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Deposition of Nano Crystalline Silicon Thin Film by Using a Neutral Beam Method at Low Temperature

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Nano-crystalline silicon (nc-Si) thin film has been used for the devices such as TFT (Thin Film Transister), solar-cell, etc., due to its excellent material properties including high carrier mobility than that of amorphous silicon (a-Si) films. Currently, nc-Si film is fabricated by re-crystallizing an a-Si film with post-treatment method such as excimer laser annealing (ELA), solid phase crystallization (SPC), metal-induced crystallization (MIC), etc. However, these troublesome post-treatment requires high processing temperature (500~600℃) which is higher than glass transition temperature. Furthermore, throughput and cost issues will become more critical as the substrate size is increased. Therefore, to simplify process steps and increase production throughput, direct nc-Si deposition at a low temperature is definitely required. Low temperature neutral beam deposition (LTNBD) is investigated as a new approach to fabricate and develop nc-Si. The difference of LTNBD to the conventional PECVD is that the nc-Si thin film formation energy of LTNBD is supplied by controlled neutral beam energies at low temperature. Decomposition of source gas (SiH_4) is enhanced by additive gas which is introduced together with source gas such as Ne, Ar, and Xe gas, resulting in the formation of low temperature nc-Si. The nc-Si made by the neutral beam deposition method shows better electrical property compared to silicon deposited by other processes at low temperature. Dark conductivity of grown silicon film was measured as a function of 1st grid voltage and additive inert gas. The surface roughness of the grown film was investigated as a function of neutral beam energy by using AFM. In addition, the film crystallinity was investigated by HRTEM, Raman spectroscopy, and X-ray diffraction analysis.