**Design and optimization of four-terminal mechanically stacked and optically coupled silicon/perovskite tandem solar cells with over 28% efficiency**

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**Supplementary Information**

Table S1: Defect parameters of different layers of simulated PSC

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameters** | **FTO** | **TiO2** | **IDL** | **Csx(FA0.4MA0.6)1-xPbI2.8Br0.2** |
| **Defect Type** | Neutral | Neutral | Neutral | Neutral |
| **Electrons Capture Cross Section (cm2)** | 2×10-14 | 2×10-14 | 2×10-14 | 2×10-14 |
| **Holes Capture Cross Section (cm2)** | 2×10-14 | 2×10-14 | 2×10-14 | 2×10-14 |
| **Energetic Distribution** | Gaussian | Gaussian | Gaussian | Gaussian |
| **Defect Energy levelReference Et** | Above EV | Above EV | Above EV | Above EV |
| **Energy level related to Reference (eV)** | 0.6 | 0.6 | 0.6 | 0.6 |
| **Nt (cm-3)** | 1×1016 | 1×1016 | 1×1016 | 2.60×1013 |
| **Reference** | [1, 2] | [2, 3] | [2, 4] | [2, 4-7] |

Table S2: Comparison between PV parameters of simulated and experimental devices of top (perovskite) and bottom (silicon) solar cells.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Work Mode | | Voc (V) | Jsc (mA/cm2) | FF (%) | PCE (%) | RS (Ωcm2) | RSH (Ωcm2) | Ref. |
| Experimental | Top Cell | 0.9±0.2 | 21.45±0.65 | 69±0.1 | 13.39±0.3 | -- | -- | [5] |
| Simulation | 0.8953 | 21.45 | 69.06 | 13.26 | 2.35 | 1×1030 | [2] |
| Experimental | Bottom Cell | 0.72 | 38.68 | 78.61 | 22.14 | -- | -- | [8] |
| Simulation | 0.72 | 38.68 | 78.62 | 22.14 | 1.30 | 1×1030 | This study |

Table S3: Experimental (Exp.) and simulated (Sim.) work comparison of different PV parameters of top and bottom cells with and without HTMs and corresponding 4-T mechanically and optically connected tandem solar cells (TSCs). FTO, ETM, HTM and Au stands for front transparent oxide, electron transport material, hole transport material and gold, respectively.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 4-T Mechanically stacked tandem solar cells | | | | | | | | | | | | |
| Top perovskite cell configurations | | **Voc (V)** | | **Jsc (mA/cm2)** | | **FF (%)** | | **PCE (%)** | | **Combined PCE (%)** | **Mode** | **Ref.** |
| Top | Bottom | Top | Bottom | Top | Bottom | Top | Bottom |
| FTO/ETM/Perovskite/HTM/Au | With HTM | 1.06 | 0.59 | 21.52 | 15.41 | 77.48 | 76.02 | 17.7 | 7.0 | 24.7 | Exp. | [9] |
| FTO/ETM/Perovskite/HTM/Au | 1.04 | 0.6 | 23.3 | 16.3 | 80.6 | 82.6 | -- | -- | 27.7 | Sim. | [10] |
| FTO/ETM/Perovskite/C | Without HTM | 1.14 | 0.69 | 23.11 | 12.29 | 80.52 | 82.50 | 21.31 | 7.07 | 28.38 | Sim. | This work |
| 4-T Optical coupled tandem solar cells | | | | | | | | | | | | |
| Top perovskite cell configurations | | **Voc (V)** | | **Jsc (mA/cm2)** | | **FF (%)** | | **PCE (%)** | | **Combined PCE (%)** | **Mode** | **Ref.** |
| Top | Bottom | Top | Bottom | Top | Bottom | Top | Bottom |
| FTO/ETM/Perovskite/HTM/Au | With HTM | 0.987 | 0.728 | 10.6 | 34.9 | 71.5 | 80.9 | 7.5 | 20.5 | 28.0 | Exp. | [11] |
| FTO/ETM/Perovskite/HTM/Au | 0.987 | 0.602 | 18.4 | 18.5 | 81.3 | 82.7 | -- | -- | 25.6 | Sim. | [10] |
| FTO/ETM/Perovskite/C | Without HTM | 1.14 | 0.70 | 21.85 | 16.13 | 80.37 | 81.97 | 20.02 | 9.32 | 29.34 | Sim. | This work |

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