ABSTRACT

The tremendous rise in fossil fuel consumption, along with its greenhouse effects, and other negative environmental impacts have resulted in research efforts that focus on renewable energy sources like hydropower, biomass, solar, wind, geothermal and ocean energy. Among these, the solar is the most promising and reliable source of energy. In semiconductor industry metal silicides have gained increased interest as contact. Among various metal silicides semiconducting iron disilicide (β-$FeSi_2$) has attracted intense research interest recently due to its remarkable optical and electrical properties. Theoretical energy conversion efficiency, as high as 23%, may be achieved in heterojunction β-$FeSi_2$/Si solar cells. However, until now, there have been limited reports on β-$FeSi_2$ solar cells with poor conversion efficiency. In this work, we investigate the photovoltaic properties of sputter-deposited β-$FeSi_2$ films for solar cell applications. We have fabricated solar cells with different structures and demonstrate that introduction of thin Al interlayer results in a significant improvement in cell performance.

The deposition and structural/electrical properties of indium tin oxide (ITO), widely used as the transparent electrode of solar cells, have been examined and compared with reported experimental results. A study of the influence of annealing temperature and the thickness of the ITO layer deposited on glass substrate has been carried out. The deposition and characteristics of aluminum doped and undoped iron disilicide thin films have been studied in detail. Structural, compositional, optical and electrical properties of the deposited films have been investigated for their applications in photovoltaic devices. A study on wide variety of $FeSi_2$ heterojunction solar cell structures has been performed for optimising the solar cell efficiency. The influence of solar cell structure, inter layer thickness, active layer thickness and post-deposition annealing have been studied systematically. The low frequency noise has been characterized for different types of solar cells with different bias for solar cell reliability studies. Effects of various parameters such as, work function of ITO, electron affinity of $FeSi_2$, thickness of different layers and traps are investigated using Silvaco ATLAS simulation tool for modelling of iron disilicide solar cells. Our study clearly shows the importance of interface engineering for performance enhancement in β-$FeSi_2$/Si solar cells. Experimental solar cell (with a structure ITO/p-β-$FeSi_2$(Al)/p^+-Si/n-Si/Al) has shown a highest efficiency of 5.28%.

Keywords: Solar cell, heterojunction, iron disilicide, indium tin oxide, interlayer, active layer, fill factor, efficiency, open circuit voltage, short circuit current, low frequency noise, 1/*f* noise, random telegraph noise, Silvaco, ATLAS.