ABSTRACT

Title: "Nanocrystalline Silicon-Germanium Alloy Thin Films: Synthesis, Characterization and Optimization for Silicon Solar Cells"

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The aim of this thesis is the one-step synthesis and optimization intrinsic nanocrystalline silicon-germanium (nc-SiGe:H) thin films through low-temperature (within 300°C) 13.56 MHz Plasma-CVD processing and 13.56 MHz sputtering deposition technique, compatible for potential device fabrication and their application to thin-film silicon tandem-structured solar cells. In first part of the thesis, the development of nanocrystalline silicon-germanium thin films by making optimal incorporation of Ge atoms in nc-Si network at ~220 °C using (SiH_4 + GeH_4 + H_2) plasma and their systematic analysis and optimization using various spectroscopic and microscopic tools and electrical characterization for photovoltaic application has been undertaken. The second part involves the systematic development of intrinsic nc-SiGe:H films with accomplishing nanocrystallinity in both Si and Ge in the film network, through increasing the hydrogen dilution optimally in the (SiH_4 + GeH_4)-plasma at ~220 °C in the device-friendly Plasma-CVD reactor, and the optimization of the optoelectronic and structural properties of the films through comprehensive analysis. In third part, Ge-rich nc-SiGe thin film has been prepared in RF-PECVD through the efficient incorporation of the Si atoms in the nanocrystalline Ge network via increasing the SiH_4 gas flow ratio in the (SiH_4 + GeH_4) plasma; as the growth conditions consistent for nc-Ge growth are completely different from the deposition conditions compatible for nc-Si growth. It has been confirmed that the decomposition of SiH_4 under nc-Ge compatible growth conditions occurs in a controlled manner that is beneficial for sustaining the nanocrystallinity in the binary SiGe alloy containing a Ge-dominated atomic composition that can provide the required infrared response and electrical transport for strategic applications in photovoltaics. In the last part of the thesis, nanocrystalline silicon germanium thin films have been achieved at a low temperature of 250 °C, from a one-step process by co-sputtering of Ge target (99.999% purity) and nc-Si wafers, using (Ar + H_2) plasma in the RF magnetron sputtering deposition system. Changes in the structural morphology and optical band gap due to the change in composition are studied.

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