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Highly crystalline In_2S_3 thin films epitaxially grown on sapphire substrates: A potential candidate for intermediate band solar cells

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The Shockley Queisser limit of single junction solar cells can be overcome by introducing an intermediate band (IB) in wide band gap materials. Thus thermalization losses can be reduced [1]. Furthermore sub-bandgap photons can be absorbed by valence band to IB and IB to conduction band transitions. According to theoretical calculations In_2S_3 hyper-doped with vanadium is a suitable candidate to realize such an IB solar cell [2].

We grew β-In_2S_3 thin films by physical co-evaporation of the elements on glass and on a-, c-, m-, and r-plane sapphire substrates. The deposition parameters were varied in a wide range to optimize the structural properties of the films. At appropriate deposition parameters (103)-orientation of β-phase In_2S_3 was enhanced. Highest crystallinity and smoothest surfaces could be realized for samples epitaxially grown on a-sapphire substrates.
Electrical characterization reveals a strong persistant photoconductivity. To investigate the photovoltaic response we fabricate pn-heterojunctions using amorphous p-type zinc-cobalt-oxide.

Further we grew In_2S_3:V on sapphire substrates using a combinatorial approach to cover within a single deposition process a wide range of doping concentrations reaching from 1.1 at.% to 11.4 at.% vanadium.
For samples with doping concentrations above a critical concentration of 3.2 at.% vanadium we find an unusual temperature dependence in mobility and charge carrier concentration, which might give evidence to the formation of an IB.

[1] Luque and Martí, *Phys. Rev. Lett.*, 1997, **78**, 5014.

[2] Palacios *et al.*, *Phys. Rev. Lett.*, 2008, **101**, 046403.

Category

Solid State (Experiment)

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