Electronic Supplementary Information (**ESI**†).

*In situ* Investigations of Halide Incorporation into Perovskite Solar Cells

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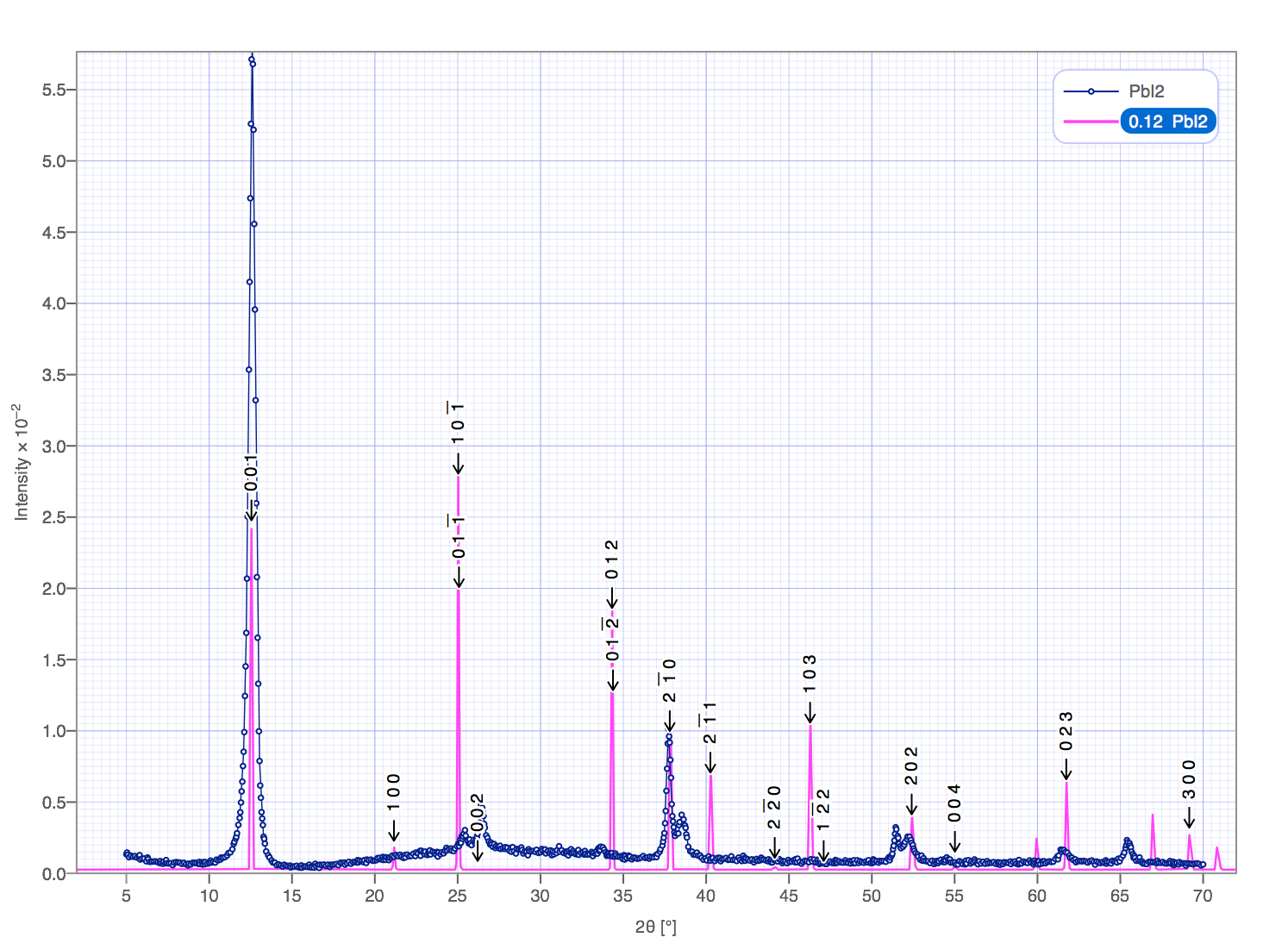
**Performance of Mixed Halide Perovskite Solar Cell**



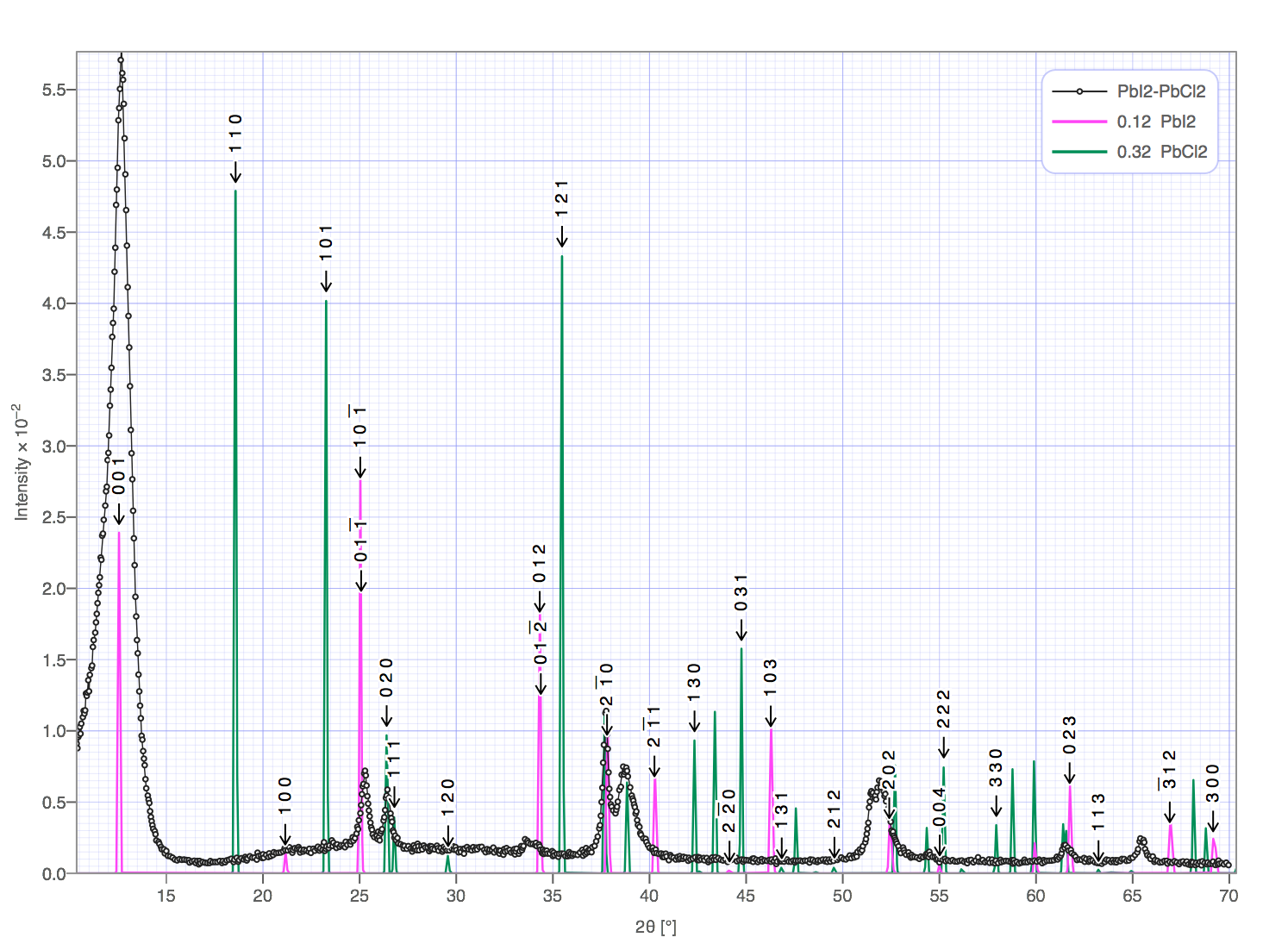
**Figure S1.** Champion photocurrent density−voltage (*J*–*V*) characteristics of a planar perovskite FAPbI3-xClx solar cell prepared in a dry environment. Measurements were done under 100 mW/cm2 AM 1.5 irradiation. Note forward and reverse bias scans are provided showing device hysteresis.

**Structure of PbI2 and PbCl2 Precursor Solutions**

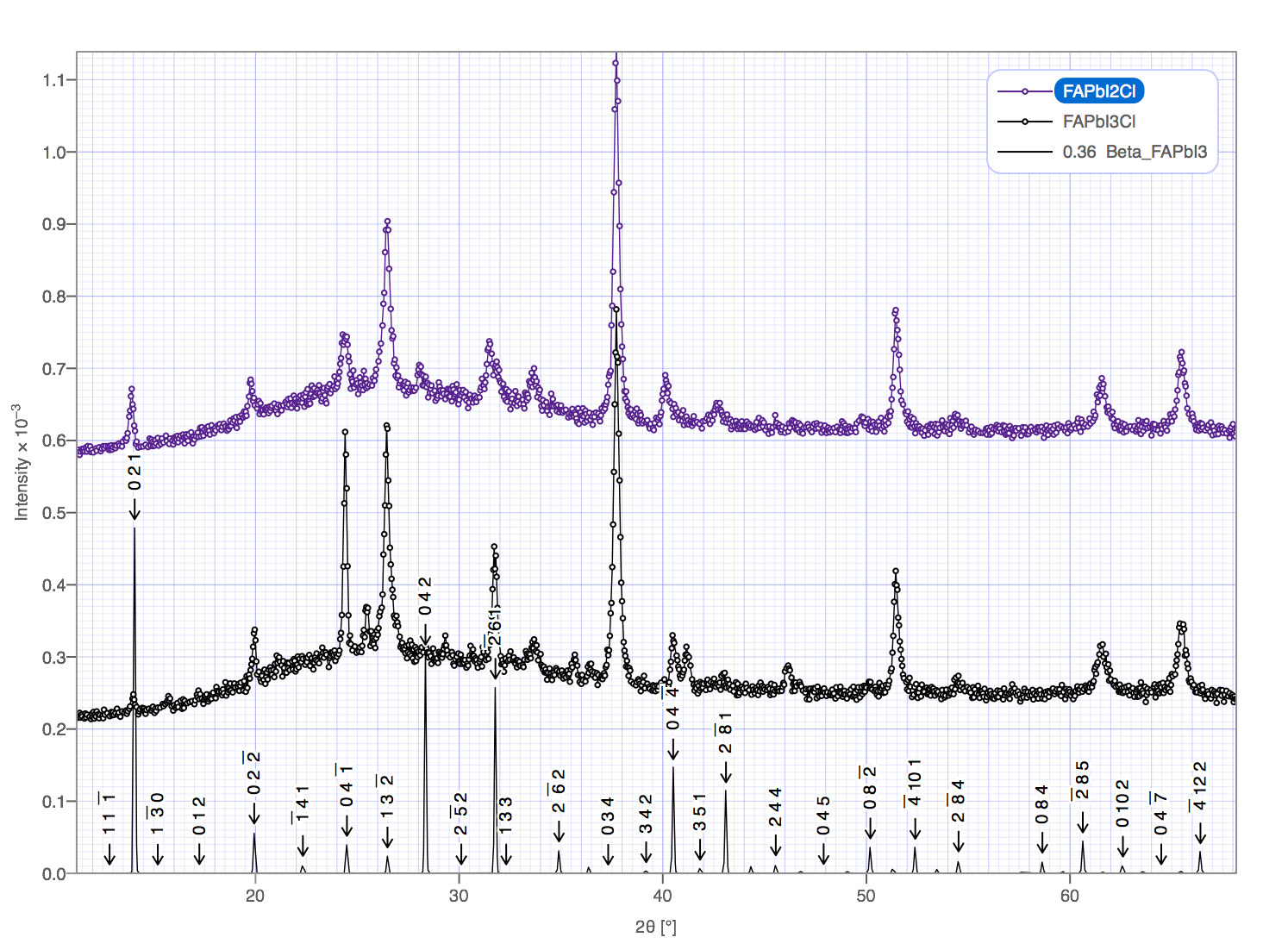
Note the films are heavily textured and do not share the same theoretical structure factors.

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**Figure S2.** X-ray diffraction profile performed on the PbI2 precursor material.



**Figure S3.** X-ray diffraction profile performed on the PbI2 and PbCl2 mixed salt solution precursor material.



**Figure S4.** X-ray diffraction profiles performed on the FAPbI2-xClx and FAPbI3-xClx, compared against predicted perovskite crystal structure.



**Figure S5.** In situ STEM gas cell setup.

**Device Fabrication and Performance**

|  |  |
| --- | --- |
| **Jsc** | **19.49 ± 0.74** |
| **Voc** | **0.86 ± 0.05** |
| **FF** | **0.63 ± 0.03** |
| **η** | **10.05 ± 0.80** |

**Table S1** shows the device average and associated standard deviation over 10 devices. We note that the devices reported could be optimized further for higher efficiencies; however, this is out of the scope of this materials focused work.