福昕软件(C)2005-2007，版权所有，仅供试用。

Solar Energy Materials & Solar Cells 94 (2010) 1049–1053

Contents lists available at ScienceDirect

Solar Energy Materials & Solar Cells

journal homepage: www.elsevier.com/locate/solmat

Regulated low cost pre-treatment step for surface texturization of large area industrial single crystalline silicon solar cell

P.K. Basu [a,*], H. Dhasmana [b], N. Udayakumar [c], Firoz Khan [d], D.K. Thakur [e]

[a] Department of Applied Sciences, Echelon Institute of Technology, Faridabad-121002, Haryana, India
[b] Center for Energy Studies, Indian Institute of Technology, Hauz Khas, New Delhi-110016, India
[c] Udhaya Energy Photovoltaics Pvt. Ltd, Coimbatore, Tamilnadu, India
[d] Electronic Materials Division, National Physical Laboratory, Dr. K.S. Krishnan Road, New Delhi-110060, India
[e] Guru Nanak Institute of Technology and Management, Ambala, Haryana, India

ARTICLE INFO

Article history:
Received 30 April 2009
Received in revised form
3 August 2009
Accepted 8 February 2010
Available online 15 March 2010

Keywords:
Single crystalline silicon solar cell
Industrial low cost process
Texturization pre-treatment process
NaOH–NaOCl
SEM, DIV, LIV analysis

ABSTRACT

Conventional pre-treatment process for saw damage removal before texturization of monocrystalline silicon wafers is by higher concentration (6–10%) caustic etch at 50–60 °C. In this paper a novel low cost approach for this pre-treatment of surface texture by a new composition of hot sodium hydroxide (NaOH) and sodium hypochlorite (NaOCl) solution is reported for industrial large area, high efficiency, single crystalline silicon solar cells. The moderate silicon etching rate of hot NaOH–NaOCl solution generates a better control on removal of damaged surface. This new damage etching process also helps in the formation of optimized pyramidal structure on silicon wafer during texturization. This process is highly suitable for thin starting raw wafers with thicknesses in 160–200 μm range used by most of cell manufacturing industries. Substantial reduction of yield loss due to breakage of wafers is achieved by using this modified process. Optimized recipe of this surface texturization process is ascertained by the Scanning Electron Microscopic (SEM) study of front textured surface on non-metallized and metallized areas. Also reflectivity, cell dark and illuminated voltage–current characteristic measurements validate the superiority of this process to the existing one, which finally leads to low cost, improved quality solar cells for any monocrystalline PV industry.

© 2010 Elsevier B.V. All rights reserved.

1. Introduction

Reduction of optical losses in single crystal silicon (C-Si) solar cells by surface texturing is one of the important issues of modern silicon photovoltaics. Many researchers [1,2] have shown the selective etching of ⟨1 0 0⟩ silicon by using sodium or potassium hydroxide solution. For monocrystalline silicon solar cells, these anisotropic etches are used to form pyramidal structure that can collect the reflected light and trap the light inside the cells by repeated reflections [3,4]. In order to enhance the pyramid nucleation, the interfacial energy of silicon/electrolyte should be reduced, so that sufficient wettability for the silicon surface can be achieved. Isopropyl alcohol (IPA) is generally mixed in the solution in order to achieve good uniformity of pyramidal structure on the silicon surface [5,6].

Pre-texturization damage removal process of the silicon helps in removing the mechanically damaged surface and other surface contaminants associated in ingot slicing process. The conventional damage removal process by higher concentration of NaOH or KOH solution often results in non-uniform or incomplete silicon etching. Ultimately it results in bad texturing, like non-uniform pyramid heights or even no pyramid formation on some wafer areas [3]. Presently most of the C-Si PV industries use thin silicon wafers (160–200 μm thickness) and high silicon etching rate of NaOH/KOH pre-treatment solution [7] poses difficulty in monitoring the time duration of damage removal etching. During higher duration of silicon etching, the breakage rate of silicon wafers increases during texturization. For less or incomplete damage etching, defect centers and contaminants on wafer surface contribute to low open circuit voltage (V_{oc}) by enhancing the cell leakage current. A modified process has been developed by Gangopadhyay et al. [8] to remove these organic and inorganic contaminants from the wafer surface and this process generates better textured surface. However, long and additional steps in their process often create other productivity problems like higher process cost and decrease in the number of wafers textured per hour. Also yield loss due to breakage of silicon wafers during texturization does not reduce as it also involves NaOH/KOH solution for the damage removal process and thus inconsistency in damage removal does not completely be eliminated.

* Corresponding author. Tel.: +91 129 2201060; fax: +91 129 2201040.
E-mail address: prabir_basu64@rediffmail.com (P.K. Basu).

0927-0248/$ - see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.solmat.2010.02.025