

Non-Destructive Solar Panel Defect Detection

Perovskite solar cells are moving at a rapid pace towards commercial viability, and it is crucial to pinpoint defects within the device thin film stack to target further improvements during the manufacturing process. Using time-resolved photoluminescence measured at several wavelengths, this innovation presents a method for mapping recombination sites and defects throughout the depth of the material and identifying problem interfaces and layers.

What is the Problem?

Perovskite solar cells offer tremendous promise for low-cost, high efficiency solar energy. With power conversion efficiencies of 26%, the focus becomes manufacturing this new type of thin-film solar cell. To achieve higher efficiencies, analyzing the source of energy losses within the device is crucial. Solar cells function by photons exciting electrons within the material into a higher state. To use this captured energy, this electron must be kept in this excited state for as long as possible. If this electron returns to the ground state and releases the stored energy, this is known as recombination, and that lost energy represents a loss in the efficiency of the cell. Therefore, it is desirable to minimize recombination from occurring in the solar cell.

Imperfections in the structure of the cell can lead to easy paths for recombination. However, in this type of thin film solar cell, these defects could be within any of the film stack's layers or on the interfaces between the films. Measurement of the rate of recombination is possible, but many methods currently used by the photovoltaic community is difficult to implement in manufacturing. Time-resolved photoluminescence (TRPL) is a widely-used technique for measuring recombination in solar cells. However, TRPL currently cannot pinpoint where the defects that it measures might be. The core problem that this innovation tackles is the modification of TRPL, such that recombination sites can be mapped.

What is the Solution?

This innovation takes time-resolved photoluminescence at multiple wavelengths to map the depth and spatial dependence of the PL signal, which indicates recombination sites within the material. PL works by shining a light at the device, and measuring the light it gives off in response. To do this, the incident light must be absorbed within the material. Changing the wavelength of light changes the probability that the light will be absorbed; shorter wavelengths with higher energy are more likely to be absorbed than long wavelength, low energy light. Due to this difference in probability, the shorter wavelength light will be absorbed closer to the surface than the longer wavelength light. Using multiple wavelengths and scanning across the material, a 3-dimensional map of the PL signal can be gained. This allows layers and interfaces

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with the highest recombination rates to be identified and targeted for manufacturing improvements.

What is the Competitive Advantage?

The use of this innovation for mapping defects and recombination sites holds several advantages over existing methods in defect detection in thin film manufacturing. The mapping of recombination sites through photoluminescence would currently require making several devices, varying the thickness of the layers or adding surface modifications to deconvolve the various signals present. This method would require much less time and materials spent on creating several samples, saving cost while providing the critical information on the losses within perovskite solar cells. As halide perovskites grow closer to commercial viability, innovations such as these to streamline and improve manufacturing are critical.

References

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