

Supporting Information for

Improving performance of ternary organic solar cells using metal oxides as charge transport layers

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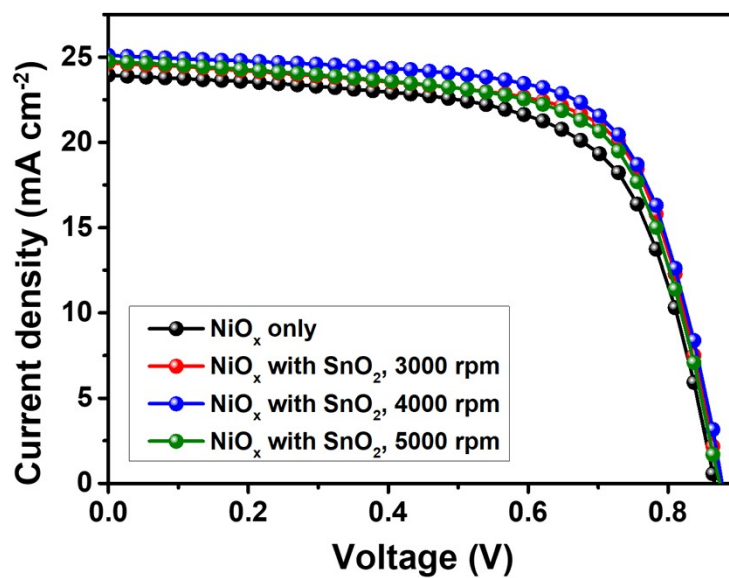


Fig. S1. J - V characteristics of the NiO_x -based OSCs without and with SnO_2 spin coated at a speed of 3000, 4000 or 5000 rpm.

Table S1. Device parameters of the NiO_x -based OSCs without and with SnO_2 spin coated at a speed of 3000, 4000 or 5000 rpm.

| Device configuration | V_{oc} (V) | J_{sc} (mA cm^{-2}) | FF (%) | Average PCE (%) |
|--------------------------------|--------------|----------------------------------|--------|-----------------|
| NiO_x only | 0.87 | 24.3 | 71.7 | 15.2 |
| With SnO_2 , 3000 rpm | 0.88 | 24.5 | 72.8 | 15.7 |
| With SnO_2 , 4000 rpm | 0.88 | 25.2 | 73.2 | 16.2 |
| With SnO_2 , 5000 rpm | 0.88 | 24.9 | 72.5 | 15.9 |

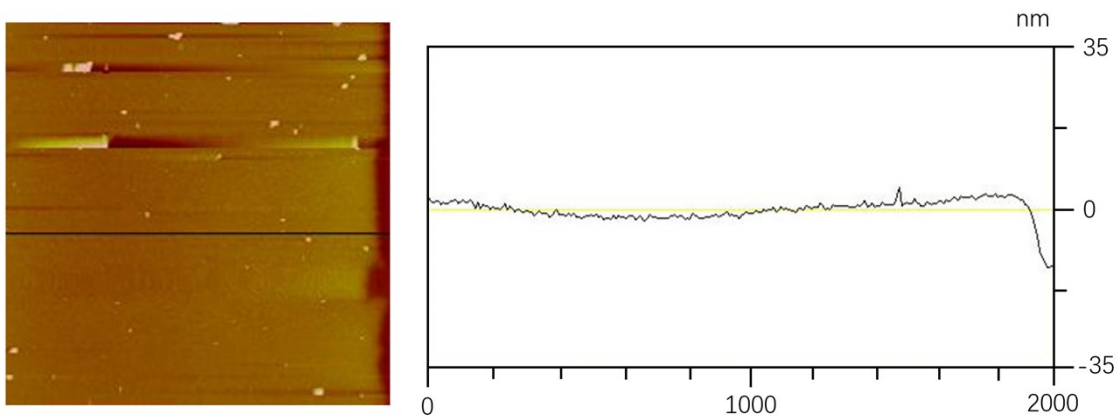


Fig. S2. AFM image of the partly covered SnO₂ film, with SnO₂ spin-coated at a speed of 4000 rpm.

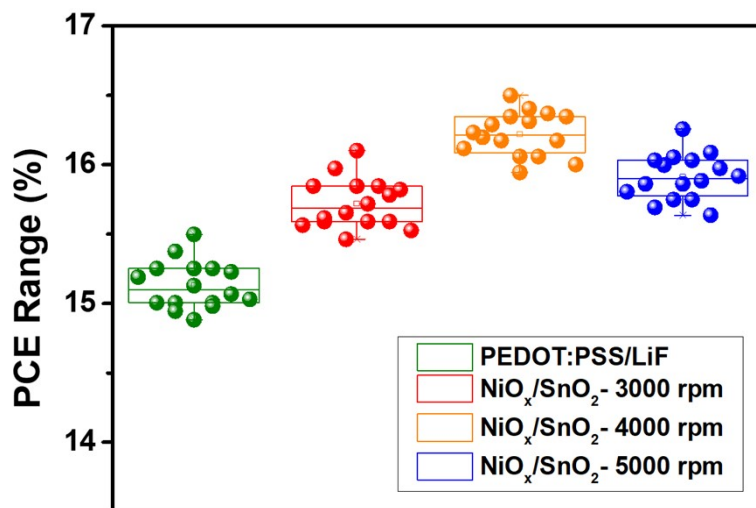


Fig. S3. PCE variations with standard deviations for OSCs using PEDOT:PSS/LiF and NiO_x/SnO₂ as the CTLs.

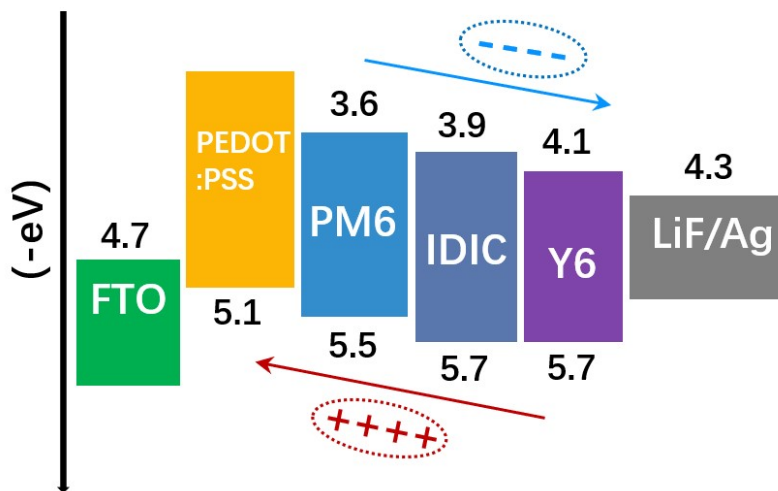


Fig. S4. Energy level alignment of the control OSCs using PEDOT:PSS and LiF as the CTLs.

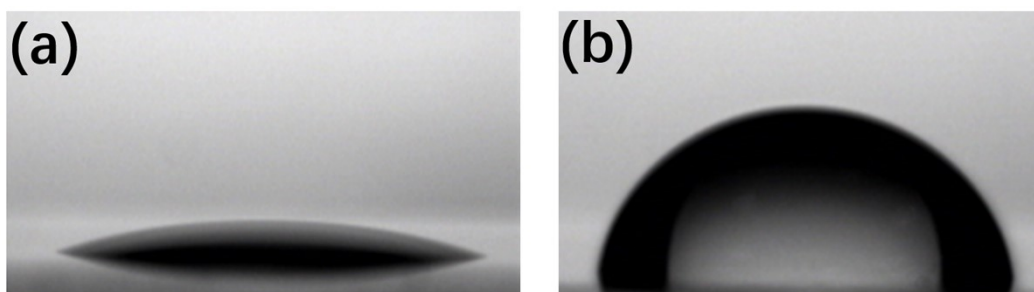


Fig. S5. Contact angle measurements of PEDOT:PSS (a) and NiO_x (b).

Table S2. Average and best PCEs for ternary organic solar cells using PM6-based active layers reported in recent years.

| Component | Average PCE | Best PCE | Reference |
|--------------------------------|---------------|---------------|--|
| PM6:IDIC:Y6 | 16.20% | 16.60% | <i>This work</i> |
| PM6:IDIC:Y6 | 16.39% | 16.52% | <i>Adv. Energy Mater.</i> 2019, 1901728 |
| PM6:IDIC:Y6 | 16.51% | 16.86% | <i>J. Mater. Chem. A</i> 2021, 9, 17035 |
| PM6:TIT-2Cl:Y6 | 16.79% | 17.00% | <i>Adv. Funct. Mater.</i> 2022, 2200629 |
| PM6:PC ₆₁ BM:Y6 | 15.90% | 16.50% | <i>Adv. Mater.</i> 2019, 1902302 |
| PM6:PC ₇₁ BM:Y6 | 16.60% | 17.10% | <i>Adv. Sci.</i> 2020, 1903419 |
| PM6:IT-4F:Y6 | 13.60% | 14.14% | <i>Dyes and Pigments</i> 2020, 181, 108613 |
| PM6:N3:PC ₇₁ BM | 16.80% | 17.42% | <i>Nat. Commun.</i> 2021, 12, 468 |
| PM6:BTP-MCA:Y6 | 16.40% | 17.00% | <i>ACS Appl. Mater. Interfaces</i> 2022, 14, 12461 |
| PM6:Y-T:Y6 | 17.04% | 17.37% | <i>Nano Energy</i> 2021, 90, 106538 |
| PM6:PM7:PC ₇₁ BM:Y6 | 17.71% | 18.09% | <i>Nat. Commun.</i> 2021, 12, 309 |
| PM6:BTP-CC:Y6 | 17.27% | 17.55% | <i>ACS Appl. Mater. Interfaces</i> 2022, 14, 36582 |
| PM6:PY-IT:BN-T | 15.85% | 16.09% | <i>Joule</i> 2021, 5, 914 |
| PM6:Cor-T-PDI:Y6 | 16.35% | 16.88% | <i>J. Mater. Chem. C</i> 2021, 9, 3826 |
| PM6:ITIC-M:Y6 | 13.27% | None | <i>Polymers</i> 2021, 13, 2398 |
| PM6:ITC-2Br1:Y6 | 16.30% | 16.60% | <i>Org. Electron.</i> 2021, 91, 106085 |