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Junctionless ultra-thin c-Si Solar cell with metamaterial back reflector

M. Choudhuri[1], A. Dhar[2], P. Banerjee[2], A. B. Roy[2], A. Kundu[2*]

[1]Department of ECE, Dr. Sudhir Chandra Sur Degree Engineering College, Dumdum, 700074, India
[2]Centre of Excellence for Green Energy and Sensor Systems (CEGESS), Indian Institute of Engineering Science and Technology (IIEST), Shibpur, 711103 India
[*]Email: kunduavra@gmail.com

A rear planar metallization is conventionally used which acts both as an electrical contact and an optical reflector in solar cells. However, a conventional mirror (electric mirror) reflects the light with a phase reversal of the incident wave, causing a reduced field intensity at the reflective surface, which is detrimental for ultra-thin substrates. Here we present a metamaterial mirror that can significantly enhance the light trapping capability.

Metamaterial mirror are capable of retaining the phase of reflected light and thus enhancing the electric field near mirror surface due to the increased surface impedance [1]. By simulation, it has been observed that the maximum electric field enhancement occurs at a groove depth of 80nm. However, nanostructuring the metal surface increases the contact area thereby increasing the surface recombination of charged carriers. To address this, a dielectric carrier selective contact (minority carrier mirror) between silicon and metal contact is implemented and the efficiency can be maximized as charge carriers can be collected at the quasi Fermi level [2]. This can be achieved by pinning the Fermi level at the metal work function. Hence, by properly tuning the dielectric band gap, metal work function with silicon band gap, a junctionless solar cell is formed. An efficiency of 7.3% in 10µm silicon and a 20% increment in efficiency is observed for structure with a metamaterial mirror. Figure 1a shows the proposed solar cell architecture and Figure 1b shows the significant electric field enhancement near mirror surface with the use of magnetic mirror as compared to that of a plane mirror when TM polarized light is incident over the structure, simulated using FEM technique.

In conclusion we present that metamaterial mirror enhances the generation of electrons and holes in ultra-thin silicon solar cell, also the recombination losses can be minimized by the implementation of carrier selective contact. In Figure 2, the ban diagram and current density vs. voltage curve are shown, evidently describing the junctionless cell property of the structure. Further it has been explained that the use of junctionless technology reduces the thermal budget thus addressing the low manufacturing cost.

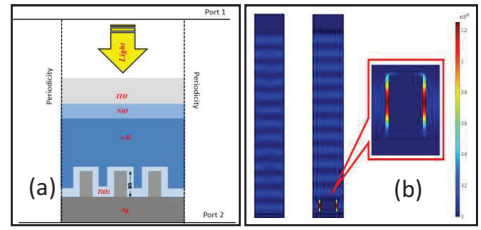

Figure 1: (a) Proposed solar cell structure, and (b) electric field enhancement by metamaterial mirror

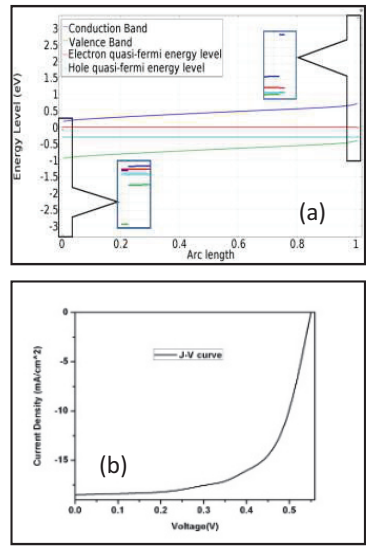

Figure 2: (a) Band diagram of the proposed structure, and (b) J-V curve

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