Characterization Of Atmospheric Pressure Plasma-Grown SiNx:H Films

J.A. Silva[1, 2], J. Vallade[1,3], R. Bazinette[1], L. Gaudy[1], F. Massines[1]
[1]*PROMES-CNRS, Rambla de la Thermodynamique, Perpignan F66100 France*
[2]*IDL Faculty of Sciences University of Lisbon, Campo Grande, 1749-016 Lisboa Portugal*
[3]*LIS Université Laval, 10 rue de l'Espinay,, Québec Canada G1L 3L5*

We present here a study of the chemical composition, optical and passivation properties of hydrogenated silicon nitride (SiN_x:H) films obtained by atmospheric pressure plasma deposition. These films are to be used as passivation and antireflection coatings for p-type crystalline silicon solar cells. The standard industrial method to obtain passivation and antireflection coatings of solar cells is the growth of SiN_x:H by low pressure plasma enhanced chemical vapor deposition (PECVD). Replacing the standard low pressure process by an atmospheric pressure plasma process has the potential to reduce the production cost of the solar cells and photovoltaic systems.

The SiN_x:H films are grown in an atmospheric pressure plasma reactor using a gas mixture composed of ammonia (NH_3), silane (SiH_4) and argon as vector gas. The plasma is created in the two zones between the electrodes, and the film growth occurs in these two areas. The reactor allows two different growth modes: a static mode in which the films grown are an image of the electrodes; and a dynamic one in which the sample holder is displaced with a defined speed enabling the homogeneous coating of the samples.

Previous results showed that using atmospheric pressure PECVD SiN_x:H films with optical properties that are similar to the low pressure films can be obtained [1]. Also the ability to obtain SiN_x:H films with an adequate passivation behavior was demonstrated [1,2].

Based on FTIR measurements, we analyze the chemical composition of the SiN_x:H films grown on static mode which achieved the best passivations: the films obtained with a plasma frequency of 200 kHz both modulated and non-modulated. The correlation between the film chemical composition, optical and passivation properties is discussed.

For the films analyzed the optical index n increases until it reaches a maximum near the entrance of the plasma (where the gases are injected) decreasing afterwards. Initially such decrease is due to the reduction of the film density (reduction of Si-H bond concentration), later by the increase of the N/Si ratio (increase of N-H/Si-H). The extinction coefficient k follows the variation of n, in fact the local values of (n,k) follow the k(n) curve usually obtained for SiN_x:H films [3]. For films grown with f=200 kHz modulated, the minimum values obtained for n and k are lower than for non-modulated plasma.

The passivation properties of the films are improved when the film density increases and depend strongly on the ratio between N-H and Si-H bonds.

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