Exfoliated zirconium trisulfide (ZrS3) as a charge transport layer for thin-film electronics

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Abstract

Transition metal trichalcogenides such as TiS_3 and ZrS_3 attracted a lot of attention due to their layered nature and formation of two-dimensional and quasi-one-dimensional structures. Characterized by $P2_1/m$ symmetry those materials crystalize as thin and long whiskers or ribbons that have weak van der Waals bonds along 'c' direction and could be described as bundles of 1D-chains stacked together to form a ribbon. The mechanical exfoliation of TiS_3 and 2D field-effect transistors with it were studied by Lipatov et. al. [1,2] and showed high on/off ratio and good field-effect mobility. Narrow bandgap of TiS_3 and high tendency to oxidation does not allow using it in optical applications. On the other hand ZrS_3 being isostructural to TiS_3 has wider bandgap of 2 eV [4] and is potentially more stable in ambient conditions. Here we show the exfoliation of ZrS_3 ribbons in organic solvents by simple ultrasound treatment producing ready to use inks for spray or slot-die coating techniques to obtain thin-film semiconductor layers with unique anisotropic behavior. We show that while spray or spin-coating methods are more conventional for perovskite solar cells, the slot-die printing method result in better quality and more compact films. This approach allowed us to produce thin-film perovskite solar cells with ZrS_3 layer acting as HTL and a series of perovskite-based light-emitting diodes with good performance.

References

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Figures

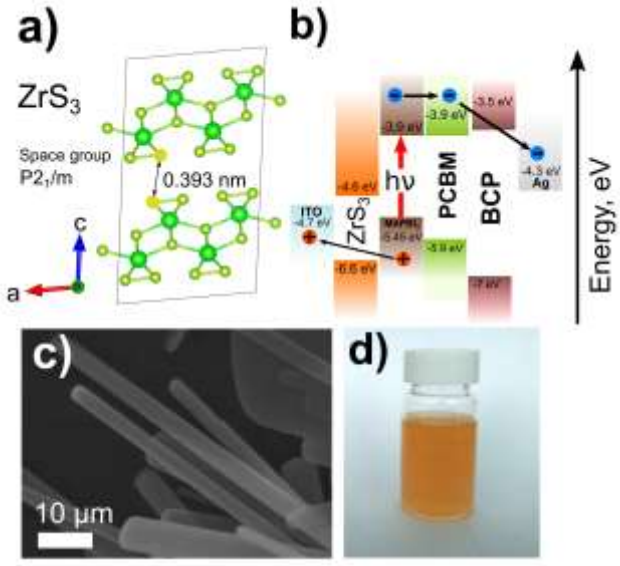

Figure 1: ZrS_3 crystal structure (a), Energy diagram of the possible solar cell (b), SEM image of ZrS_3 ribbons (c), Dispersion of ZrS_3 in IPA after exfoliation

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