Poster Presentation

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Sustainable single source precursor derived quantum cutting $Si_{1-x-y}Ge_xC_y$ Thin films

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Owing to its unlimited abundance, the successful conversion of solar energy to electric current with high efficiency have been a topic of interest in recent days. A conventional solar cell made of crystalline Si is limited by the Shockley-Queisser limit of only 33%, which states the highest attainable conversion efficiency (from solar energy to electricity) of the solar cell material. The value obtained is based under the assumption that upon absorption of a single electron-hole pair by a single photon in a conventional solar cell, the major portion of photon that was absorbed is wasted by means of phonon scattering and thermal radiation (thermal losses). The unfavorable efficiency coupled with cost factors associated with respect to starting material, high temperature processing steps and strict parameter controls questions the sustainability of conventional cells in commercial domain.

Reduction of high energy loss and non-dissipative recombination mechanisms coupled with prospects to enhance energy harvesting are some of the futuristic approach in the design of efficient photovoltaic devices. Though efforts are made with triple junction devices such as integrated devices based on GaInP and GaInAs and Ge which could attain an efficiency of 40.7% under concentrated sunlight, costs associated with production does not favor sustainable commercialization. Henceforth, it is realized that ideally a single junction solar cell circumventing the aforementioned losses by utilization of the excess energy of hot carriers by either Carrier Multiplication or Multi Excition Generation which basically yields higher photo-voltage via extraction of hot carriers prior to thermalization and/ or generate multiple electron-hole pairs per photon enhancing the photocurrent, is desired for sustainable solar cell production and energy conservation. Quantum cutting materials which basically adopts downconversion phenomena with the absorption of a single photon whilst emitting multiple photons coupled with quantum efficiency higher than 100% is often found attractive for this application. PbS and CdSe and lanthanides are the usual materials utilized for this purposes however, owing to the high costs of starting materials and concerns over toxicity, the sustainability and cost-effectiveness of these materials are highly questionable. Though not widely studied, reports on earth abundant materials containing Si, Ge and C and its prospects as highly efficient and nontoxic spectral converter have been studied by Timmermann et al and others.

In our present study, single source precursor containing the elements desired Si, Ge and C have been synthesized and fabricated into Si1-x-yGexCy thin films by Low Pressure Chemical Vapour Deposition onto two different substrates. Thin films attained in both substrates exhibit quantum cutting behavior with QE exceeding that of 400% and 500% in some cases. The compositional analysis, thin film thickness, morphology and particle size examined by various characterization techniques provide insights into the possible downconverting mechanisms in the thin films. The simplicity and hostile environment-friendly approach adopted in the synthesis and cost-effective fabrication of thin films coupled with interesting optical properties observed, provides avenue and insights in the prospective usage and integration of this compound and thin films in sustainable photovoltaics and potential optoelectronics applications.

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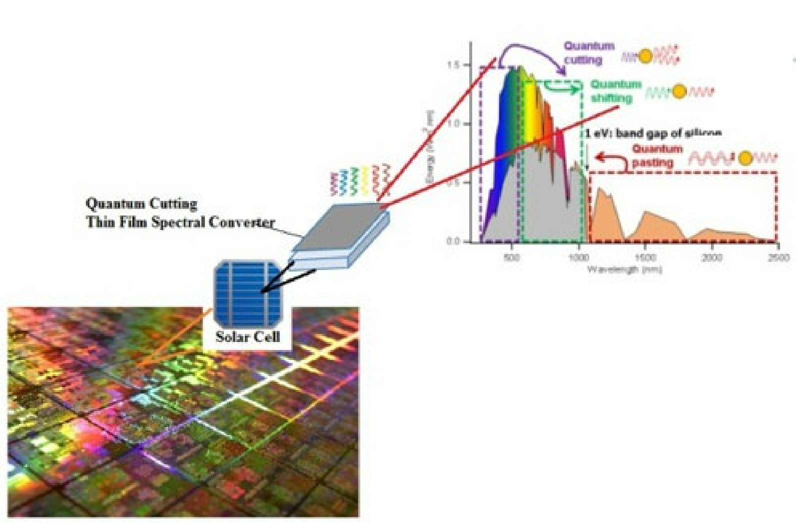

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