Large-area Perovskite Thin Film Fabrication Using Bar Coating with Air Knife Quenching

Yingao Hu, Material Science&Engineering
Mentor:Feng Yan, Associate Porfessor
School for Engineering of Matter, Transport and Energy

QR CODE

Background

Since perovskite thin films appeared in solar cells in 2010, their photoelectric conversion efficiency has been continuously improved, and they have a tendency to replace silicon because of their lower price. Currently, researchers are committed to commercializing them. However, large-area perovskite thin film fabrication usually has problems such as uneven film formation and defects. Large-area fabrication requires precise control of parameters such as solution concentration, substrate temperature and coating speed. Effective quenching can prevent the formation of defects such as pinholes and cracks, thereby making the film more uniform.

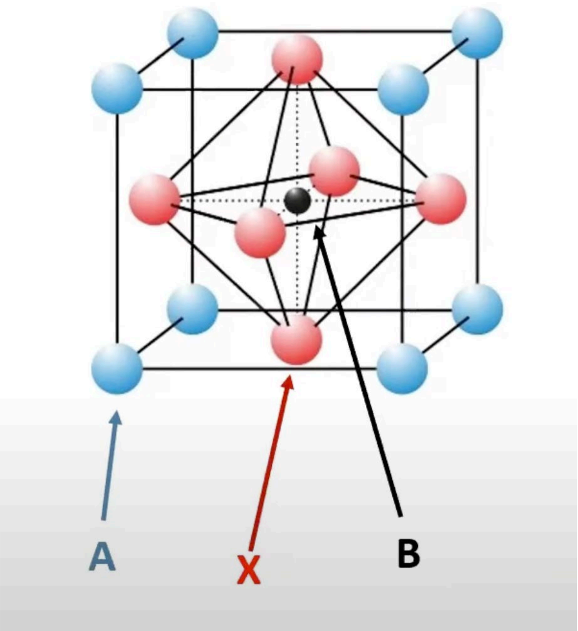

Fig.1 The sturcture of perovskite

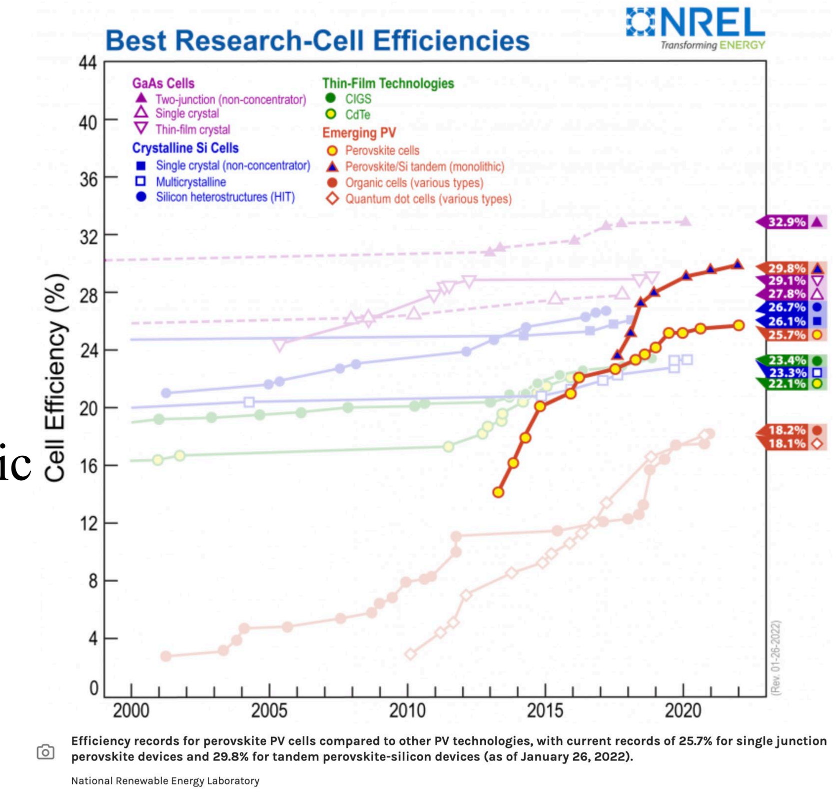

Fig.2 It shows the photoelectric conversion efficiency increasing

Objective

To achieve uniform and defect-free large-area perovskite films by optimizing coating speed, solution volume, air knife angle, and other key parameters.

Procedure

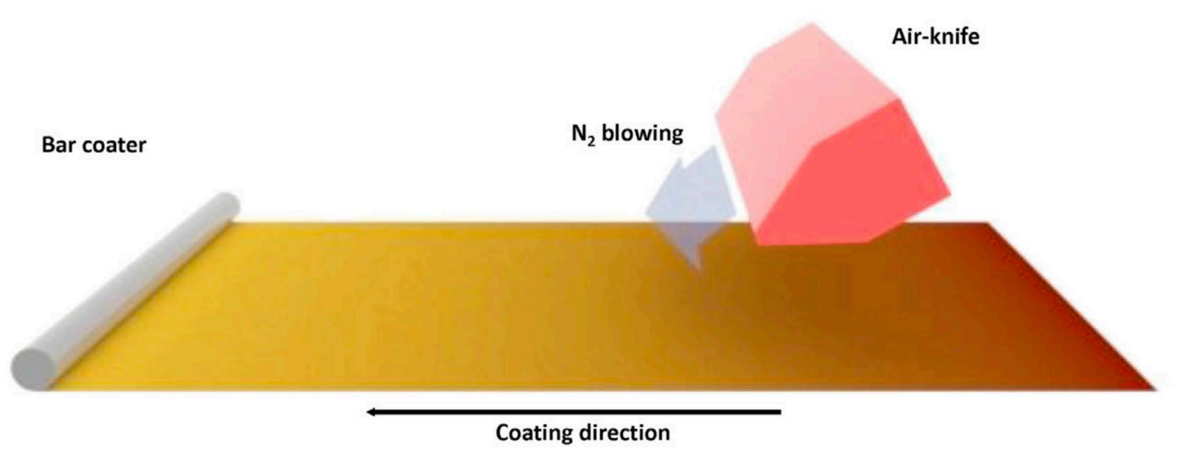

Fig.3 Schematic diagram of air knife assisted bar coating. The process was designed such that the air-knife is introduced after the metal bar.[1]

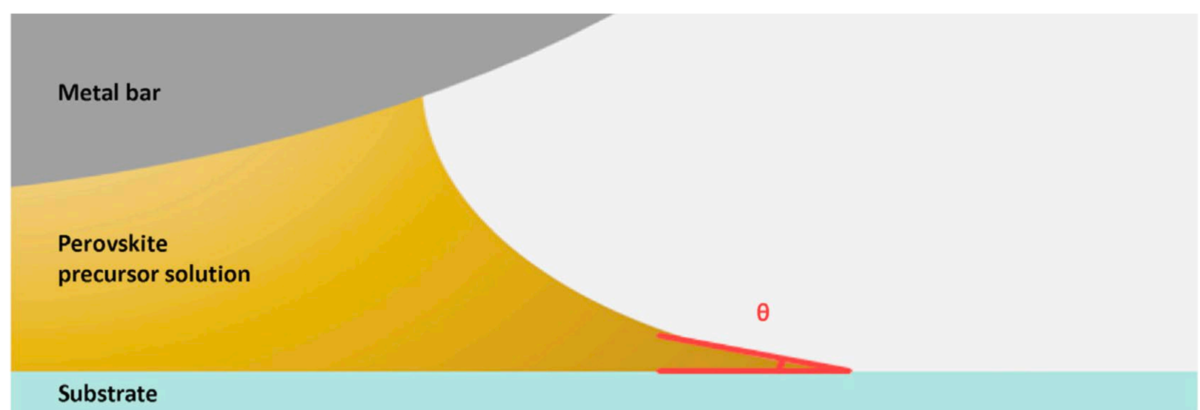

Fig.4 In this case, heterogeneous nucleation is triggered as the perovskite precursor solution thinly spreads on the substrate.[1]

Results

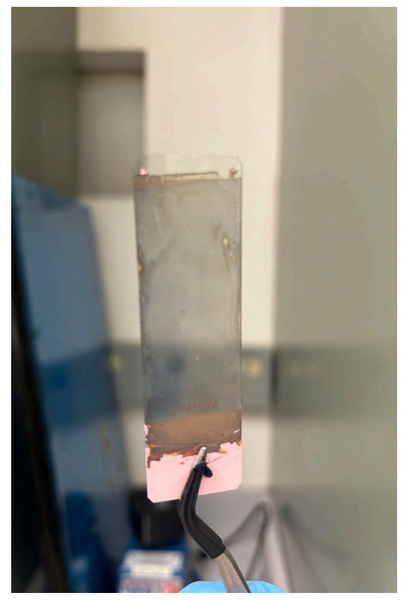

Fig.5 Perovskite thin film reference (no Air Knife Blow)
It can be seen that the perovskite film slide used as a control is relatively transparent and has many defects.

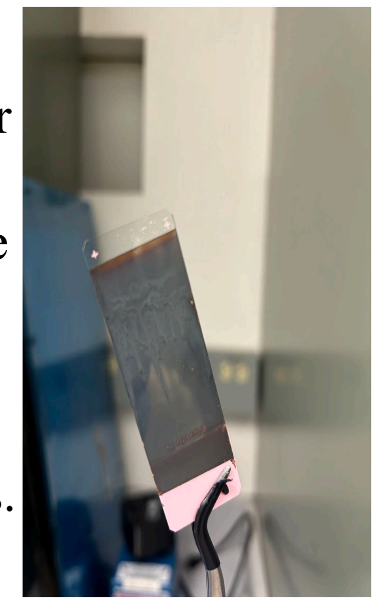

Fig.6 Perovskite film slide with Air Knife Quenching
The air-quenched perovskite film has fewer defects and a darker color. The liquid fluid on the upper part was found to be caused by excessive wind pressure.

PL Data of Perovskite thin film

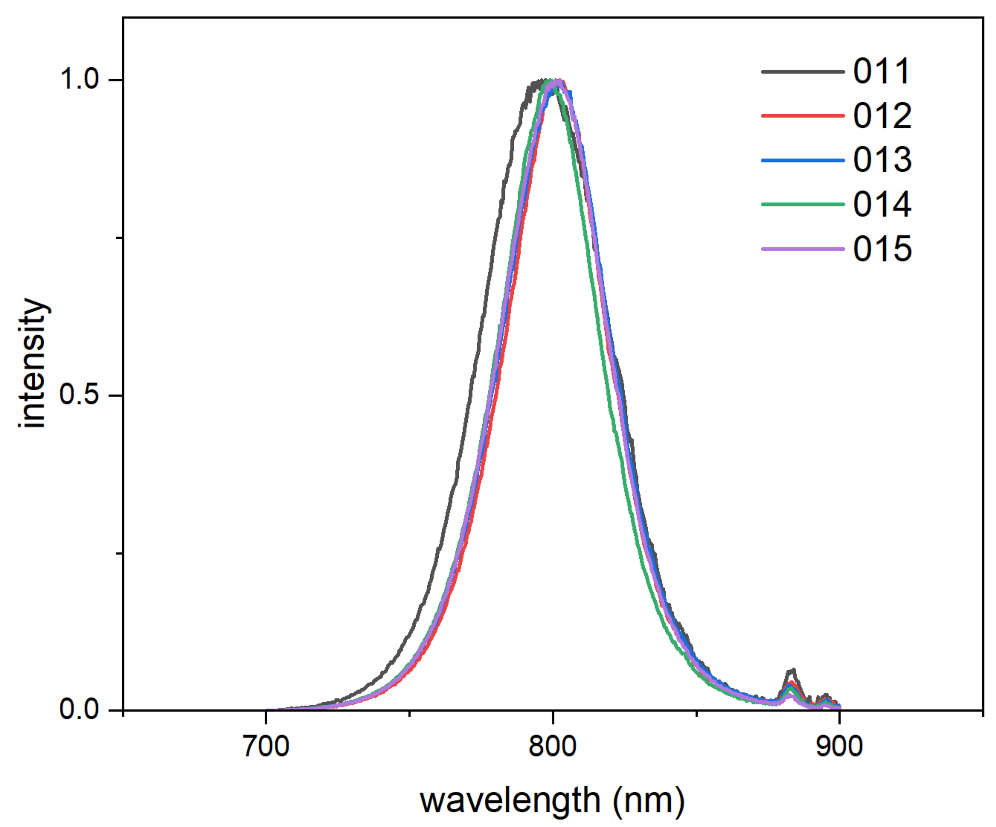

Fig.7 The larger the wavelength, the smaller the band gap. A larger band gap can produce a higher open circuit voltage, which improves efficiency. It will also be more stable. However, it may only absorb high-energy photons, which will reduce the current. From the figure we can see that the wavelengths of 12-15 are close, around 800nm. 11 is the control group. The wavelength of 15 looks slightly larger. Fluctuations close to 900nm are considered to be instrument problems.

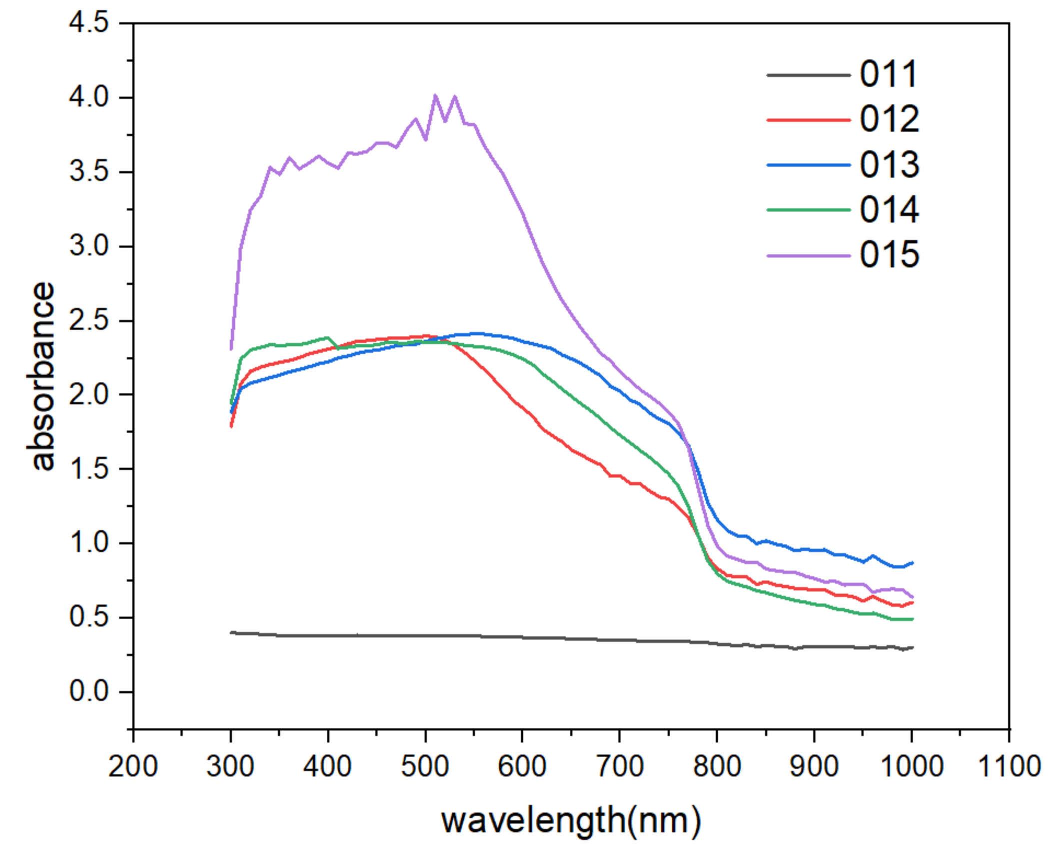

Fig.8 Absorbance

It is obvious from the figure that the absorbance of 11 as a control group is very low at all wavelengths. 15 In the range of 300-600nm, that is, the absorbance pattern in the visible light range is significantly higher. This proves that 15 absorbs more light than several other samples in the visible range. The absorbance of all samples gradually decreased in the 700-1000nm range, which is the infrared range, showing that perovskite does not have good absorbance in the infrared range. Although more research was conducted based on the parameters of 15, the reason why 15 could have such a high absorbance could not be found, and the effect of 15 could no longer be reproduced.

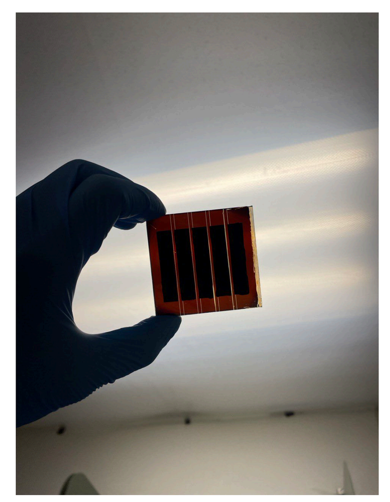

Fig.9 Device made by spin-coating

Conclution & Future work

From the experimental results, it can be seen that too high wind pressure will cause the perovskite precursor solution to flow and affect the overall uniformity. In subsequent experiments, too much solution will make this phenomenon more serious. Failure to air quench will cause more problems. Therefore, it is critical to master the wind pressure and the corresponding solution volume. In future research, new preparation methods may be tried to prepare complete solar cell devices.

FURI

Reference

Yoo, Jin Wook, et al. "Efficient perovskite solar mini-modules fabricated via bar-coating using 2-methoxyethanol-based formamidinium lead tri-iodide precursor solution." Joule 5.9 (2021): 2420-2436.
Bhattarai, Sagar, et al. "A detailed review of perovskite solar cells: Introduction, working principle, modelling, fabrication techniques, future challenges." Micro and Nanostructures (2022): 207450.

ASU Ira A. Fulton Schools of Engineering
Arizona State University