Wesleyan University

Solar Cell Characteristics: An SEM Insight.

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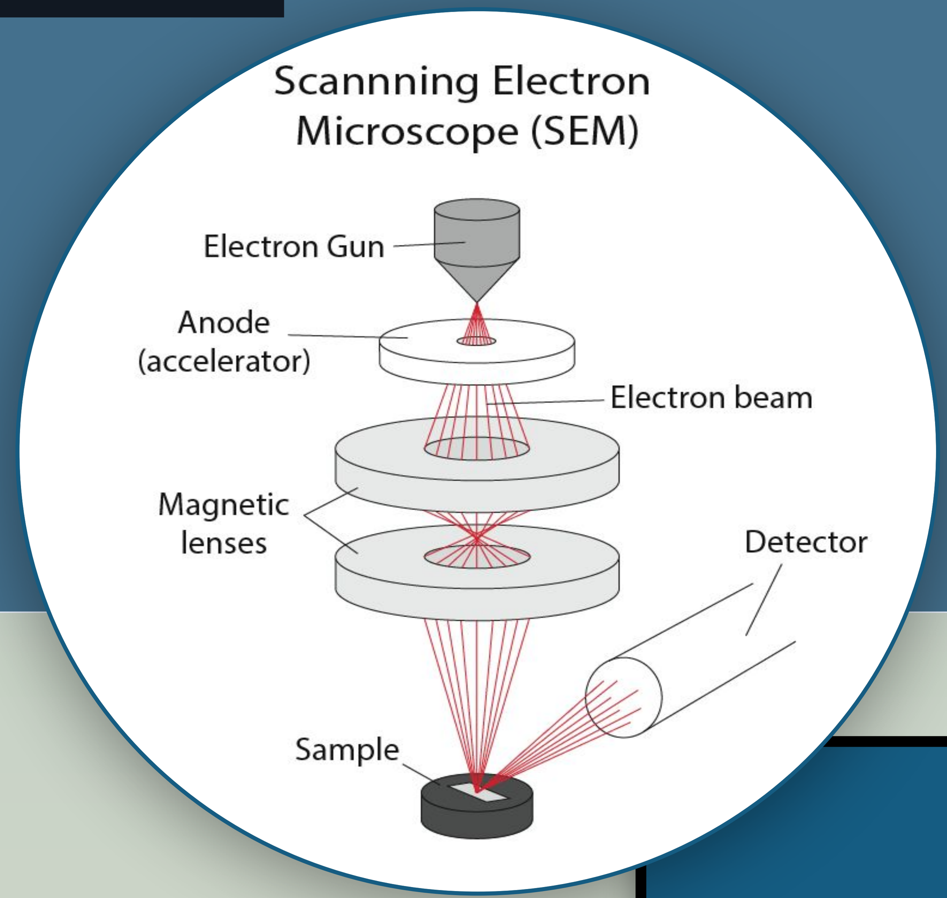


Introduction

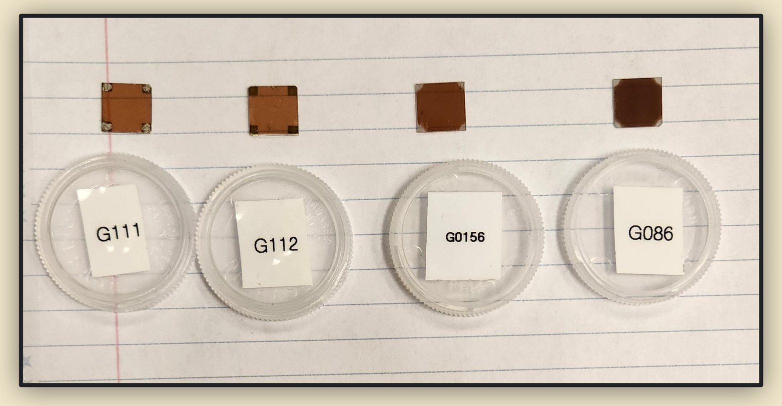
Solar cells are essential components of modern renewable energy systems, converting sunlight directly into electricity. As global demand for clean energy rises, improving the efficiency and durability of these devices has become a major focus in sustainable technology. Microscopic characteristics—including grain boundaries, defects on the surface, and uniformity of the material—have a significant impact on the way solar cells operate. Understanding these substances on a microscopic scale is therefore of critical value. Techniques like Scanning Electron Microscopy (SEM) can help scientists visualize fine structural details, giving insight that informs the development of better and more reliable solar cells.

Methodology

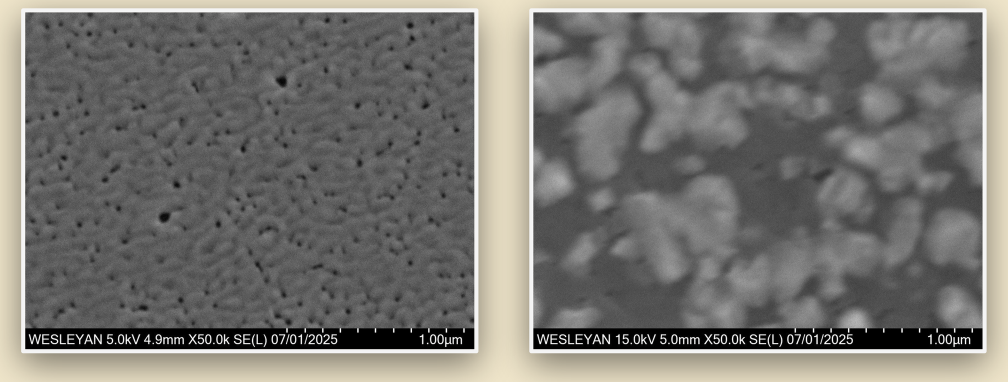
Scanning Electron Microscopy (SEM) was employed to study the surface microstructure of the crystalline Silicon, thin-Film, and perovskite Solar Cells. SEM produces high-resolution images of material surfaces using a focused electron beam. The electrons are accelerated through voltages (1-30 kV), which, together with beam intensity, determine penetration depth and signal strength. Increased voltage provides deeper penetration, whereas reduced voltage increases surface resolution. Zoom (Magnification) is varied by the size of the scanned area, which, if reduced, results in increased magnification.

- **Secondary Electron (SE) imaging highlights surface characteristics like grain boundaries and texture, even down to very high resolution.**
- **Backscattered Electron (BSE) imaging reveals interior features and compositional contrast because of variations of atomic numbers**

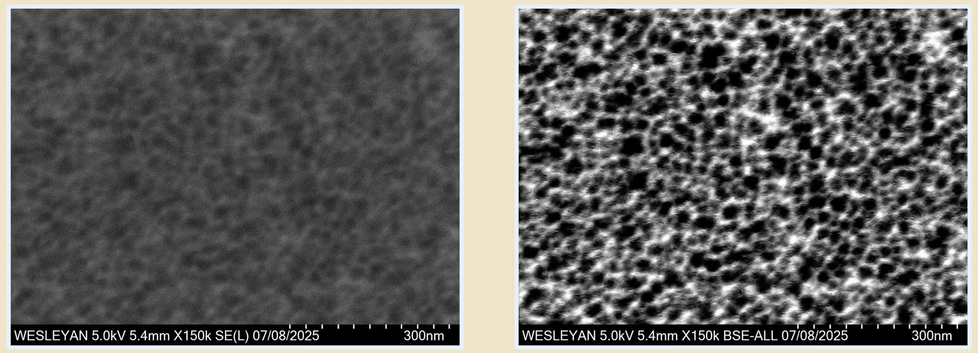
Results



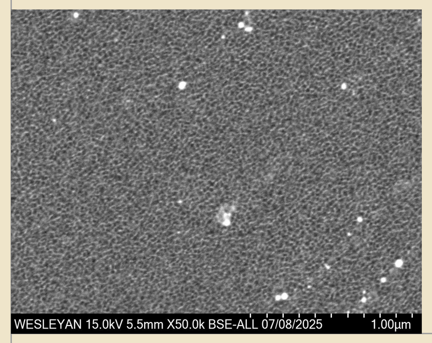
Four $BaZrS_3$ samples showing clear similarity on macroscopic level.



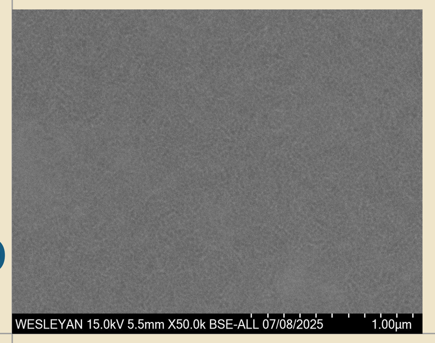
BZS 112(Left) & BZS 086(Right) both samples looking significantly different under the SEM.



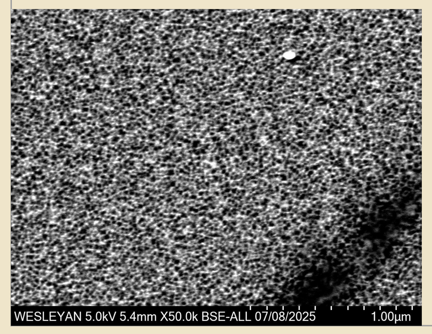
SE SiAu image BSE SiAu image



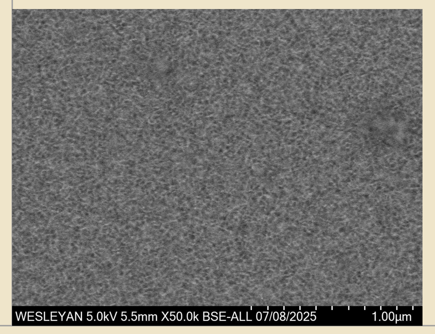
15kV 30



15kV 5



5kV 30



5kV 5

Image Conditions

SEM analysis of sample BZS 112 at 50K magnification was performed under four imaging conditions: 5 kV/30 intensity, 5 kV/5 intensity, 15 kV/30 intensity, and 15 kV/5 intensity. These variations revealed clear differences in surface and internal feature visibility. At 5 kV, both intensity settings produced high surface resolution, clearly showing grain boundaries, textures, and surface defects. The 5 kV/30 intensity image (Fig. 3) was the sharpest, though slight charging effects were observed. In contrast, 15 kV settings (Figs. 1 and 2) provided deeper beam penetration, making internal microstructural features more visible but reducing surface clarity. The 5 kV/30 intensity image (Fig. 3) was especially effective for revealing deeper grain structures.

Next Steps

Future research will be dedicated to the comparison of more solar cell materials to evaluate microstructural differences among various technologies, namely monocrystalline, polycrystalline, and thin-film solar cells. Through the comparison, it will be possible to determine how material structure impacts essential figures of merit like charge carrier transport, recombination, as well as long-term stability.

Acknowledgement

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