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Research on the Multi-electrode Plasma Discharge for the Large Area PECVD Processing

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Recently, there are many researches in order to increase the deposition rate (D/R) and improve film uniformity and quality in the deposition of microcrystalline silicon thin film. These two factors are the most important issues in the fabrication of the thin film solar cell, and for the purpose of that, several process conditions, including the large area electrode (more than 1.1 X 1.3 (m2)), higher pressure (1 ~ 10 (Torr)), and very high frequency regime (VHF, 40 ~ 100 (MHz)), have been needed. But, in the case of large-area capacitively coupled discharges (CCP) driven at frequencies higher than the usual RF (13.56 (MHz)) frequency, the standing wave and skin effects should be the critical problems for obtaining the good plasma uniformity, and the ion damage on the thin film layer due to the high voltage between the substrate and the bulk plasma might cause the defects which degrade the film quality. In this study, we will propose the new concept of the large-area multi-electrode (a new multi-electrode concept for the large-area plasma source), which consists of a series of electrodes and grounds arranged by turns. The experimental results with this new electrode showed the processing performances of high D/R (1 ~ 2 (nm/sec)), controllable crystallinity (~70% and controllable), and good uniformity (less than 10%) at the conditions of the relatively high frequency of 40 MHz in the large-area electrode of 280 X 540 mm2. And, we also observed the SEM images of the deposited thin film at the conditions of peeling, normal microcrystalline, and powder formation, and discussed the mechanisms of the crystal formation and voids generation in the film in order to try the enhancement of the film quality compared to the cases of normal VHF capacitive discharges. Also, we will discuss the relation between the processing parameters (including gap length between electrode and substrate, operating pressure) and the processing results (D/R and crystallinity) with the process condition map for μc-Si:H formation at a fixed input power and gas flow rate. Finally, we will discuss the potential of the multi-electrode of the 3.5G-class large-area plasma processing (650 X 550 (mm2) to the possibility of the expansion of the new electrode concept to 8G class large-area plasma processing and the additional issues in order to improve the process efficiency.

Keywords: Large area, Plasma, Thin film, VHF