TANDEM SOLAR CELLS USING HYBRID ORGANIC/INORGANIC NANOCOMPOSITES

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Despite continuing effort focused on organic photovoltaic (PV) cells, the highest power-conversion efficiency (η_p) reported so far is 6.5% [J. Y. Kim et al., Science **317**, 222 (2007)], which is far below that of thin-film solar cells based on inorganic materials. The limitation in η_p is directly related to the lifetimes of excitons in organic semiconductors, and consequently internal quantum efficiency, and therefore inherent to these materials. At the same time, an advantage of organic semiconductors is the diverse set of available materials with electrical and optical properties that can be tuned by modifying the molecular structures. This flexibility in materials holds great promise for high-efficiency organic PV cells, especially when combined in a tandem configuration. Therefore, we consider organic PV cells (particularly those using hybrid organic/inorganic nanocomposites (NCs)) in lateral- and vertical-tandem structures (Fig. 1).

The innovative approaches of our work are described below:

(i) We propose a lateral tandem cell (Fig. 1(a)) consisting of a one-dimensional periodic array of dispersive-focusing elements and resonant sub-cells that are continuously-tuned and series-connected. The dispersive-focusing element spectrally re-distributes incoming solar photons to establish a wavelength distribution on the sub-cells. The device geometry of the sub-cells is continuously varied in one dimension to allow incident photons to resonantly excite the cell at that location. We estimate the power-conversion efficiency of the lateral tandem cell will approach 20%, assuming an ideal dispersive-focusing element is available.

(ii) We propose a vertical tandem cell (Fig. 1(b)) consisting of multiple hybrid NCs tuned to different wavelength ranges and connected by tunnel junctions. This multi-layer device is enabled by matrix-assisted pulsed laser evaporation (MAPLE), which also provides a method to precisely engineer the nanostructure of hybrid NCs, e.g. through thin-film thickness control and nanoparticle distribution.

(iii) We propose a vertical tandem cell (Fig. 1(c)) combining hybrid NCs with amorphous Si PV cells in order to achieve high quantum efficiency in the λ =1-2μm range. This novel tandem cell could approach the *performance of single-crystal Si at the price point of amorphous Si*. Also, the integration of hybrid NC devices with amorphous or crystalline Si could create opportunities for low-cost, multi-functional technologies, such as hybrid NC solar cell power for remote sensors.

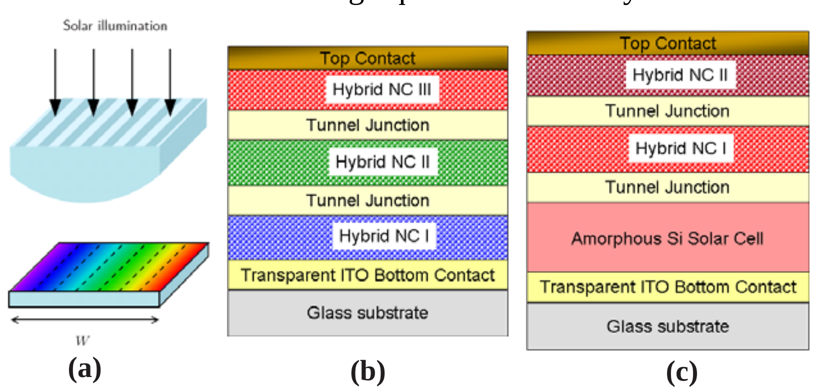

Figure 1. Schematic diagrams of hybrid NC PV cells in (a) lateral- and (b), (c) vertical-tandem configurations. In (a), only one period is shown.