Assessing the Environmental Impact of Various Fabrication Methods for Organic Photovoltaics

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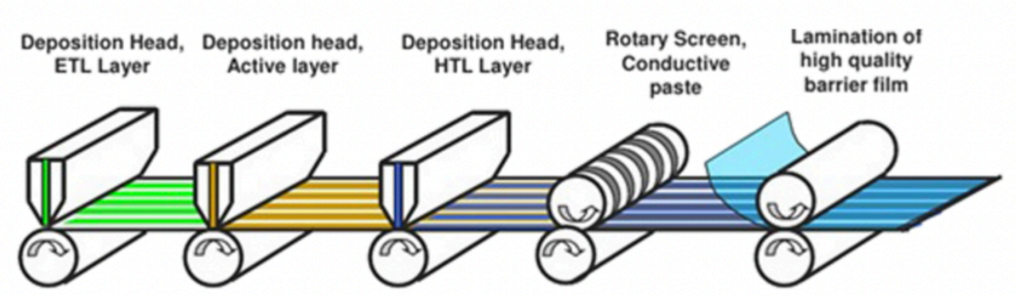
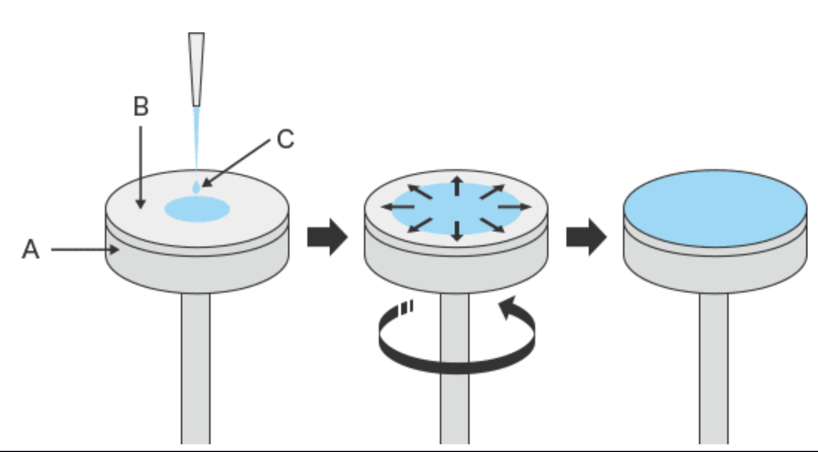
GET UP
Green Energy Technology Undergraduate Program

Introduction and Goal

As the world moves toward greener and more environmentally friendly technologies, solar cells are often advertised as a clean and sustainable method to harvesting natural energy. While silicon-based solar cells are the most manufactured solar cell on the market, organic photovoltaics (OPVs) have begun to receive attention due to their cheap, light materials, lower material toxicity, lower temperature manufacture and other benefits when compared to their inorganic counterparts. However, the manufacturing process has not yet been standardized and optimized for OPVs.



In order to make them competitive in the global market, an efficient, sustainable fabrication method must be established. The goal of this project to compare the cost, sustainability, and environmental effects of two such fabrication methods: spin coating and Process One roll-to-roll coating.

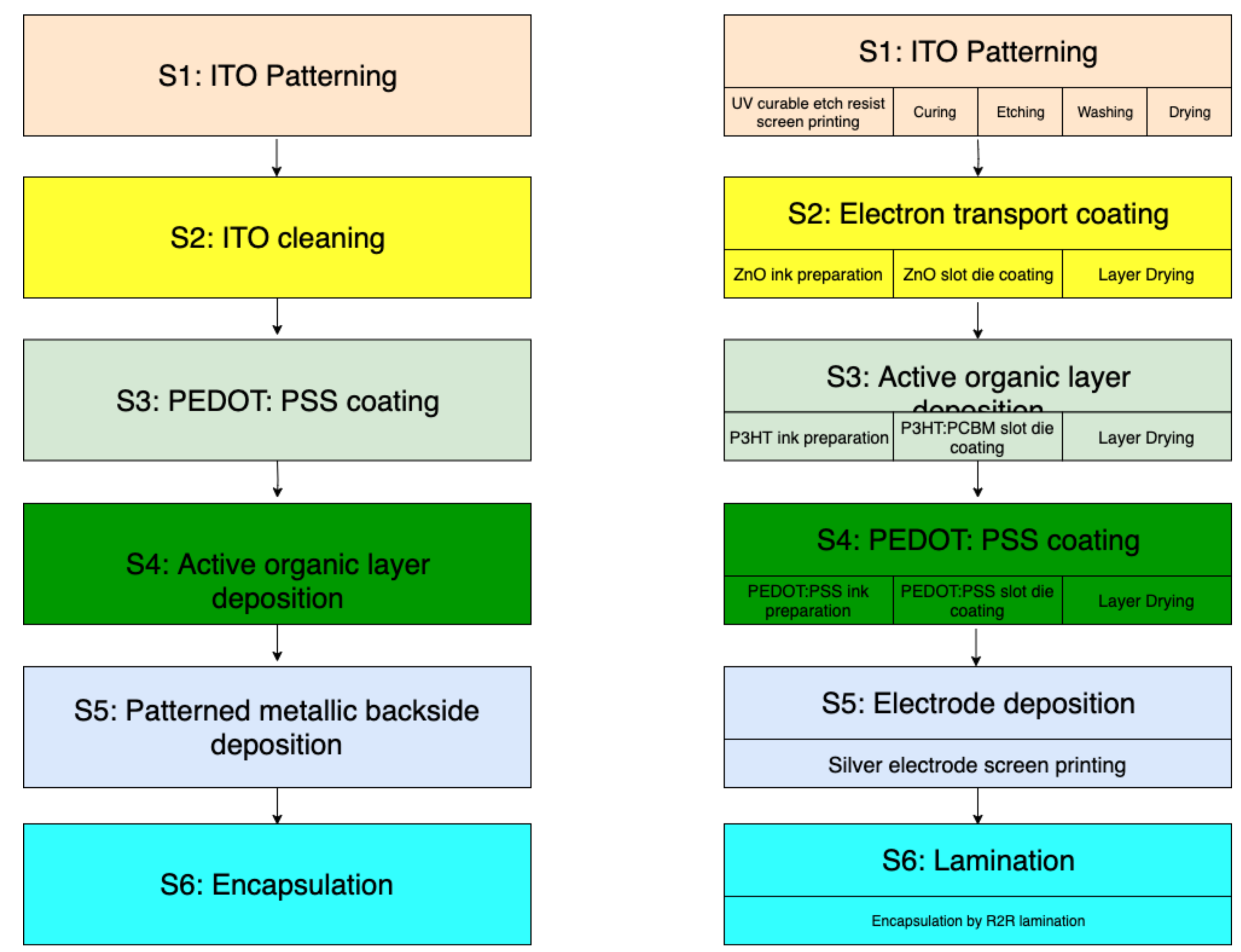


Methods

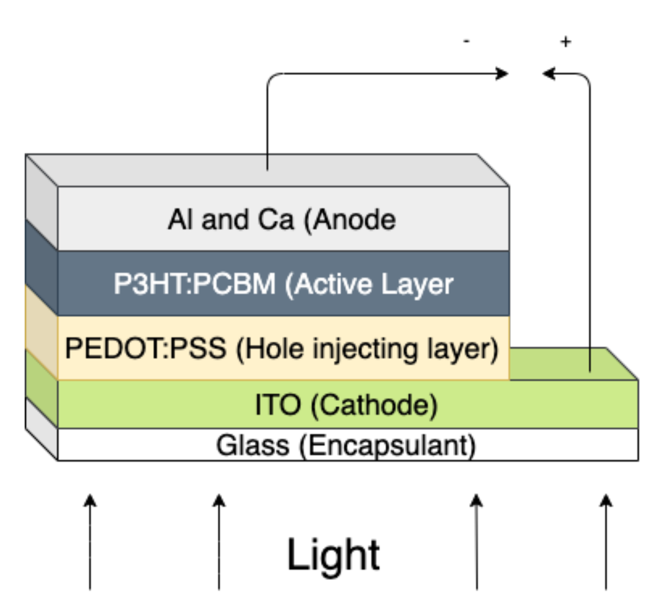
We are performing a Life Cycle Assessment (LCA) on both methods from cradle-to-grave. An LCA is a technique for assessing the environmental aspects and impacts associated with a product by compiling an inventory of inputs and outputs of a system. A material inventory list is formed which tabulated all the raw materials and machinery to create an organic solar cell following each method. From this, metrics such as Energy Pay Back Time (EPBT) and Greenhouse Gas Emissions can be calculated.

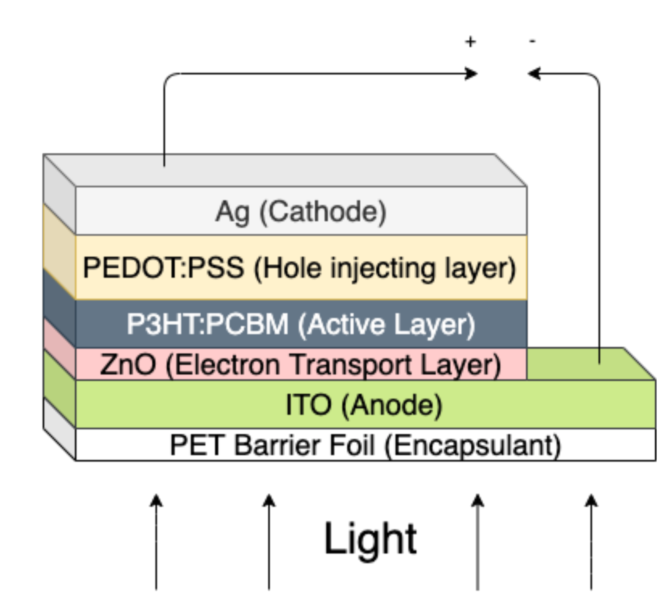
Results

Steps of fabrication process – Spin coating (left) and roll-to-roll (right)



Schematics of manufactured OPV – spin coating (left) and roll-to-roll (right

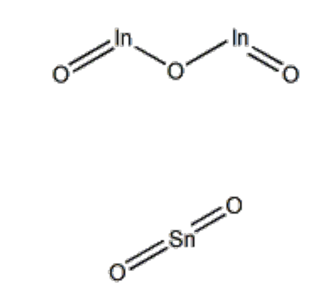




- In the respective literature, it is noted that spin coating has higher direct process energy (energy used powering machinery) and embedded energy (energy used to make raw materials) than Process One's.
- A 1 m^2 module of an OPV made by spin coating with a power conversion efficiency (PCE) of 5% has an EPBT of 4 years, which is on par with inorganic PVs. An OPV made by Process One's roll-to-roll method with the same PCE has an EPBT of 0.81 years. However, the Process One method is currently only capable of making OPV's with PCE's between 1.25-3%, with EPBTs of 3.24 and 1.35 years, respectively.

Conclusion

- Spin coating is suited for creating smaller modules of OPVs. When considering larger scale production, it becomes ineffective due to the lack of efficiency of use of its materials.
- Process One's roll-to-roll coating method has low power conversion efficiencies, but has quick energy pay back times/
- Indium Tin Oxide, a commonly used electrode in OPVs, contributes most of the embedded material energy in both processes. An alternative to ITO needs to be found in order to reduce the embedded energy and thusly, the energy pay back time.



Future Work

- Calculating other metrics such as cost and material toxicity would further the comparison between the two fabrication methods.
- As this is a cradle-to-grave assessment, clean disposal methods would also need to be researched.
- Reviewing literature of ITO alternatives is a must in order to reduce general OPVs embedded energies.

References

1. Espinosa, N., García-Valverde, R., Urbina, A. and Krebs, F., 2011. A life cycle analysis of polymer solar cell modules prepared using roll-to-roll methods under ambient conditions. *Solar Energy Materials and Solar Cells*, 95(5), pp.1293-1302.
2. [2] García-Valverde, R., Cherni, J. and Urbina, A., 2010. Life cycle analysis of organic photovoltaic technologies. *Progress in Photovoltaics: Research and Applications*, 18(7), pp.535-558.
3. 3. S. Razza, S. Castro-Hermosa, A. Di Carlo, T. Brown, APL Materials, in press, doi:10.1063/1.4962478.
4. 4. N. Espinosa et al., Life cycle assessment of ITO-free flexible polymer solar cells prepared by roll-to-roll coating and printing. *Solar Energy Materials and Solar Cells*. 97, 3-13 (2012).

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