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Investigation of p-type nanocrystalline silicon oxide thin film prepared at various growth temperatures

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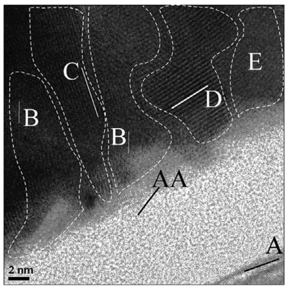
HIGHLIGHTS

- P-type nano-crystalline silicon oxide layer was grown at a low temperature.
- These films show wider optical gap and high electrical conductivity.
- Crystalline volume fraction was high at 80 °C deposition temperature.
- Rear emitter solar cell shows better characteristics with this layer.

GRAPHICAL ABSTRACT



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ABSTRACT

Substrate temperature has an important role on the characteristic properties of a plasma deposited thin film silicon. In a heterojuction (HJ) solar cell, the higher deposition temperature initiates unwanted thermal diffusion of atom from one layer to another, thereby degrading device characteristics. Hence, we investigated the effect of substrate temperatures (T_s) on p-type material and HJ device characteristics. We prepared p-type nanocrystalline silicon oxide (p-nc-SiO:H) layer at different $T_{s,}$ varying from 170 °C to 80 °C and observed that its opto-electronic properties improve at a lower T_s. These p-nc-SiO:H were used in HJ solar cell as emitter and we found that the film prepared at 80 °C gives the best result. This emitter layer shows wide optical gap (2.32 eV), high electrical conductivity (3.5 S/cm) and high crystallinity (44%). In the rear emitter HJ solar cells, an improvement in fill factor from 72.2% to 74.5%, open circuit voltage from 708 mV to 718 mV and power conversion efficiency (PCE) from 19.3% to 20.1% was observed when the emitter of the cells was prepared at 170 °C–80 °C.

1. Introduction

Hydrogenated silicon oxide thin film is one of the most versatile semiconductor materials, prepared in a conventional plasma enhanced chemical vapor deposition (PECVD). It was proposed to be a two phase material [1], having silicon rich and oxygen rich phases. These two phases play two different roles. The electrical conductivity and optical transparency of the materials are determined by the Si-rich and O-rich phases respectively [1,2]. Because of this, the interest in p-type and n-type silicon oxide is growing steadily for its application in solar cell [1–7]. It is expected that an improved p-type silicon oxide layer will find its wider usefulness, as its opto-electronic properties can be varied in a suitable deposition condition. In this material, the oxygen content can be varied from 0 to 25 at.% [8,9]. Various preparation conditions

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