi, G. Martinez-Denegri, J. Martorell, *J. Mater. Chem. A* **2017**, 5, 25476.
- [4] G. Zhao, W. Wang, T. Bae, S. Lee, C. Mun, S. Lee, H. Yu, G. Lee, M. Song, J. Yun, *Nat. Commun.* **2015**, 6, 8830.
- [5] H. Kang, S. Jung, S. Jeong, G. Kim, K. Lee, *Nat. Commun.* **2015**, 6, 6503.
- [6] J. Wang, F. Fei, Q. Luo, S. Nie, N. Wu, X. Chen, W. Su, Y. Li, C. Ma, *ACS Appl. Mater. Interfaces* **2017**, 9, 7834.
- [7] Lu, S.; Lin, J.; Liu, K.; Yue, S.; Ren, K.; Tan, F.; Wang, Z.; Jin, P.; Qu, S.; Wang, Z. *Acta Mater.* **2017**, 130, 208–214.
- [8] W. Kim, S. Kim, I. Kang, M. S. Jung, S. J. Kim, J. K. Kim, S. M. Cho, J. -H. Kim, J. H. Park, *ChemSusChem* **2016**, 9, 1042 .
- [9] J. H. Seo, I. Hwang, H. -D. Um, S. Lee, K. Lee, J. Park, H. Shin, T. -H. Kwon, S. J. Kang, K. Seo, *Adv. Mater.* **2017**, 29, 1701479.
- [10] X. Yang, X. Hu, Q. Wang, J. Xiong, H. Yang, X. Meng, L. Tan, L. Chen, Y. Chen, *ACS Appl. Mater. Interfaces* **2017**, 9, 26468.
- [11] N. Kim, H. Kang, J. -H. Lee, S. Kee, S. H. Lee, K. Lee, *Adv. Mater.* **2015**, 27, 2317.
- [12] X. Fan, B. G. Xu, S. H. Liu, C. H. Cui, J. Z. Wang, F. Yan, *ACS Appl. Mater. Interfaces* **2016**, 8, 14029.
- [13] B. J. Worfolk, S. C. Andrews, S. Park, J. Reinspach, N. Liu, M. F. Toney, S. C. B. Mannsfeld, Z. Bao, *Proc. Natl. Acad. Sci. U.S.A.* **2015**, 112, 14138.
- [14] M. Kaltenbrunner, M.S. White, E.D. Glowacki, T. Sekitani, T. Someya, N.S. Sariciftci, S. Bauer, *Nat. Commun.* **2012**, 3, 770.
- [15] H. Park, S. Chang, X. Zhou, J. Kong, T. Palacios, S. Gradečak, *Nano lett.* **2014**, 14, 5148.
- [16] I. Jeon, K. Cui, T. Chiba, A. Anisimov, A.G. Nasibulin, E. I. Kauppinen, S. Maruyama, Y. Matsuo, *J. Am. Chem. Soc.* **2015**, 137, 7982.