Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Ultrathin graphene-based solar cells

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Imaging of the device cross section

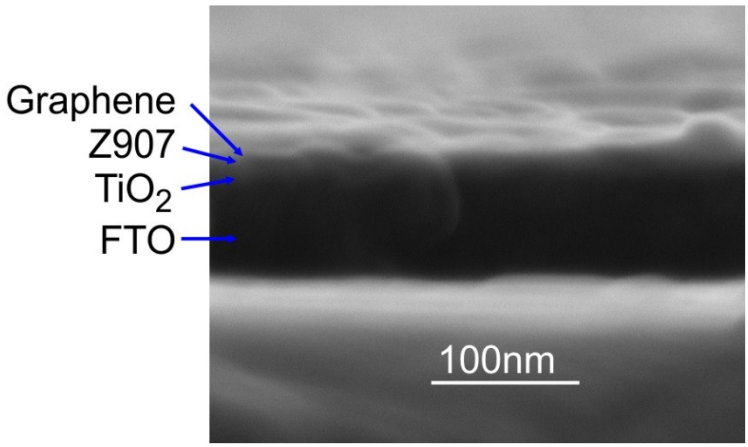

Fig. S1 Cross sectional SEM image of the device structure

The SEM image shows a brighter region on top of the FTO that was associated with the TiO2 layer. The dye and graphene reside on top of this layer but due to their low thickness they cannot be imaged. We therefore conducted spectroscopic characterization of their status.

XPS characterization of the Graphene layer

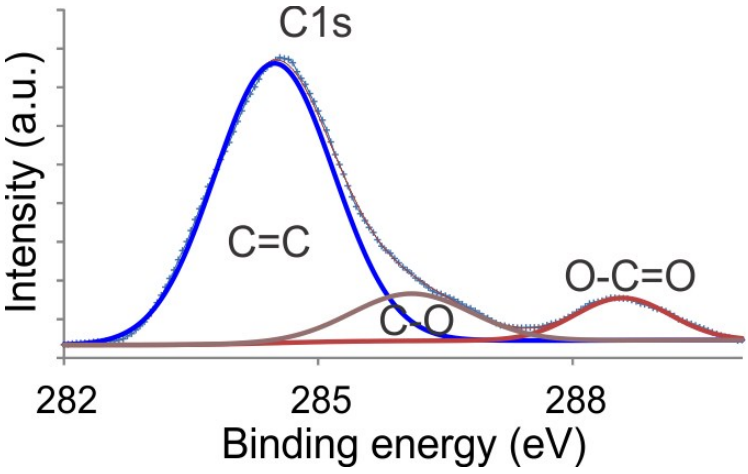

Fig. S2 XPS Ti2p peak

X-ray photoelectron spectroscopy was conducted on the surface of the sample and the C1s peak was deconvoluted into contributions from sp^2 bonded carbon and carbon which was single- and double bonded to impurities.[1] These impurities are thought to originate from residue brought about by the dry transfer of graphene by thermal release tape and defects in the graphene lattice.

XPS characterization of the dye layer

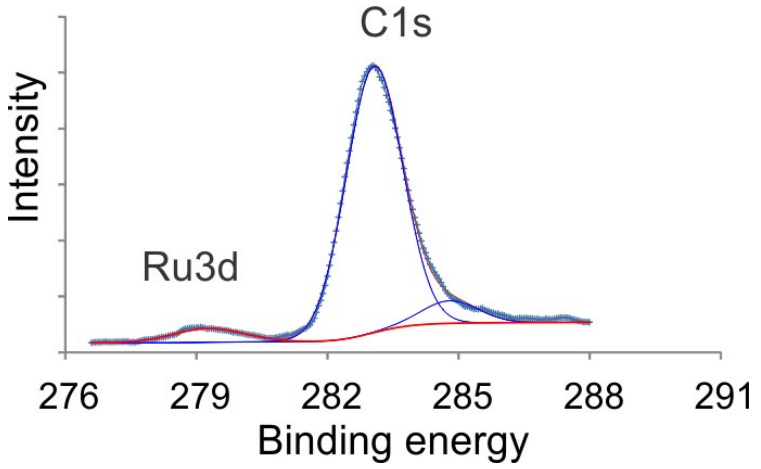

Fig. S3 XPS Ti2p peak

Sputtering (3keV Ar+ beam, $1\mu A/mm^2$) was conducted for 10s to remove the graphene layer and a clear Ruthenium 3d peak was observed that indicated the presence of Z907 dye. This peak was not observed before sputtering.

XPS characterization of the TiO_2 layer

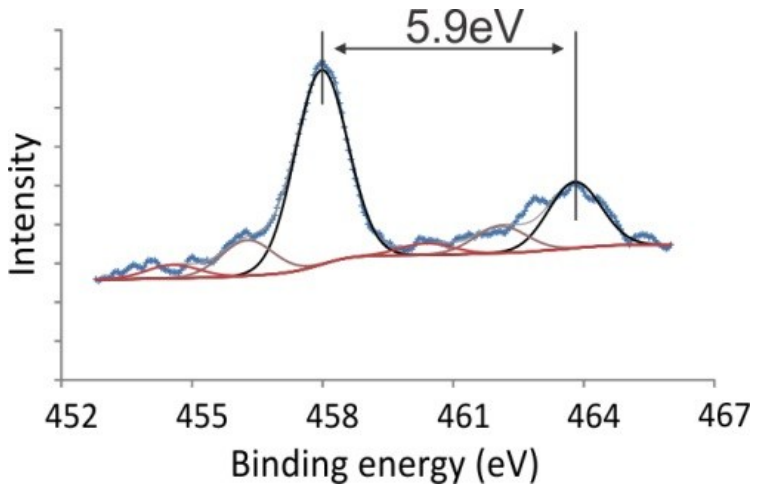

Fig. S4 XPS Ti2p peak

The chemical composition of the TiO_2 layer was investigated after sputtering of the dye layer for another 10s. Deconvolution of the Ti 2p peak shows two main peaks at 457.9 and 483.8eV. These peaks correspond to the singlet and doublet peaks of Ti^{4+} and represent the stable titanium oxide. Additional peaks at lower binding energies correspond to Ti^{2+} and Ti^{3+}. These lower

oxidation states originate from oxygen vacancies and indicate the low quality of the sputtered TiO_2 layer[2]. The peak separation between $2p_{1/2}$ and $2p_{3/2}$ peaks was found to be 5.9eV which is larger than the previously observed separation for crystalline TiO2 in anatase configuration, suggesting that the TiO_2 layer is amorphous or composed of other oxide textures.[3]

References

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2. J. Ning, D. Wang, D. Han, Y. Shi, W. Cai, J. Zhang and Y. Hao, *Journal of Crystal Growth*, 2015, **424**, 55-61.
3. G. Liu, F. Shan, W. Lee and B. Shin, *Journal of Korean Physical Society*, 2007, **50**, 1827.