



Available online at www.sciencedirect.com

ScienceDirect

Procedia

Energy Procedia 124 (2017) 267-274

www.elsevier.com/locate/procedia

7th International Conference on Silicon Photovoltaics, SiliconPV 2017

Shielded hydrogen passivation – a novel method for introducing hydrogen into silicon

Gabrielle Bourret-Sicotte^a, Phillip Hamer^{a,b}, Ruy S. Bonilla^a, Katherine Collett^a, Peter R. Wilshaw^a

^aThe University of Oxford, Department of Materials, 16 Parks Rd, Oxford, OX1 3PH, United Kingdom ^bThe University of New South Wales, School of Photovoltaics and Renewable Energy Engineering, Tyree Energy Technology Building, UNSW, Sydney, 2052, NSW, Australia

Abstract

This paper reports a new approach for exposing materials, including solar cell structures, to atomic hydrogen. This method is dubbed Shielded Hydrogen Passivation (SHP) and has a number of unique features offering high levels of atomic hydrogen at low temperature whilst inducing no damage. SHP uses a thin metallic layer, in this work palladium, between a hydrogen generating plasma and the sample, which shields the silicon sample from damaging UV and energetic ions while releasing low energy, neutral, atomic hydrogen onto the sample. In this paper, the importance of the preparation of the metallic shield, either to remove a native oxide or to contaminate intentionally the surface, are shown to be potential methods for increasing the amount of atomic hydrogen released. Excellent, damage free, surface passivation of thin oxides is observed by combining SHP and corona discharge, obtaining minority carrier lifetimes of 2.2 ms and J_0 values below 5.47 fA/cm². This opens up a number of exciting opportunities for the passivation of advanced cell architectures such as passivated contacts and heterojunctions.

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

Keywords: Hydrogen; Passivation; Direct Plasma Hydrogenation; Defect Kinetics; Crystalline Silicon

1. Introduction

The use of atomic hydrogen to passivate impurities and defects in silicon has been widely reported in the literature with the broad consensus being that the effectiveness of this process is heavily reliant upon the quantity of

hydrogen introduced into the silicon [1], [2]. In particular, recent work on thin oxides for passivated contacts has shown significant reductions in recombination at silicon interfaces after exposure to hydrogen [3], [4].

Whilst hydrogen containing dielectrics, such as silicon nitride or aluminium oxide, have proven to be excellent sources of atomic hydrogen under annealing at temperatures ranging from 400-900 °C [1], [5], [6], not all cell structures incorporate such dielectrics or high temperature processing. For these devices it would be preferable to have a direct source of atomic hydrogen. In the absence of a dielectric source typical sources include forming gas anneals or hydrogen plasma exposure.

Forming gas annealing causes no damage to silicon surfaces, and has been demonstrated to be capable of significantly improving surface passivation of Si/SiO2 interfaces [7], [8], however because the hydrogen is in the molecular form it is less effective in the absence of surface damage or a layer to split the hydrogen molecules [2]. In contrast direct exposure to a hydrogen containing plasma introduces vastly greater concentrations of atomic hydrogen, unfortunately a consequence of the plasma exposure is significant damage to the silicon surface [2]. This damage can be greatly reduced through the use of a remote hydrogen plasma system [9], [10], where the plasma is confined such that there is no direct line of sight between the plasma and the samples. Such systems have been successfully used in high efficiency passivated contact cell architectures [11].

The primary sources of damage from plasmas are a) hard UV radiation, b) impingement of energetic particles and c) charge deposition on unearthed surfaces (e.g. on an existing dielectric layer). The effect of each of these will vary based on the structure of the sample being exposed and the temperature of exposure. In a recent letter the authors proposed Shielded Hydrogen Passivation (SHP) as an alternative approach to avoid such damage, whilst still exposing samples to atomic hydrogen [12]. This was achieved through the insertion of an appropriate "shield" between a hydrogen containing plasma and the samples. In order to be most effective this shield should possess the following properties:

- 1. It should not transmit UV radiation
- 2. It must be chemically stable such that it is not itself damaged through plasma exposure
- 3. It should be electrically conductive such that it can be grounded. This ensures that electrical charges will not penetrate and build up on the sample
- 4. It should be highly permeable to hydrogen

The materials most likely to fill all these requirements are metals, with the extensively studied interactions of palladium with hydrogen making this a logical starting point.

1.1. Behavior of hydrogen in palladium

The diffusion mechanisms of hydrogen through palladium are well known due to extensive research in the hydrogen purification sector [13]. Palladium is commonly used as a purification membrane due to its catalytic properties and the high concentration of hydrogen that can be dissolved in the bulk [8]. The diffusion of hydrogen through palladium occurs in distinctive steps, as described by Pick *et al* [14].

If the hydrogen source is in molecular form, the first step, upon reaching the surface of Pd, is its dissociation into atomic hydrogen adsorbed to the metal surface. Atomic hydrogen then diffuses into the bulk until it reaches the opposite surface (diffusion of molecular hydrogen through the bulk does not occur). The release mechanism of hydrogen from Pd is usually reported as a recombinative desorption process by which atomic hydrogen recombines into its molecular form on the surface and is only then released into the surroundings.

The situation in the present work is different to most reported conditions in that the Pd is exposed to atomic hydrogen from the plasma. This condition means that the catalytic action of dissociating molecular hydrogen into its atomic form before transport is no longer required. In the experiments presented in this paper, there is still fast transport of atomic hydrogen through bulk Pd, but the recombinative desorption step is counterproductive as it would release molecular hydrogen from below the shield, which is not useful in passivating defects in silicon [15].

Since results presented here have shown successful introduction of atomic hydrogen into silicon samples using SHP, it is inferred that atomic hydrogen is released from the surface of the Pd shield. The authors do not believe that exposing Pd to an atomic hydrogen source has stopped the release of molecular hydrogen, but that it leads to

Download English Version:

https://daneshyari.com/en/article/5444567

Download Persian Version:

https://daneshyari.com/article/5444567

Daneshyari.com