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Design and optimization of ultrathin crystalline silicon solar cells using an efficient back reflector

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Thin film solar cells are cheaper but having low absorption in longer wavelength and hence, an effective light trapping mechanism is essential. In this work, we proposed an ultrathin crystalline silicon solar cell which showed extraordinary performance due to enhanced light absorption in visible and infrared part of solar spectrum. Various designing parameters such as number of distributed Bragg reflector (DBR) pairs, anti-reflection layer thickness, grating thickness, active layer thickness, grating duty cycle and period were optimized for the optimal performance of solar cell. An ultrathin silicon solar cell with 40 nm active layer could produce an enhancement in cell efficiency ~ 15 % and current density ~ 23 mA/cm^2. This design approach would be useful for the realization of new generation of solar cells with reduced active layer thickness. [http://dx.doi.org/10.1063/1.4921944]

I. INTRODUCTION

Today, the cost reduction of silicon solar cells is a serious issue to scientific community. To address this issue, thin film technology has been employed and demonstrated the low cost silicon solar cells whereas such thin film silicon solar cells are having poor absorption in longer wavelength region due to indirect band gap of silicon material. To overcome this problem several design schemes have been reported in literatures such as textured grating, dielectric grating, metal nanoparticles or nanograting, alternate arrangement of metal/dielectric grating etc.[1–5] These ideas are found to be effective because of scattering the incident light and coupling it into the fundamental material. Recently, application of metal nanostructures such as nanoparticles/nanograting in solar cells have found to be promising for light trapping due to plasmonic surface which yields efficient guiding and manipulation of photons through a mechanism of collective oscillating electrons at the surface of the metal nanostructures. Surface plasmon resonance can be induced between the propagation path of light and metal surface which can ultimately enhance the absorption of light to an optimal level. In simple words, surface plasmon is nothing than gathering of electrons at the surface of metal which makes a path of propagation along it and surface plasmonic energy is concentrated at the tip of metal nanoparticels/nanogratings. Due to this unique nature, surface plasmon resonance have found its application in solar cells which contribute to the enhancement of light absorption if the metal nanostructure is placed adjacent to active region of solar cell.

Xiao et al. have reported a design of an ultrathin-film silicon solar cell configuration by using one-dimensional plasmonic nanograting onto the bottom of the solar cell.[6] They have observed 90 % enhancement of photocurrent in the considered wavelength range through a 200 nm thickness crystalline silicon solar cell. The analysis of obtained result was suggested for the realization of

