Manufacturing High-Quality Crystalline $CsPbBr_3$ Perovskite Photoactive Films in Open-Air

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Background

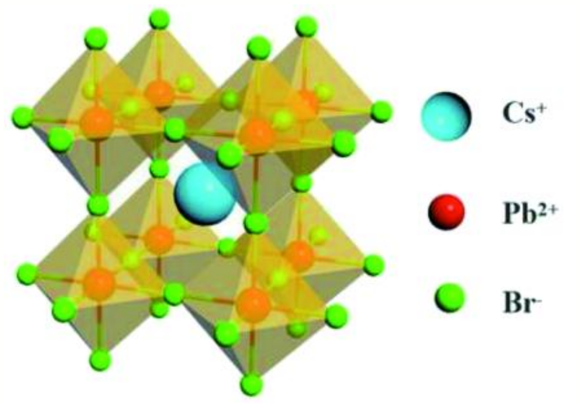


Fig.1: $CsPbBr_3$ crystal structure

- **What is a perovskite?** Compound with an ABX3 crystal structure (A=cation, B=Ge, Bi, Pb, Sn; X=halide). Emerging as a promising material for solar cells due to their high absorption, low cost, and scalability.
- **Why $CsPbBr_3$?** This compound's inorganic nature creates a higher bandgap (~2.3 eV), making them ideal for tandem applications.
- **Problem Statement:** The crystal coverage and thickness must be optimized to prevent short circuits and maintain high efficiency.
- **Approach**: Starch can be added to slow down nucleation (number of crystals) in a cheap and non-toxic way. This will allow for crystal formation in the dendrite regime.
- **Dendrite Regime:** The dendrite regime is when rapid crystal formation leads to collisions between individual crystals. This phenomenon creates a continuous film.

Goals

- Develop a continuous, light-absorbing crystal film perovskite films
- Aim for a perovskite thickness of ~500nm
- Utilize blade coating to enable scalable industrial production

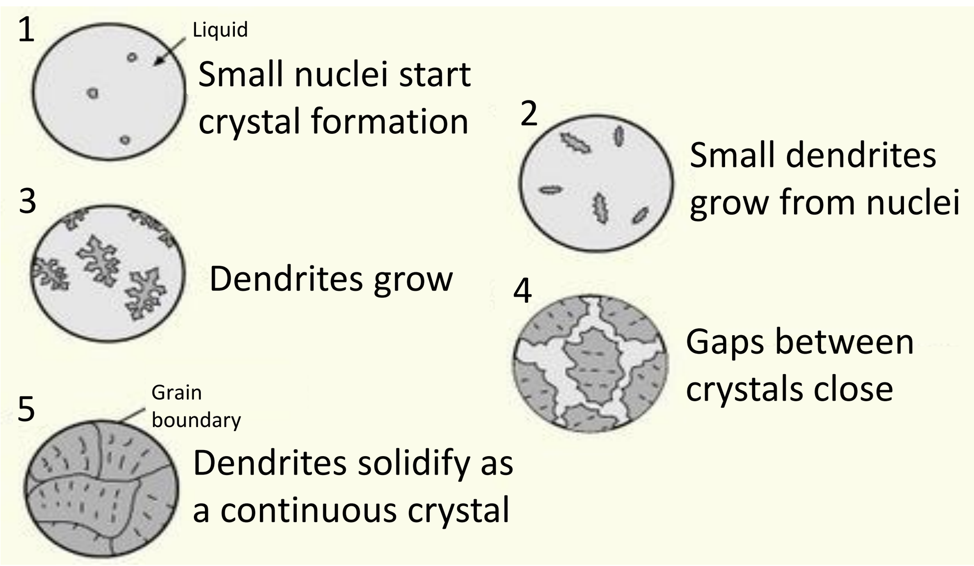


Fig.2: Crystal formation in the dendrite regime

Process

- Cesium bromide, lead (II) bromide, solvent dimethyl sulfoxide(DMSO), and starch were combined and mixed in a glove box.
- Glass slides were coated using a blade coater set at a height of 1250µm, speed of 10mm/s, temperature of 40°C. The amount of ink on each film was an independent variable that ranged from 35-65µm based on the sample.
- After a sample was coated, it was transferred to a hot plate set at 250°C to anneal the perovskite crystals for 5 minutes.

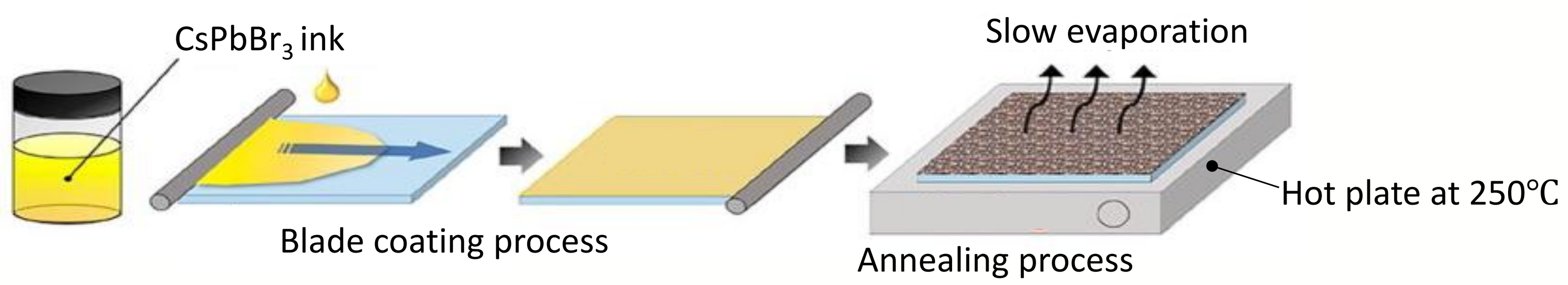
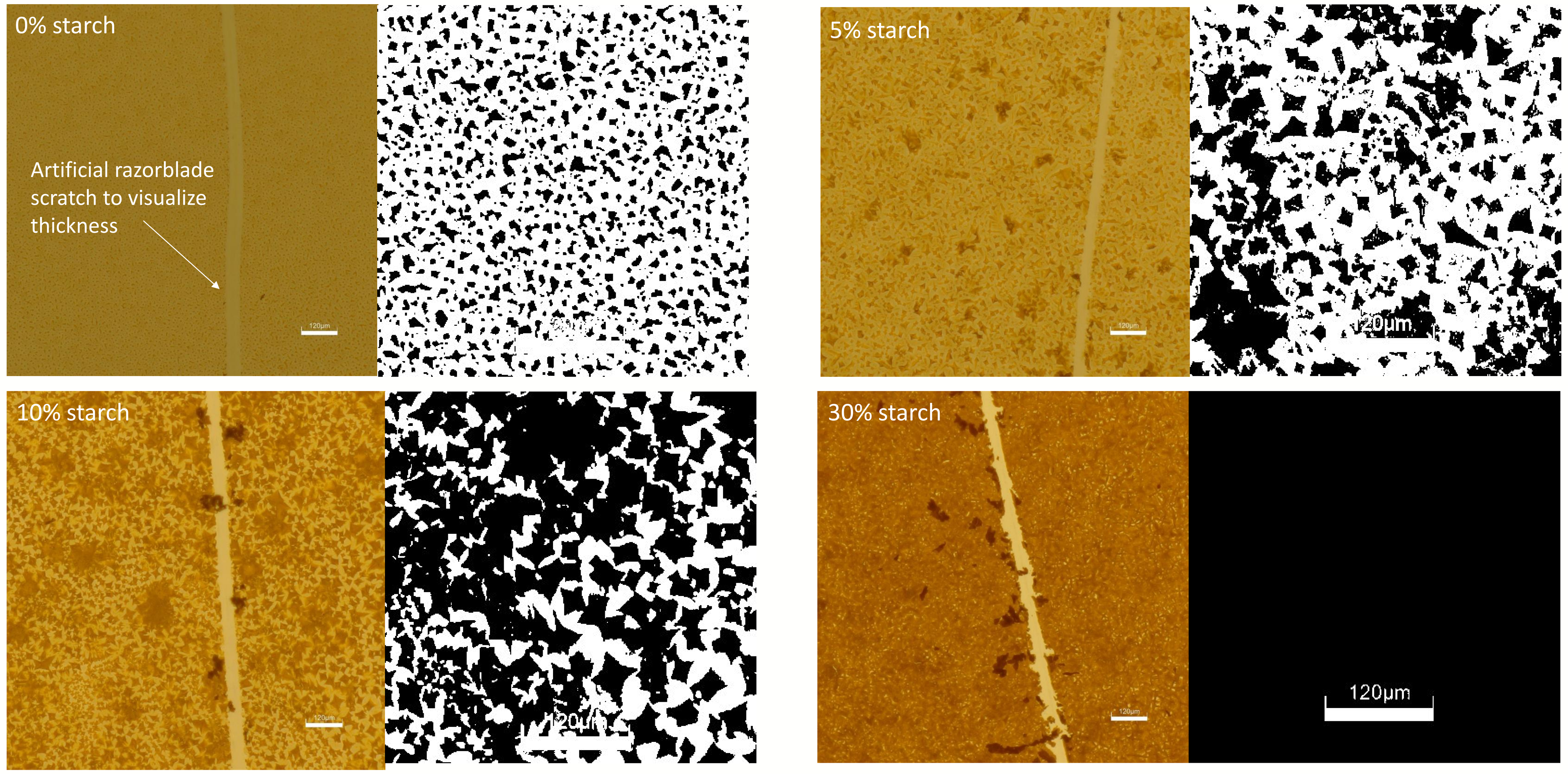


Fig.3: Blade Coating Procedure

Findings

Four samples shown at 217x magnification with scratch and corresponding crystal coverage image (ImageJ software)



Amount of Starch	Crystal Coverage	Average Crystal Cluster Area	Average Thickness	Notes
0%	23.3%	40.7 μm^2	305 nm	Poor crystal coverage
5%	37.6%	357 μm^2	407 nm	Good thickness, poor coverage
10%	62.5%	3560 μm^2	1,060 nm	Beginning of dendrite regime. Most promising sample set
30%	100%	N/A	5,790 nm	Dendrite regime achieved, too thick

Future Research

- Fill in conducting gaps by blade coating a ~10 nm thick acrylic (polymethyl methacrylate or PMMA) layer on top of the 10% starch perovskites.
- Testing other conductive polymer materials and inorganic perovskite compounds such as $CsPbI_3$

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References
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Figure 3: Yao H, Shi S, Li Z, Ci Z, Zhu G, Ding L, Jin Z. 2020. Strategies from small-area to scalable fabrication for perovskite solar cells. Journal of Energy Chemistry. 57:567–586. doi:https://doi.org/10.1016/j.jechem.2020.08.033. https://www.sciencedirect.com/science/article/pii/S2095495620305969.

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