Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 124 (2017) 288–294

Energy Procedia

www.elsevier.com/locate/procedia

7th International Conference on Silicon Photovoltaics, SiliconPV 2017

A comparison study of boron emitter passivation by silicon oxide and a PECVD silicon nitride stack

Barbora Mojrová[a]*, Haifeng Chu[b], Christop Peter[b], Pirmin Preis[b], Jan Lossen[b], Valentin D. Mihailetchi[b], Radovan Kopecek[b]

[a] *Departement of Microelectronics The Faculty of Electrical Engineering and Communication Brno University of Technology Technicka 3058/10, Brno 616 00, Czech Republic*

[b] *ISC Konstanz e. V., Rudolf-Diesel-Str. 15, Konstanz 78467, Germany*

Abstract

Surface recombination of minority charge carriers is a significant loss mechanism in crystalline-Si (c-Si) solar cells. For n^+ (phosphorous) doped regions a sufficient surface passivation is achieved by using a silicon nitride (SiN_X) film deposited by Plasma Enhanced Chemical Vapour Deposition (PECVD). However, on p^+ boron doped regions, SiN_X does not passivate the surface. Instead, a stack of layers comprising of a thin silicon dioxide (SiO_2), or aluminium oxide (Al_2O_3), and a SiN_X film is commonly used to passivate boron doped regions.

In this study we investigated the passivation quality of boron doped emitters by varying the composition of SiO_2/SiN_X stack layers. For this purpose, *n*-PERT (passivated emitter, rear totally-diffused) solar cells with boron doped front side emitter and phosphorous doped back-surface-field (BSF), as well as symmetrical boron doped structures, were fabricated on 6-inch *n*-type wafers.

The results show that the optimum passivation is achieved by a stack layer of a thermal SiO_2, with a thickness of at least 10 nm, and a SiN_X layer with a low refractive index. The chemical composition of SiN_X capping layer plays an important role for surface passivation. A more Si-rich SiN_X layer show significant degradation in surface passivation of the stack, due to the increase in the density of interface states (D_{it}) and fixed positive charges (Q_{tot}) at the interface.

© 2017 The Authors. Published by Elsevier Ltd.
Peer review by the scientific conference committee of SiliconPV 2017 under responsibility of PSE AG.

Keywords: Solar cell; boron emitter; *n*-PERT; passivation; NAOS

* Corresponding author. Tel.: +420 54114 6107; fax: +420 54114 6298.
E-mail address: xmojro00@stud.feec.vutbr.cz

1876-6102 © 2017 The Authors. Published by Elsevier Ltd.
Peer review by the scientific conference committee of SiliconPV 2017 under responsibility of PSE AG.
10.1016/j.egypro.2017.09.301

1. Introduction

Surface passivation of heavily doped p^+ emitters is required in order to realize cost-effective industrial high-efficiency solar cells based on *n*-type silicon wafers. The boron emitter can be passivated by a dielectric having a low density of interface states (D_{it}), potentially in combination with a high fixed negative charge density. However conventional SiN_X is not suitable for p^+ surface passivation [1]. One of the reasons for the relatively poor surface passivation of p^+ surfaces by SiN_X is related to the very high fixed charge density in PECVD SiN_X. It is attributed to the band gap defects that SiN_X form during deposition, which are more detrimental to p^+ Si [2, 3]. It was observed that the fixed charge density can be reduced by adding a thin silicon oxide layer between the crystalline silicon and the SiN_X film. Another approach to passivate p^+ layer is based on using thin Al_2O_3 dielectric with the negative charge as a surface passivation layer and SiN_X as an antireflection coating (ARC) layer [4-7].

2. Experimental part

2.1. Sample preparation

In this work we investigated the passivation of boron doped emitters with different SiO_2/SiN_X stack layers. For this purpose we used, on the one hand, an *n*-PERT cell with a homogeneous diffused front boron emitter and a phosphorous back-surface-field (BSF) and on the other hand, symmetrical boron diffused test structure. Both device structures were fabricated on 6-inch *n*-type monocrystalline Si wafers with base resistivity of 2.5 Ωcm. Standard industrial processes were used, which included wet chemical alkaline texturization, cleaning by HCl, HF, and HF/O_3 solutions, diffusion in quartz tube furnaces containing phosphoryl chloride ($POCl_3$; for n^+ BSF) or boron tribromide (BBr_3; for p^+ emitter). For the solar cell devices the back side was chemically polished and the n^+ BSF diffusion was passivated by a thermal SiO_2/ SiN_X stack. Screen printing and firing through of commercial silver containing pastes were applied to both sides for metallization. A schematic cross-section of the studied solar cells is presented in the Fig. 1.

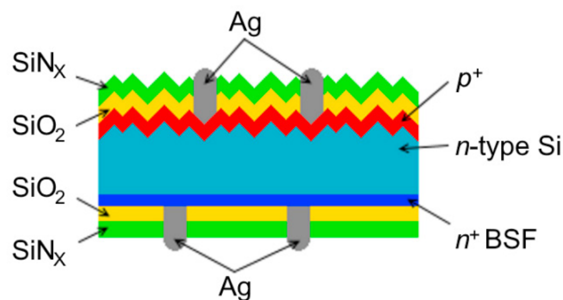

Fig. 1. Schematic cross-section of the investigated *n*-PERT cells.

2.2. Passivation stacks

All solar cells were processed identically, with the exception of boron emitter passivation. For the boron emitter 5 different passivation stacks were investigated and compared, as detailed in Table I. First, the stacks G1 and G2 aimed to investigate the effect of SiO_2 interfacial layer thickness on the passivation quality of the SiO_2/SiN_X stack. A symmetrical boron diffused test structure was used, in addition to the solar cells, to find the optimum thickness of the SiO_2 in the stack. Here, a thermal SiO_2 was grown in situ during the BBr_3 diffusion on boron emitter surface with a thickness of about 40 nm. Subsequently the thick SiO_2 layer was partially etched (thinned) in HF (2%) solution to yield various thicknesses, followed by a 62 nm PECVD SiN_X antireflection coating (ARC; n ≈ 2) deposition of the capping layer to complete the passivation stack.

Then, the stacks G1 and G3 aimed to compare different SiO_2 interface passivation layers, whereas the SiN_X capping layer was kept the same (ARC; n ≈ 2). Stack G3 contained a 1.5 nm chemical SiO_2 interfacial layer grown

Download English Version:

https://daneshyari.com/en/article/5444570

Download Persian Version:

https://daneshyari.com/article/5444570

Daneshyari.com