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Pulsed PECVD of vertically aligned SnS nanowalls for solar cell applications

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The electric performance of a solar cell is mostly determined by the quality of the absorbing layer. Besides environmental harmlessness, a high absorption coefficient and a high charge carrier mobility are desirable. Since orthorhombic tin sulfide (SnS) fulfills most of the required criteria, it is regarded as a promising candidate for solar cell applications. Nevertheless, by now, the highest reported efficiency for SnS-based solar cells does not exceed 5%. Since orthorhombic SnS is naturally a layered structure, charge transport is anisotropic along the [001] direction. The performance of tin sulfide as absorber material in solar cells might be significantly improved by using aligned nanostructured SnS, namely SnS nanowalls. We report on a novel synthesis of phase-pure, crystalline SnS nanowalls via plasma-enhanced chemical vapor deposition (PECVD) using a single-source precursor. The precursor was fully characterized via, e.g., TGA, MAS-^{119}Sn-NMR, and single-crystal diffraction. In a home-built setup, the metal-organic complex is evaporated and then transported into a pulsed 13.56 MHz capacitively-coupled RF plasma. Silicon wafers and ITO-covered glass slides are used as substrates. After PECVD, the homogeneously deposited nanowalls turned the substrate surface to be dull, black, and non-reflecting. Structure characterization was done via, e.g., SEM, XRD, electron diffraction, and conductivity measurements. We prove the nanowalls to be phase-pure, with their growth direction along [001], which would advantageously minimize recombination processes and improve charge transport in devices with conventional top and bottom electrodes, e.g., solar cells.

Besides the characterization of the readily grown SnS samples, we also intensively investigated the plasma processes via spatially resolved optical emission spectroscopy (OES). The gained two-dimensional plasma maps were translated into electron-temperature maps via a convenient semi-empirical approach. Hence, a detailed in-situ monitoring of the plasma processes is enabled.

Keywords

PECVD

Nanowalls

Plasma-mapping