Monolithic Selenium/Silicon Tandem Solar Cells

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Elemental selenium, the world's oldest photovoltaic material, is reemerging as a promising inorganic thin-film PV absorber. With a direct bandgap of 1.95 eV in its trigonal phase and a high absorption coefficient (>10^5 cm^{-1}) in the visible region, it is a promising candidate for the top cell in tandem devices. Furthermore, its long-term air stability, monoatomic composition, and low melting point of 220°C makes processing simple, low-cost, and compatible with most bottom cells.

We present the first monolithically integrated selenium/silicon tandem solar cell, demonstrating a highly encouraging open-circuit voltage of 1.68 V. Guided by device simulations, we identify critical energy barriers restricting the flow of charge carriers and investigate the potential of using other carrier-selective contact materials, resulting in a tenfold increase in the overall power conversion efficiency. In parallel with the tandem devices, we fabricate and characterize bifacial single junction selenium solar cells to gain insights into the polarity-dependent PV performance. In view of these results, we set forth strategies for further improving the device performance to realize higher efficiency selenium/silicon tandem solar cells.