Materials Science & Engineering Doctoral Defense

Characterization of Novel Thin-Films and Structures for Integrated Circuit and Photovoltaic Applications

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abstract

Thin films have been widely used in various applications. This research focuses on the characterization of novel thin films in the integrated circuits and photovoltaic techniques. The ion implanted layer in silicon can be treated as ion implanted thin film, which plays an essential role in the integrated circuits fabrication. Novel rapid annealing methods, i.e. microwave annealing and laser annealing, are conducted to activate ion dopants and repair the damages, and then are compared with the conventional rapid thermal annealing (RTA). In terms of As^+ and P^+ implanted Si, the electrical and structural characterization confirms that the microwave and laser annealing can achieve more efficient dopant activation and recrystallization than conventional RTA. The efficient dopant activation in microwave annealing is attributed to ion hopping under microwave field, while the liquid phase growth in laser annealing provides its efficient dopant activation. The characterization of dopants diffusion shows no visible diffusion after microwave annealing, some extent of end range of diffusion after RTA, and significant dopant diffusion after laser annealing.

For photovoltaic applications, an indium-free novel three-layer thin-film structure (transparent composited electrode (TCE)) is demonstrated as a promising transparent conductive electrode for solar cells. The characterization of TCE mainly focuses on its optical and electrical properties. Transfer matrix method for optical transmittance calculation is validated and proved to be a desirable method for predicting transmittance of TCE containing continuous metal layer, and can estimate the trend of transmittance as the layer thickness changes. TiO_2/Ag/TiO_2 (TAgT) electrode for organic solar cells (OSCs) is then designed using numerical simulation and shows much higher Haacke figure of merit than indium tin oxide (ITO). In addition, TAgT based OSC shows better performance than ITO based OSC when compatible hole transfer layer is employed. The electrical and structural characterization of hole transfer layers (HTLs) in OSCs reveals MoO_3 is the compatible HTL for TAgT anode. In the end, the reactive ink printed Ag film for solar cell contact application is studied by characterizing its electromigration lifetime. A percolative model is proposed and validated for predicting the resistivity and lifetime of printed Ag thin films containing porous structure

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