Area: Crystalline and Thin Film Silicon PV

LONG-TERM DEGRADATION OF FRONT SIDE COPPER METALLIZATION OF SILICON SOLAR CELLS

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The global photovoltaic module production capacity at the end of 2016 was estimated to be > 90 GWp; the market share of above 90% for the crystalline silicon solar cells [1]. Currently, contact formation using screen printing is the dominant technology in the silicon based photovoltaic industry, as it is simple and fast. However, metallization of this kind has the disadvantage in having a lower aspect ratio and higher contact resistance, high cost, limiting solar cell efficiency [2, 3]. Using Ni/Cu plating techniques is a good solution to improve the efficiency of metallization processes with precision and low contact resistance.

In this work , we formed a Cu/Ni/Si structure, the Ni and Cu film were deposited on textured silicon substrate by electroplating process replacing the expensive sputtering process. The electroless Ni film was first deposited on textured Si substrate and the electroless Ni samples were annealed at 500 ^{o}C. Then Ni surface etching was done in an HNO_3 solution to remove unreacted nickel. Afterward, Ni and Cu plating using electroplating arrangements were applied to form the Ni barrier layer and Cu electrode, respectively. The electroplating times of nickel layer were 120 second. The electroplating times of copper layer are 750 second. The Cu/Ni/Si samples were annealed isothermally in furnace at 300 - 800 ^{o}C in Ar/H_2 atmosphere for 10 min.

Fig. 1 show STEM image of sample annealed at 300 and 500 ^{o}C. After annealing at 300 ^{o}C, the multilayer structure appeared to be preserved (Fig. 1(a)). EDS STEM maps using the (a) Cu K, (b) Ni K and (c) Si K lines. STEM-EDS imaging allowed us to find the formation of nickel silicide layer between the nickel layer and silicon substrate. EDS profiles show that copper do not diffuse into the silicon substrate. Spot TEM–EDS analysis from the nickel silicide layer reveals the presence of Ni_2Si. It showed that the diffusion barrier of nickel layer and/or nickel silicide are stable with copper and silicon at 300 ^{o}C. Agglomeration is observed after annealing at 500 ^{o}C for 10 min, which suggests that the rupture of the barrier layer has taken place (Fig. 1(b)). STEM-EDS imaging show that copper diffuse into silicon substrate.

This work has investigated the diffusion barrier performance of electroplating nickel film for Cu metallization. The diffusion barrier properties of nickel film against Cu penetration have been investigated by STEM. The nickel film was found to be against Cu at 300 ^{o}C.

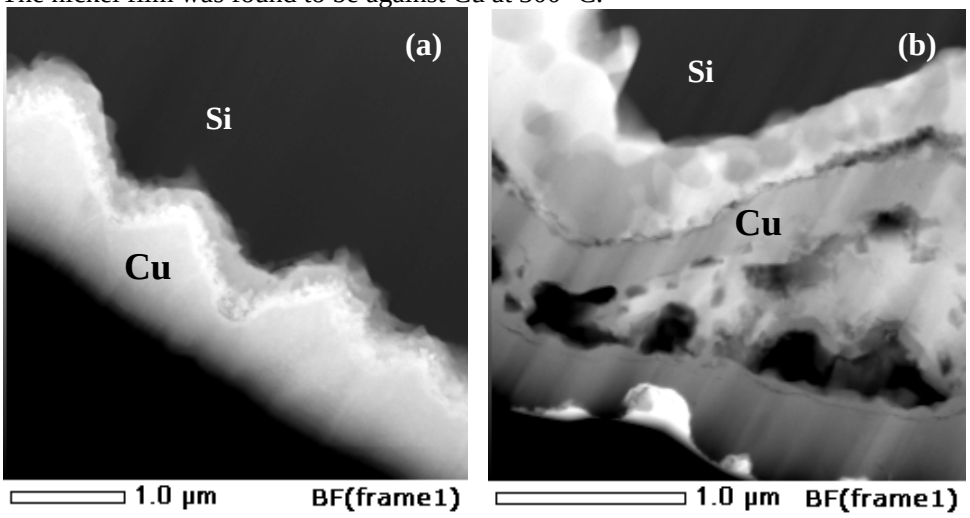

Figure 1: STEM image of sample annealed at (a) 300 and (b) 500 ^{o}C for 10 min.

[1] Inter. Technology Roadmap for Photovoltaic Results 2016, ITRPV 8th Edition 2017.
[2] A. Rehman, S.H. Lee, Materials 7 (2014) 1318 – 1341.
[3] A. Rehman, S.H. Lee, E.G. Shin, S.H. Lee, Materials Letters161(2015)181–184.