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Large area $CuInGaSe_2$ Nanodome array structures using silicon Nitride-based Nanotip Arrays as a Template for solar cell applications

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Quaternary semiconductor copper indium gallium diselenide (CIGS), due to their promising abilities and performance, is one of the most efficient absorber material for solar cell applications for addressing our future energy needs [1]. The band gap of CIGS can be adjusted from 1.04 eV to 1.67eV and CIGS solar cells have ability to use very thin absorber layers in the order of several micrometers in thickness [2]. Nanostructures have attracted much attention from researchers due to their fundamental properties [3]. Particularly, Nanodome structures combines many nanophotonic effects to both efficiently reduce reflection of light and enhance absorption of light over broad spectral range [4]. For all photovoltaic devices, to improve the performance and reduce the cost, efficient light management by both enhancing optical absorption and reducing incident light reflection are important [5].

In the present study, CIGS nanodome array structures were prepared using silicon nitride nanotip arrays (SiN-NTAs) on the silicon substrate as a template. Using dry etching technique, the SiN-NTAs were prepared with nanotip height of ~ 400 nm and a period of ~ 1 µm. Molybdenum of thickness 500 nm was deposited on surface-cleaned SiN-NTAs substrate by sputtering technique [see Fig.1]. CIGS with different thickness of 500 nm, 1 µm, 1.5 µm and 2 µm were deposited on the molybdenum layer by sputtering with better uniformity. As CIGS thickness increases from 500 nm to 2 µm with an interval of 500 nm, nanostructure morphologies changed from well separated nanodomes to overlapped nanodomes [Refer Fig.2]. Crystalline nature and pure chalcopyrite phase of CIGS was confirmed by XRD analysis. From optical images, comparatively 500 nm CIGS thickness nanodomes sample looks more dark black in colour. Lowest reflectance was observed in lower wavelength region (400-900 nm) for nanodomes with thickness of 500 nm as well as in higher wavelength region (950-1100 nm) for nanodomes with thickness of 1.5 µm. The band gap of 1.02 eV was observed from differential reflectance spectra. We believe that demonstrated CIGS nanodome array structures can boost the device efficiency. Solar cell device fabrication based on these nanodome structures is under process.

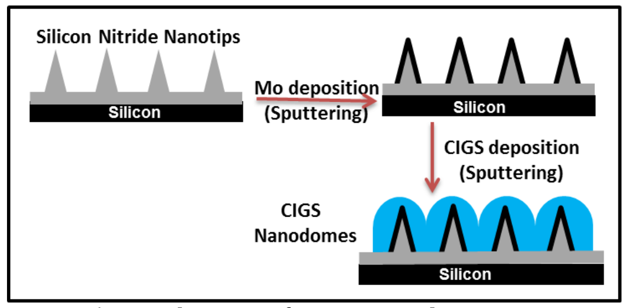

Fig.1: Schematic of CIGS Nanodome array.

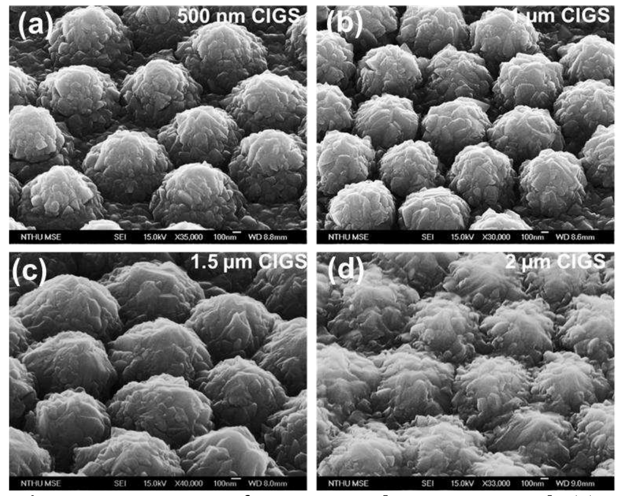

Fig.2: SEM images of CIGS nanodome arrays with (a) 500 nm CIGS (b) 1 µm CIGS (c) 1.5 µm CIGS (d) 2 µm CIGS

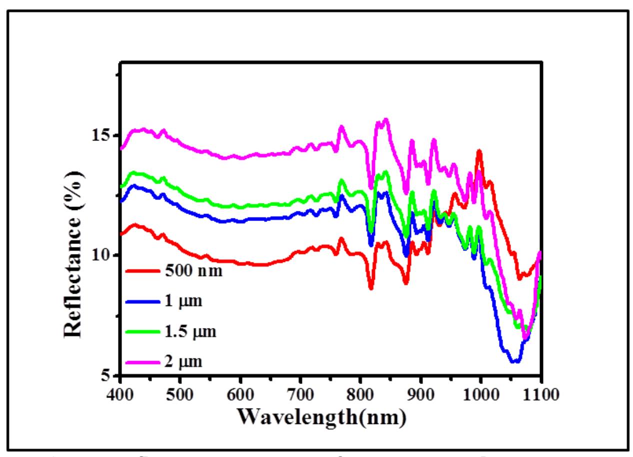

Fig.3: Reflectance spectra of CIGS Nanodome arrays with different CIGS thickness.

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