



ELSEVIER

Contents lists available at ScienceDirect

Data in Brief

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

Data Article

Optical properties and impedance spectroscopy analyses for microscale Si pillar solar cells



Malkeshkumar Patel, Joondong Kim*

Photoelectric and Energy Device Applications Lab (PEDAL) and Department of Electrical Engineering, Incheon National University, 119 Academy Rd. Yeonsu, Incheon 406772, Republic of Korea

ARTICLE INFO

Article history:

Received 12 May 2017

Received in revised form

7 June 2017

Accepted 10 July 2017

Available online 14 July 2017

Keywords:

Si pillars

Optical properties

Impedance spectroscopy

Reflectance profiles

ABSTRACT

In this data article, optical properties and impedance spectroscopy analyses were applied for the 5 μm -height pillar Si solar cells to analyzed the insight of the Si geometric effect (Yadav et al., 2017) [1]. The surface reflectance data measured for all Si pillar samples (Fixed height of 5 μm with varying width and period. Geometric features of Si pillars are summarized in Table 1) are presented. Statistical data after analysis are summarized in the table, to profile the integrated reflectance quantitatively. Impedance spectroscopy analyses of all the samples were performed to demonstrate the bias-dependent space charge region. Mott–Schottky investigation shows the enhancement of built-in potential values due to the pillar structures.

© 2017 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

Specifications Table

Subject area	Physics, Electrical Engineering
More specific subject area	Solar cells
Type of data	Figures, Table
How data was acquired	UV-visible spectrophotometer (UV-2600, Shimadzu), Potentiostat/Galvanostat (ZIVE SP1, WonA Tech, Korea)

* Corresponding author.

E-mail address: joonkim@inu.ac.kr (J. Kim).

Data format	Analyzed
Experimental factors	Optical Reflectance: 5 μm -height pillar Si solar cells Impedance spectroscopy: Frequency range 1 MHz to 1 Hz Bias range \rightarrow -0.7 V to 0.4 V in step of 0.1 V Mott-Schottky: Frequency \rightarrow 20 kHz Bias range \rightarrow -0.8 V to 0.4 V
Experimental features	Realizing high-performing Si solar cells by using periodic structures
Data source location	Incheon National University, Incheon-406772, Korea
Data accessibility	The data are with this article

Value of the data

- Area under the curve of reflectance of the Si microscale pillar solar cells would be useful to estimate the overall reflectance quantitatively; this analysis could be applicable to efficient anti reflectance coating researches.
- The bias dependent impedance spectra revealed the functional modulation of the space charge region of Si pillar solar cells.
- The Mott–Schottky measurement demonstrates the enhanced built-in potential according to the pillar structures.

1. Data

Fig. 1 shows surface reflectance of various microstructured Si solar cell, recorded by diffused integrated sphere UV-visible spectrophotometer. Microstructure Si samples are well detailed in our report [1]. Table 1 shows the integrated area under the curve of reflectance profiles. Impedance

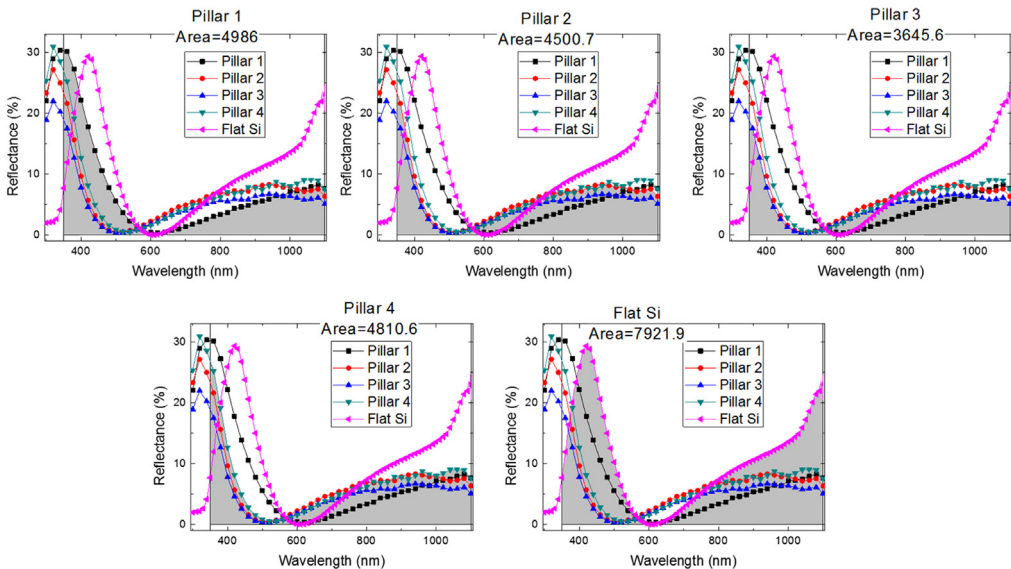


Fig. 1. Reflectance profiles microstructure Si solar cells. Area was integrated for the photon wavelength range from 350 nm to 1100 nm. Solid gray region is shown for integration function.

Table 1
Parameters of 5 μm scale Si pillar structures. Summary of integrated area under the curve of reflectance spectra, as shown in Fig. 1.

Sample	Area under the curve = $\int_{350\text{nm}}^{1100\text{nm}} R(\lambda) d\lambda$
Flat Si	7921.9
Pillar 1 (width=2 μm , period=4 μm , depth=5 μm)	4986.0
Pillar 2 (width=2 μm , period=7 μm , depth=5 μm)	4500.7
Pillar 3 (width=5 μm , period=7 μm , depth=5 μm)	3645.6
Pillar 4 (width=5 μm , period=10 μm , depth=5 μm)	4810.6

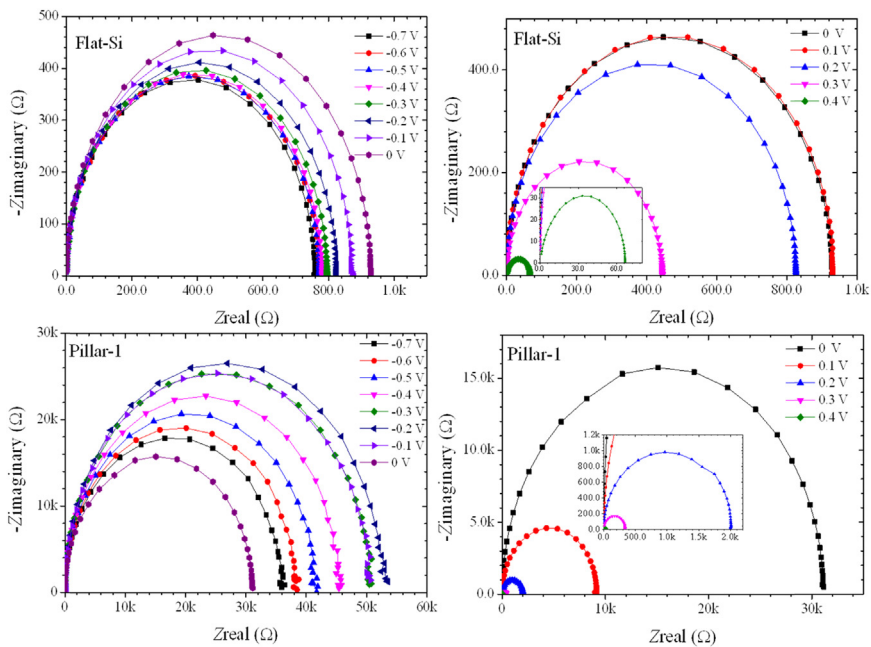


Fig. 2. Impedance spectra of the planar sample and pillar-1 at different applied bias.

spectra of the reference flat Si device and champion pillar-1 device are shown in Fig. 2. Impedance spectra of the pillar Si devices are shown in Fig. 3. Impedance spectra of all the devices are shown for forward and reverse bias dark conditions. The Mott–Schottky characteristics of all the samples are shown in Fig. 4.

2. Experimental design, materials and methods

2.1. Sample preparation

The 500 μm thick p-type (100) Si wafer (Czochralski) was used as a base substrate. To form the microscale pillar structures, the photolithography mask patterns were previously formed on the Si substrate, which serve as the etching mask during the Si etching process. The exposed Si region is going to etch away. For the reactive etching, SF_6 -plasma was employed for several loops for 10 min to etch the residual polymer layer and the exposed Si parts without the PR masks.

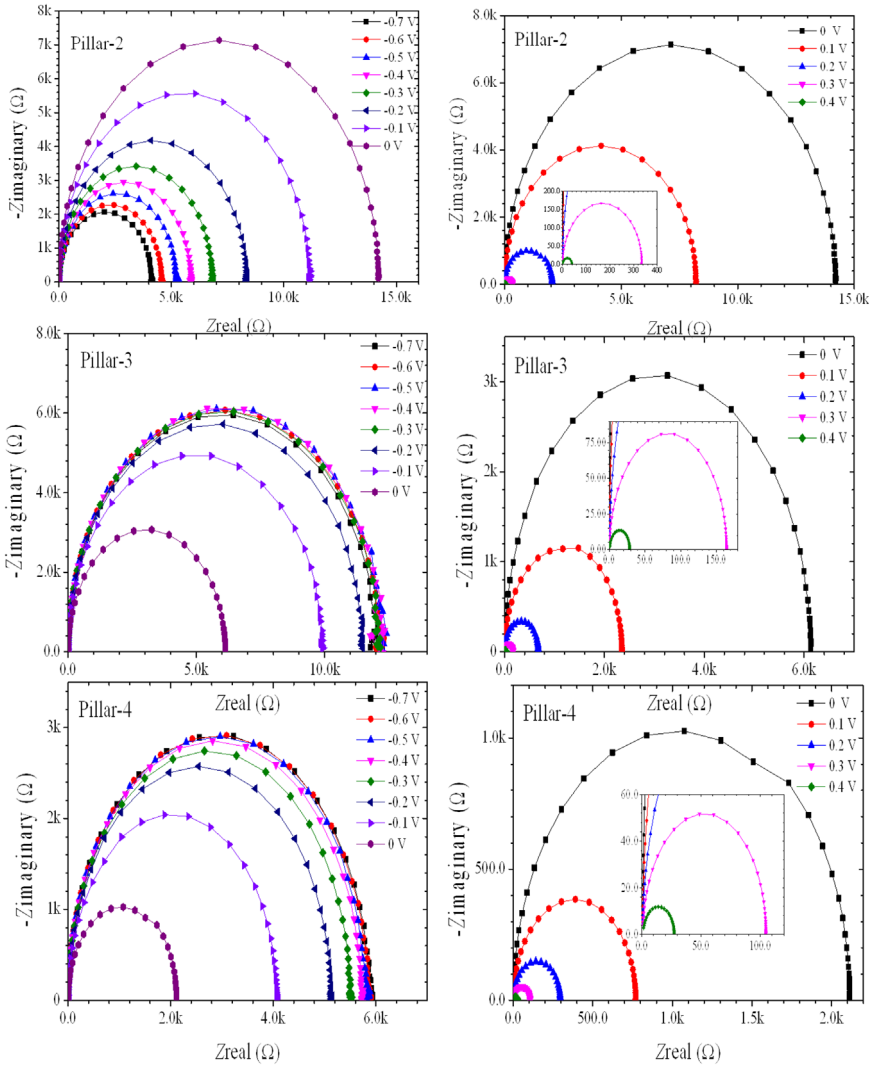


Fig. 3. Electrochemical Impedance Spectra of pillar-2, pillar-3 and pillar-4 at different applied bias.

For the formation of a p–n junction, n-type doping was done using phosphorous oxy-chloride (POCl₃) source. After the formation of the n-type layer, a buffered hydrofluoric acid (5% HF) solution was used to remove the phosphosilicate glass (PSG). A thin 80 nm SiN_x layer was formed over n-type layer, which actively acts as an antireflection coating and passivating layer. The size of the samples was 3.2×3.2 cm² which is among one of the most efficient micro-structured solar cell with this area. The metal contacts were formed by screen printing the silver (Ag) and aluminium (Al) paste at front and back contacts, respectively, before co-firing. Planar cells with the same area but without any micro-structures were used to produce a planar junction device for the performance comparison [1].

2.2. Sample characterizations

Reflectance data for the fabricated samples between the wavelength ranges from 300 nm to 1100 nm are presented in Fig. 1. An integrated sphere attachment supplied with UV–vis

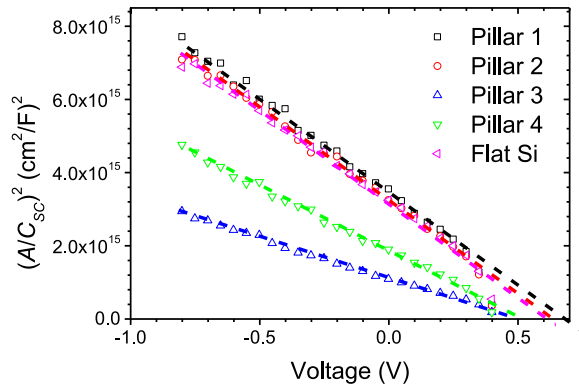


Fig. 4. Mott Schottky plots for all the fabricated devices.

spectrophotometer (Shimadzu-2600) was used for carrying out the diffused reflectance measurements. A necessary baseline correction was done prior to recording the reflectance spectra by using BaSO₄ pallets. The area under the curve of reflectance profiles shown by Gray solid region is summarized in Table 1. The area under the curve was estimated over the photon wavelength range 350 nm (lower limit) to 1100 nm (upper limit). Integration function was applied for summing the finite region of interval 1 nm.

Impedance spectra of the planar and the Pillar 1 device are presented in Fig. 2. These data were measured in the dark condition for the forward bias and reverse bias conditions. The cole-cole plots for reverse bias (left) and forward bias (right) of the flat and pillar-1 devices are shown discretely. These data were recorded for the applied bias range from -0.7 V to 0.4 V with an interval of 0.1 V. These measurements were performed over the frequency range from 1 MHz to 1 Hz. Fig. 3 shows the cole-cole plots recorded for the Pillar-2, pillar-3 and pillar-4 devices. These plot shows the relation of real impedance (Z') vs imaginary impedance (Z'').

Mott–Schottky characteristics ($1/C^2$ -V characteristics) obtained by using the Potentiostat/Galvanostat (ZIVE SP1, WonA Tech, Korea) is shown in Fig. 4. The Potentiostat/Galvanostat was calibrated with a standard static and dynamic circuit before the impedance and Mott–Schottky measurement. The MS measurements were performed at 20 kHz of frequency.

Acknowledgements

The authors acknowledge the financial support of the Basic Science Research Program through the National Research Foundation (NRF) of Korea by the Ministry of Education (NRF-2015R1D1A1A01059165), Korea Research Fellowship Program through the NRF by the Ministry of Science, ICT and Future Planning (NRF-2015H1D3A1066311) and Incheon National University.

Transparency document. Supplementary material

Transparency data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.dib.2017.07.016>.

Reference

- [1] Pankaj Yadav, Malkeshkumar Patel, Hyunyub Kim, Hyunki Kim, Joondong Kim, Junsin Yi, Dong-Wook Kim, Routes for realizing high-performing Si solar cells by using periodic structures, Mater. Res. Bull. 94 (2017) 92–99. <http://dx.doi.org/10.1016/j.materresbull.2017.05.027>.