|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Simulated ETL** | **Device Number** | **Device Architecture** | **Voc (V)** | **Jsc (mA/cm2)** | **FF(%)** | **PCE (%)** |
| **ZnO** | 1 | ITO/ZnO/DS PbS Ink/**PbS-EDT**/Au | 0.8106 | 23.113 | 58.52 | 10.96 |
| 2 | ITO/ZnO/DS PbS Ink/**PEDOT:PSS**/Au | 0.9217 | 23.962165 | 61.59 | 13.60 |
| 3 | ITO/ZnO/DS PbS Ink/**CuI**/Au | 1.0754 | 25.365046 | 64.47 | 17.59 |
| 4 | ITO/ZnO/DS PbS Ink/**CuO**/Au | 1.0155 | 26.772673 | 69.96 | 19.02 |
| 5 | ITO/ZnO/DS PbS Ink/**Cu2O**/Au | 1.0789 | 26.043758 | 68.67 | 19.30 |
| 6 | ITO/ZnO/DS PbS Ink/**CuSCN**/Au | 1.0790 | 26.189745 | 67.97 | 19.21 |
| 7\* | ITO/ZnO/DS PbS Ink/**MoO3**/Au | 1.0800 | 26.789329 | 69.24 | 20.03 |
| 8 | ITO/ZnO/DS PbS Ink/**NiO**/Au | 1.0789 | 26.641622 | 67.62 | 19.44 |
| 9 | ITO/ZnO/DS PbS Ink/**Spiro-MeOTAD**/Au | 1.0736 | 24.549230 | 64.94 | 17.12 |
| TiO2 | 10 | ITO/ TiO2/DS PbS Ink/ **PbS-EDT** /Au | 0.8102 | 23.105293 | 59.34 | 11.11 |
| 11 | ITO/ TiO2/DS PbS Ink/ **PEDOT:PSS** /Au | 0.9214 | 23.940109 | 62.37 | 13.76 |
| 12 | ITO/ TiO2/DS PbS Ink/ **CuI** /Au | 1.0748 | 25.354308 | 65.09 | 17.74 |
| 13 | ITO/ TiO2/DS PbS Ink/ **CuO** /Au | 1.0153 | 26.772402 | 70.84 | 19.26 |
| 14 | ITO/ TiO2/DS PbS Ink/ **Cu2O** /Au | 1.0784 | 26.034198 | 69.38 | 19.48 |
| 15 | ITO/ TiO2/DS PbS Ink/ **CuSCN** /Au | 1.0785 | 26.183758 | 68.66 | 19.39 |
| 16\* | ITO/ TiO2/DS PbS Ink/ **MoO3** /Au | 1.0795 | 26.786260 | 69.98 | 20.24 |
| 17 | ITO/ TiO2/DS PbS Ink/ **NiO** /Au | 1.0784 | 26.642853 | 68.31 | 19.63 |
| 18 | ITO/ TiO2/DS PbS Ink/**Spiro-MeOTAD**/Au | 1.0729 | 24.526081 | 65.62 | 17.27 |
| SnO2 | 19 | ITO/ SnO2/DS PbS Ink/ **PbS-EDT** /Au | 0.6868 | 14.086291 | 51.45 | 4.98 |
| 20 | ITO/ SnO2/DS PbS Ink/ **PEDOT:PSS** /Au | 0.8006 | 15.257475 | 53.84 | 6.58 |
| 21 | ITO/ SnO2/DS PbS Ink/ **CuI** /Au | 0.9570 | 17.305723 | 53.84 | 8.92 |
| 22 | ITO/ SnO2/DS PbS Ink/ **CuO** /Au | 0.9173 | 19.866553 | 57.85 | 10.54 |
| 23 | ITO/ SnO2/DS PbS Ink/ **Cu2O** /Au | 0.9599 | 18.466216 | 57.85 | 10.25 |
| 24 | ITO/ SnO2/DS PbS Ink/ **CuSCN** /Au | 0.9600 | 18.699737 | 56.76 | 10.19 |
| 25 | ITO/ SnO2/DS PbS Ink/ **MoO3** /Au | 0.9606 | 19.849610 | 57.51 | 10.97 |
| 26 | ITO/ SnO2/DS PbS Ink/ **NiO** /Au | 0.9600 | 19.510589 | 55.64 | 10.42 |
| 27 | ITO/ SnO2/DS PbS Ink/**Spiro-MeOTAD**/Au | 0.9545 | 16.132542 | 55.55 | 8.55 |
| IGZO | 28 () | ITO/ IGZO /DS PbS Ink/ **PbS-EDT** /Au | 0.9275 | 22.704742 | 47.17 | 9.93 |
| 29 | ITO/ IGZO /DS PbS Ink/ **PEDOT:PSS** /Au | 0.9150 | 23.630426 | 57.74 | 12.48 |
| 30 () | ITO/ IGZO /DS PbS Ink/ **CuI** /Au | 1.0924 | 25.021306 | 60.00 | 16.40 |
| 31 | ITO/ IGZO /DS PbS Ink/ **CuO** /Au | 1.0083 | 26.420626 | 66.18 | 17.63 |
| 32 () | ITO/ IGZO /DS PbS Ink/ **Cu2O** /Au | 1.0636 | 25.709988 | 65.78 | 17.99 |
| 33 () | ITO/ IGZO /DS PbS Ink/ **CuSCN** /Au | 1.0639 | 25.844929 | 65.12 | 17.91 |
| 34 () | ITO/ IGZO /DS PbS Ink/ **MoO3** /Au | 1.0637 | 26.447206 | 66.33 | 18.66 |
| 35 () | ITO/ IGZO /DS PbS Ink/ **NiO** /Au | 1.0631 | 26.279457 | 64.84 | 18.12 |
| 36 () | ITO/ IGZO /DS PbS Ink/**Spiro-MeOTAD**/Au | 1.0871 | 24.239767 | 60.59 | 15.97 |
| C60 | 37 | ITO/ C60 /DS PbS Ink/ **PbS-EDT** /Au | 0.5767 | 10.476059 | 51.28 | 3.10 |
| 38 | ITO/ C60 /DS PbS Ink/ **PEDOT:PSS** /Au | 0.6909 | 11.466862 | 53.93 | 4.27 |
| 39 | ITO/ C60 /DS PbS Ink/ **CuI** /Au | 0.8511 | 13.003912 | 54.71 | 6.05 |
| 40 | ITO/ C60 /DS PbS Ink/ **CuO** /Au | 0.8129 | 14.965161 | 58.55 | 7.12 |
| 41 | ITO/ C60 /DS PbS Ink/ **Cu2O** /Au | 0.8539 | 13.918638 | 58.63 | 6.97 |
| 42 | ITO/ C60 /DS PbS Ink/ **CuSCN** /Au | 0.8540 | 14.076122 | 57.60 | 6.92 |
| 43 | ITO/ C60 /DS PbS Ink/ **MoO3** /Au | 0.8546 | 14.968090 | 58.24 | 7.45 |
| 44 | ITO/ C60 /DS PbS Ink/ **NiO** /Au | 0.8539 | 14.656686 | 56.57 | 7.08 |
| 45 | ITO/ C60 /DS PbS Ink/**Spiro-MeOTAD**/Au | 0.8482 | 12.171179 | 56.15 | 5.80 |
| CdS | 46() | ITO/ CdS /DS PbS Ink/ **PbS-EDT** /Au | 0.6139 | 13.366031 | 51.39 | 4.22 |
| 47 | ITO/ CdS /DS PbS Ink/ **PEDOT:PSS** /Au | 0.7275 | 14.574174 | 53.93 | 5.72 |
| 48 | ITO/ CdS /DS PbS Ink/ **CuI** /Au | 0.8861 | 16.430478 | 54.74 | 7.97 |
| 49 | ITO/ CdS /DS PbS Ink/ **CuO** /Au | 0.8436 | 18.710962 | 59.07 | 9.32 |
| 50 | ITO/ CdS /DS PbS Ink/ **Cu2O** /Au | 0.8890 | 17.504596 | 58.84 | 9.16 |
| 51 | ITO/ CdS /DS PbS Ink/ **CuSCN** /Au | 0.8891 | 17.693919 | 57.83 | 9.10 |
| 52 | ITO/ CdS /DS PbS Ink/ **MoO3** /Au | 0.8898 | 18.721855 | 58.62 | 9.77 |
| 53 | ITO/ CdS /DS PbS Ink/ **NiO** /Au | 0.8890 | 18.375993 | 56.88 | 9.29 |
| 54 | ITO/ CdS /DS PbS Ink/**Spiro-MeOTAD**/Au | 0.8834 | 15.416157 | 56.15 | 7.65 |
| CeO2 | 55 | ITO/ CeO2/DS PbS Ink/ **PbS-EDT** /Au | 0.5431 | 12.966584 | 51.07 | 3.60 |
| 56 | ITO/ CeO2 /DS PbS Ink/ **PEDOT:PSS** /Au | 0.6569 | 14.308278 | 53.62 | 5.04 |
| 57 | ITO/ CeO2/DS PbS Ink/ **CuI** /Au | 0.8132 | 16.260298 | 54.87 | 7.26 |
| 58 | ITO/ CeO2/DS PbS Ink/ **CuO** /Au | 0.7741 | 18.706722 | 58.98 | 8.54 |
| 59 | ITO/ CeO2 /DS PbS Ink/ **Cu2O** /Au | 0.8161 | 17.426910 | 59.04 | 8.40 |
| 60 | ITO/ CeO2 /DS PbS Ink/ **CuSCN** /Au | 0.8161 | 17.613126 | 58.01 | 8.34 |
| 61 | ITO/ CeO2/DS PbS Ink/ **MoO3** /Au | 0.8168 | 18.731810 | 58.71 | 8.98 |
| 62 | ITO/ CeO2 /DS PbS Ink/ **NiO** /Au | 0.8161 | 18.321370 | 57.01 | 8.53 |
| 63 | ITO/ CeO2 /DS PbS Ink/**Spiro-MeOTAD**/Au | 0.8107 | 15.236223 | 56.25 | 6.95 |

**INFLUENCE OF N-TYPE DOPING of DS PbS Ink**

**Architecture: ITO/TiO2/DS PbS/ MoO3/Au**

Voc

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 100nm | 200nm | 300nm | 400nm | 500nm | 600nm |
| 1013 | 1.1016 | 1.0789 | 1.0636 | 1.0521 | 1.0429 | 1.0352 |
| 1014 | 1.1016 | 1.0789 | 1.0636 | 1.0520 | 1.0429 | 1.0351 |
| 1015 | 1.1015 | 1.0787 | 1.0633 | 1.0517 | 1.0423 | 1.0342 |
| 1016 | 1.1003 | 1.0771 | 1.0619 | 1.0502 | 1.0402 | 1.0310 |
| 1017 | 1.0972 | 1.0899 | 1.0818 | 1.0735 | 1.0653 | 1.0571 |
| 1018 | 1.1355 | 1.1346 | 1.1294 | 1.1230 | 1.1157 | 1.1082 |
| 1019 | 1.1896 | 1.1915 | 1.1884 | 1.1835 | 1.1777 | 1.1713 |
| 1020 | 1.2472 | 1.2498 | 1.2471 | 1.2426 | 1.2369 | 1.2307 |
| 1021 | 1.3071 | 1.3097 | 1.3070 | 1.3024 | 1.2967 | 1.2904 |
| 1022 | 1.3672 | 1.3696 | 1.3668 | 1.3622 | 1.3565 | 1.3502 |

Jsc

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 100nm | 200nm | 300nm | 400nm | 500nm | 600nm |
| 1013 | 21.722209 | 28.108224 | 31.375730 | 33.340018 | 34.602754 | 35.441403 |
| 1014 | 21.722207 | 28.108195 | 31.375553 | 33.339372 | 34.600998 | 35.437468 |
| 1015 | 21.722187 | 28.107987 | 31.374265 | 33.332766 | 34.582965 | 35.392860 |
| 1016 | 21.721992 | 28.104525 | 31.346426 | 33.178099 | 33.770717 | 32.270876 |
| 1017 | 21.718068 | 27.286189 | 26.109313 | 22.602410 | 18.393016 | 14.446516 |
| 1018 | 18.997883 | 19.201077 | 16.484184 | 13.328864 | 10.480392 | 8.136902 |
| 1019 | 15.916966 | 15.389470 | 13.012318 | 10.526156 | 8.339699 | 6.542764 |
| 1020 | 15.384193 | 14.733439 | 12.433265 | 10.070500 | 7.998474 | 6.292842 |
| 1021 | 15.483031 | 14.821245 | 12.492831 | 10.109350 | 8.023637 | 6.309124 |
| 1022 | 15.572707 | 14.928028 | 12.580943 | 10.174958 | 8.070470 | 6.341900 |

FF

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 100nm | 200nm | 300nm | 400nm | 500nm | 600nm |
| 1013 | 83.59 | 80.45 | 77.70 | 74.66 | 71.36 | 67.75 |
| 1014 | 83.58 | 80.45 | 77.68 | 74.61 | 71.26 | 67.57 |
| 1015 | 83.55 | 80.37 | 77.47 | 74.06 | 70.09 | 65.55 |
| 1016 | 83.14 | 79.62 | 74.49 | 66.76 | 58.58 | 52.42 |
| 1017 | 82.38 | 73.99 | 70.60 | 68.11 | 66.67 | 65.91 |
| 1018 | 82.76 | 82.64 | 82.49 | 82.36 | 82.18 | 82.12 |
| 1019 | 88.47 | 88.62 | 88.70 | 88.75 | 88.80 | 88.91 |
| 1020 | 89.63 | 89.69 | 89.73 | 89.78 | 89.84 | 89.87 |
| 1021 | 90.11 | 90.14 | 90.18 | 90.21 | 90.27 | 90.19 |
| 1022 | 90.47 | 90.50 | 90.53 | 90.56 | 90.63 | 90.54 |

PCE

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 100nm | 200nm | 300nm | 400nm | 500nm | 600nm |
| 1013 | 20.00 | 24.40 | 25.93 | 26.19 | 25.75 | 24.86 |
| 1014 | 20.00 | 24.40 | 25.92 | 26.17 | 25.71 | 24.79 |
| 1015 | 19.99 | 24.37 | 25.84 | 25.96 | 25.27 | 23.99 |
| 1016 | 19.87 | 24.10 | 24.80 | 23.26 | 20.58 | 17.44 |
| 1017 | 19.63 | 22.00 | 19.94 | 16.53 | 13.06 | 10.06 |
| 1018 | 17.85 | 18.00 | 15.36 | 12.33 | 9.61 | 7.41 |
| 1019 | 16.75 | 16.25 | 13.72 | 11.06 | 8.72 | 6.81 |
| 1020 | 17.20 | 16.52 | 13.91 | 11.23 | 8.89 | 6.96 |
| 1021 | 18.24 | 17.50 | 14.72 | 11.88 | 9.39 | 7.34 |
| 1022 | 19.26 | 18.50 | 15.57 | 12.55 | 9.92 | 7.75 |

**INFLUENCE OF P-TYPE DOPING of DS PbS Ink**

**Architecture: ITO/TiO2/DS PbS/ MoO3/Au**

Voc

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 100nm | 200nm | 300nm | 400nm | 500nm | 600nm |
| 1013 | 1.1016 | 1.0789 | 1.0636 | 1.0521 | 1.0429 | 1.0352 |
| 1014 | 1.1016 | 1.0789 | 1.0636 | 1.0521 | 1.0430 | 1.0353 |
| 1015 | 1.1017 | 1.0792 | 1.0639 | 1.0526 | 1.0437 | 1.0362 |
| 1016 | 1.1029 | 1.0815 | 1.0676 | 1.0582 | 1.0516 | 1.0471 |
| 1017 | 1.1122 | 1.1012 | 1.0946 | 1.0908 | 1.0887 | 1.0874 |
| 1018 | 1.1262 | 1.1279 | 1.1264 | 1.1249 | 1.1240 | 1.1234 |
| 1019 | 1.1115 | 1.1200 | 1.1213 | 1.1211 | 1.1206 | 1.1202 |
| 1020 | 1.1773 | 1.1825 | 1.1833 | 1.1831 | 1.1828 | 1.1826 |
| 1021 | 1.2426 | 1.2472 | 1.2479 | 1.2477 | 1.2474 | 1.2472 |
| 1022 | 1.3040 | 1.3085 | 1.3091 | 1.3089 | 1.3086 | 1.3084 |

Jsc

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 100nm | 200nm | 300nm | 400nm | 500nm | 600nm |
| 1013 | 21.722210 | 28.108231 | 31.375769 | 33.340160 | 34.603140 | 35.442277 |
| 1014 | 21.722212 | 28.108259 | 31.375945 | 33.340795 | 34.604855 | 35.446137 |
| 1015 | 21.722231 | 28.108546 | 31.377644 | 33.346097 | 34.619235 | 35.477582 |
| 1016 | 21.722397 | 28.110606 | 31.387077 | 33.368193 | 34.644930 | 35.460862 |
| 1017 | 21.723100 | 28.072390 | 30.942946 | 32.056265 | 32.354598 | 32.360775 |
| 1018 | 21.625274 | 27.008046 | 28.586934 | 28.865694 | 28.777275 | 28.640764 |
| 1019 | 21.183163 | 25.690251 | 26.690000 | 26.692690 | 26.494691 | 26.319456 |
| 1020 | 20.990742 | 25.260421 | 26.119910 | 26.058116 | 25.834188 | 25.649554 |
| 1021 | 20.964714 | 25.207333 | 26.051709 | 25.984040 | 25.758781 | 25.574638 |
| 1022 | 20.962967 | 25.205713 | 26.050894 | 25.984699 | 25.761120 | 25.578621 |

FF

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 100nm | 200nm | 300nm | 400nm | 500nm | 600nm |
| 1013 | 83.59 | 80.45 | 77.70 | 74.67 | 71.38 | 67.79 |
| 1014 | 83.59 | 80.46 | 77.72 | 74.72 | 71.49 | 67.97 |
| 1015 | 83.62 | 80.54 | 77.91 | 75.19 | 72.38 | 69.51 |
| 1016 | 83.94 | 81.25 | 78.90 | 76.50 | 74.27 | 72.47 |
| 1017 | 85.47 | 82.24 | 78.74 | 76.61 | 75.55 | 75.06 |
| 1018 | 84.39 | 82.37 | 81.08 | 80.40 | 80.08 | 79.94 |
| 1019 | 83.01 | 82.53 | 82.25 | 82.11 | 82.04 | 82.01 |
| 1020 | 88.19 | 88.17 | 88.12 | 88.10 | 88.10 | 88.10 |
| 1021 | 89.41 | 89.35 | 89.33 | 89.33 | 89.33 | 89.34 |
| 1022 | 89.96 | 89.90 | 89.89 | 89.89 | 89.89 | 89.89 |

PCE

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 100nm | 200nm | 300nm | 400nm | 500nm | 600nm |
| 1013 | 20.00 | 24.40 | 25.93 | 26.19 | 25.76 | 24.87 |
| 1014 | 20.00 | 24.40 | 25.94 | 26.21 | 25.80 | 24.94 |
| 1015 | 20.01 | 24.43 | 26.01 | 26.39 | 26.15 | 25.56 |
| 1016 | 20.11 | 24.70 | 26.44 | 27.01 | 27.06 | 26.91 |
| 1017 | 20.65 | 25.42 | 26.67 | 26.79 | 26.61 | 26.42 |
| 1018 | 20.55 | 25.09 | 26.11 | 26.11 | 25.90 | 25.72 |
| 1019 | 19.55 | 23.75 | 24.61 | 24.57 | 24.36 | 24.18 |
| 1020 | 21.79 | 26.34 | 27.24 | 27.16 | 26.92 | 26.72 |
| 1021 | 23.29 | 28.09 | 29.04 | 28.96 | 28.70 | 28.49 |
| 1022 | 24.59 | 29.65 | 30.65 | 30.57 | 30.30 | 30.09 |

**Concurrent Effect of Defect Density & Concentration**

**n-type DS PbS Ink**

**Voc**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 1x1013 | 5x1013 | 1x1014 | 5x1014 | 1x1015 | 5x1015 | 1x1016 | 5x1016 |
| 1013 | 1.1384 | 1.0918 | 1.0636 | 0.9939 | 0.9633 | 0.8897 | 0.8549 | 0.7605 |
| 1014 | 1.1384 | 1.0918 | 1.0636 | 0.9937 | 0.9630 | 0.8894 | 0.8545 | 0.7601 |
| 1015 | 1.1384 | 1.0917 | 1.0633 | 0.9920 | 0.9606 | 0.8863 | 0.8508 | 0.7558 |
| 1016 | 1.1384 | 1.0912 | 1.0619 | 0.9843 | 0.9493 | 0.8628 | 0.8225 | 0.7269 |
| 1017 | 1.1419 | 1.1041 | 1.0818 | 1.0141 | 0.9769 | 0.8827 | 0.8412 | 0.7424 |
| 1018 | 1.1657 | 1.1453 | 1.1294 | 1.0709 | 1.0354 | 0.9407 | 0.9001 | 0.8094 |
| 1019 | 1.2106 | 1.1991 | 1.1884 | 1.1486 | 1.1268 | 1.0751 | 1.0540 | 1.0057 |
| 1020 | 1.2671 | 1.2568 | 1.2471 | 1.2094 | 1.1880 | 1.1374 | 1.1172 | 1.0728 |
| 1021 | 1.3263 | 1.3163 | 1.3070 | 1.2699 | 1.2483 | 1.1971 | 1.1770 | 1.1330 |
| 1022 | 1.3860 | 1.3761 | 1.3668 | 1.3300 | 1.3084 | 1.2567 | 1.2367 | 1.1925 |

**Jsc**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 1x1013 | 5x1013 | 1x1014 | 5x1014 | 1x1015 | 5x1015 | 1x1016 | 5x1016 |
| 1013 | 31.511426 | 31.450968 | 31.375730 | 30.786960 | 30.082454 | 25.471337 | 21.473267 | 9.898355 |
| 1014 | 31.511405 | 31.450877 | 31.375553 | 30.786101 | 30.080773 | 25.464103 | 21.461117 | 9.876899 |
| 1015 | 31.511764 | 31.450503 | 31.374265 | 30.777638 | 30.063669 | 25.389191 | 21.335676 | 9.658639 |
| 1016 | 31.509741 | 31.436969 | 31.346426 | 30.638558 | 29.793176 | 24.304664 | 19.623445 | 7.181330 |
| 1017 | 30.039354 | 28.155829 | 26.109313 | 16.959175 | 12.756638 | 7.091065 | 5.537573 | 2.789408 |
| 1018 | 22.266307 | 19.275405 | 16.484184 | 7.849855 | 5.151079 | 2.204135 | 1.665309 | 960.274049E-3 |
| 1019 | 17.100018 | 15.020876 | 13.012318 | 6.240939 | 3.889555 | 1.312207 | 887.600630E-3 | 407.332215E-3 |
| 1020 | 15.954253 | 14.183715 | 12.433265 | 6.165630 | 3.817955 | 1.208489 | 792.299512E-3 | 330.833058E-3 |
| 1021 | 15.802074 | 14.149535 | 12.492842 | 6.323432 | 3.898785 | 1.198359 | 781.991416E-3 | 321.652531E-3 |
| 1022 | 15.793964 | 14.196554 | 12.580944 | 6.430463 | 3.955797 | 1.198458 | 781.047958E-3 | 320.747404E-3 |

**FF**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 1x1013 | 5x1013 | 1x1014 | 5x1014 | 1x1015 | 5x1015 | 1x1016 | 5x1016 |
| 1013 | 83.30 | 79.54 | 77.70 | 70.53 | 65.52 | 50.05 | 43.32 | 30.47 |
| 1014 | 83.29 | 79.52 | 77.68 | 70.49 | 65.47 | 49.98 | 43.24 | 30.39 |
| 1015 | 83.23 | 79.37 | 77.47 | 70.13 | 65.00 | 49.17 | 42.35 | 29.57 |
| 1016 | 82.77 | 77.80 | 74.49 | 62.52 | 55.95 | 39.41 | 32.86 | 22.98 |
| 1017 | 82.32 | 76.14 | 70.60 | 54.04 | 49.72 | 45.38 | 44.73 | 44.59 |
| 1018 | 85.91 | 84.16 | 82.49 | 76.24 | 73.22 | 67.09 | 64.90 | 60.46 |
| 1019 | 89.04 | 88.93 | 88.70 | 87.90 | 87.29 | 85.49 | 83.97 | 79.89 |
| 1020 | 89.83 | 89.86 | 89.73 | 89.52 | 89.37 | 88.90 | 88.80 | 87.33 |
| 1021 | 90.25 | 90.29 | 90.18 | 90.06 | 89.97 | 89.75 | 89.45 | 89.00 |
| 1022 | 90.60 | 90.64 | 90.53 | 90.43 | 90.36 | 90.22 | 89.86 | 88.77 |

**PCE**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 1x1013 | 5x1013 | 1x1014 | 5x1014 | 1x1015 | 5x1015 | 1x1016 | 5x1016 |
| 1013 | 29.88 | 27.31 | 25.93 | 21.58 | 18.98 | 11.34 | 7.95 | 2.29 |
| 1014 | 29.88 | 27.31 | 25.92 | 21.57 | 18.97 | 11.32 | 7.93 | 2.28 |
| 1015 | 29.86 | 27.25 | 25.84 | 21.41 | 18.77 | 11.06 | 7.69 | 2.16 |
| 1016 | 29.69 | 26.69 | 24.80 | 18.86 | 15.83 | 8.26 | 5.30 | 1.20 |
| 1017 | 28.24 | 23.67 | 19.94 | 9.29 | 6.20 | 2.84 | 2.08 | 0.92 |
| 1018 | 22.30 | 18.58 | 15.36 | 6.41 | 3.90 | 1.39 | 0.97 | 0.47 |
| 1019 | 18.43 | 16.02 | 13.72 | 6.30 | 3.83 | 1.21 | 0.79 | 0.33 |
| 1020 | 18.16 | 16.02 | 13.91 | 6.68 | 4.05 | 1.22 | 0.79 | 0.31 |
| 1021 | 18.91 | 16.82 | 14.72 | 7.23 | 4.38 | 1.29 | 0.82 | 0.32 |
| 1022 | 19.83 | 17.71 | 15.57 | 7.73 | 4.68 | 1.36 | 0.87 | 0.34 |

**p-type DS PbS Ink**

**Voc**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 1x1013 | 5x1013 | 1x1014 | 5x1014 | 1x1015 | 5x1015 | 1x1016 | 5x1016 |
| 1013 | 1.1384 | 1.0918 | 1.0636 | 0.9939 | 0.9633 | 0.8898 | 0.8550 | 0.7606 |
| 1014 | 1.1384 | 1.0918 | 1.0636 | 0.9941 | 0.9636 | 0.8901 | 0.8554 | 0.7611 |
| 1015 | 1.1384 | 1.0919 | 1.0639 | 0.9959 | 0.9660 | 0.8929 | 0.8588 | 0.7652 |
| 1016 | 1.1384 | 1.0933 | 1.0676 | 1.0120 | 0.9874 | 0.9132 | 0.8799 | 0.7954 |
| 1017 | 1.1411 | 1.1103 | 1.0946 | 1.0594 | 1.0432 | 0.9836 | 0.9383 | 0.8384 |
| 1018 | 1.1466 | 1.1348 | 1.1264 | 1.1025 | 1.0911 | 1.0586 | 1.0385 | 0.9548 |
| 1019 | 1.1304 | 1.1257 | 1.1213 | 1.1054 | 1.0973 | 1.0757 | 1.0651 | 1.0365 |
| 1020 | 1.1891 | 1.1862 | 1.1833 | 1.1726 | 1.1669 | 1.1508 | 1.1425 | 1.1189 |
| 1021 | 1.2532 | 1.2505 | 1.2479 | 1.2379 | 1.2323 | 1.2167 | 1.2081 | 1.1841 |
| 1022 | 1.3144 | 1.3117 | 1.3091 | 1.2994 | 1.2938 | 1.2783 | 1.2695 | 1.2452 |

**Jsc**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 1x1013 | 5x1013 | 1x1014 | 5x1014 | 1x1015 | 5x1015 | 1x1016 | 5x1016 |
| 1013 | 31.511431 | 31.450988 | 31.375769 | 30.787150 | 30.082826 | 25.472938 | 21.475959 | 9.903114 |
| 1014 | 31.511452 | 31.451078 | 31.375945 | 30.788000 | 30.084491 | 25.480117 | 21.488031 | 9.924493 |
| 1015 | 31.511678 | 31.451959 | 31.377644 | 30.796138 | 30.100427 | 25.549368 | 21.605183 | 10.134798 |
| 1016 | 31.512063 | 31.456363 | 31.387077 | 30.846001 | 30.201132 | 26.041894 | 22.494838 | 11.913096 |
| 1017 | 31.463839 | 31.221961 | 30.942946 | 29.336370 | 28.141708 | 24.665764 | 22.775791 | 16.506141 |
| 1018 | 31.150008 | 29.841681 | 28.586934 | 24.128316 | 22.163137 | 18.337130 | 16.899075 | 13.622730 |
| 1019 | 30.850056 | 28.657742 | 26.690000 | 20.420250 | 17.799980 | 12.602352 | 10.737322 | 7.317642 |
| 1020 | 30.752285 | 28.295945 | 26.119910 | 19.304963 | 16.460460 | 10.739720 | 8.678657 | 4.997545 |
| 1021 | 30.744850 | 28.254632 | 26.051709 | 19.164157 | 16.288384 | 10.492099 | 8.400973 | 4.670535 |
| 1022 | 30.749929 | 28.256458 | 26.050894 | 19.155657 | 16.276211 | 10.470336 | 8.375079 | 4.636807 |

**FF**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 1x1013 | 5x1013 | 1x1014 | 5x1014 | 1x1015 | 5x1015 | 1x1016 | 5x1016 |
| 1013 | 83.30 | 79.54 | 77.70 | 70.53 | 65.53 | 50.07 | 43.35 | 30.49 |
| 1014 | 83.30 | 79.59 | 77.72 | 70.57 | 65.57 | 50.15 | 43.43 | 30.57 |
| 1015 | 83.37 | 79.74 | 77.91 | 70.87 | 65.95 | 50.91 | 44.31 | 31.40 |
| 1016 | 84.00 | 80.81 | 78.90 | 71.39 | 66.95 | 56.23 | 51.67 | 39.84 |
| 1017 | 85.71 | 82.08 | 78.74 | 68.03 | 64.04 | 57.99 | 56.68 | 53.64 |
| 1018 | 84.80 | 82.87 | 81.08 | 74.71 | 71.42 | 62.27 | 58.14 | 51.23 |
| 1019 | 83.12 | 82.67 | 82.25 | 80.54 | 79.50 | 75.71 | 73.36 | 66.60 |
| 1020 | 88.18 | 88.15 | 88.12 | 87.85 | 87.72 | 86.97 | 86.47 | 84.44 |
| 1021 | 89.28 | 89.30 | 89.33 | 89.42 | 89.32 | 89.33 | 89.17 | 88.80 |
| 1022 | 89.83 | 89.86 | 89.89 | 89.98 | 89.91 | 89.97 | 89.87 | 89.71 |

**PCE**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Carrier Concentration | 1x1013 | 5x1013 | 1x1014 | 5x1014 | 1x1015 | 5x1015 | 1x1016 | 5x1016 |
| 1013 | 29.88 | 27.31 | 25.93 | 21.58 | 18.99 | 11.35 | 7.96 | 2.30 |
| 1014 | 29.88 | 27.33 | 25.94 | 21.60 | 19.01 | 11.37 | 7.98 | 2.31 |
| 1015 | 29.91 | 27.39 | 26.01 | 21.74 | 19.18 | 11.61 | 8.22 | 2.44 |
| 1016 | 30.13 | 27.79 | 26.44 | 22.28 | 19.97 | 13.37 | 10.23 | 3.78 |
| 1017 | 30.77 | 28.45 | 26.67 | 21.14 | 18.80 | 14.07 | 12.11 | 7.42 |
| 1018 | 30.29 | 28.06 | 26.11 | 19.87 | 17.27 | 12.09 | 10.20 | 6.66 |
| 1019 | 28.99 | 26.67 | 24.61 | 18.18 | 15.53 | 10.26 | 8.39 | 5.05 |
| 1020 | 32.25 | 29.59 | 27.24 | 19.89 | 16.85 | 10.75 | 8.57 | 4.72 |
| 1021 | 34.40 | 31.55 | 29.04 | 21.21 | 17.93 | 11.40 | 9.05 | 4.91 |
| 1022 | 36.31 | 33.30 | 30.65 | 22.40 | 18.93 | 12.04 | 9.56 | 5.18 |