3. REVIEW OF LITERATURE

[Vikram Bhosle, et.al, 2013] had presented an improvement in c-Si solar cell performance for high sheet resistance (Rsheet) emitters fabricated by ion implantation. Author investigated the effect of sheet resistance (60–115 Ω/sq) on cell efficiency (CE) and also evaluated the effect of dopant profile shape on the contact resistance for the ion implanted emitters and showed that the best results were obtained for those cells with emitter Rsheet ~ 70-75 Ω/sq. Simulation had done using TCAD which showed that the use of Nd at a depth of the order of 10’s of nm below the Si surface leads to better agreement between the experimental and simulated Rseries, FF and CE than assuming that the contact is made with Si at the original wafer surface. Fully implanted blanket emitter (homogenous emitter) cells were fabricated on p-type Cz wafers using standard solar cell processing with screen printed front Ag (DuPont Solamet PV17A) and Al (Monocrystal 1203). The doping level in the emitter regions is controlled via precision doping enabled by ion implantation, which leads to formation of a high quality emitter. Dry oxidation is implemented during the subsequent anneal of the implanted dopant to simultaneously passivate the emitter with the thermal oxide that is retained in the finished cell structure since there is no PSG clean required after anneal. To evaluate the effect of sheet resistance on the performance of ion implanted cells, namely emitter quality and contact resistance, the Rsheet (60 – 115 Ω/sq) was systematically varied by varying the implanted dose. The characteristic change in CE due to emitter Rsheet had been studied. The optimal CE (avg ~ 19.43%,) was achieved for emitters with Rsheet in the range 70-75 Ω/sq. The results provided may be a guide for further optimization of the emitter profile via ion implantation [33].

[Namjoon Heo, et.al, 2013] has presented a topology optimization for thin film Si solar cell to improve the efficiency in a specified wavelength range from 700 nm to 800 nm. The authors had discussed the previous work in which optimal texturing design of back reflector for a single wavelength using the so-called SIMP method based topology optimization has been demonstrated and it was confirmed that optimal back reflector shape obtained by the method is effective for light trapping and improving the energy flux efficiency in the absorbing layer. In topology optimization, the material distribution was changing and the problem solving were performed repeatedly during the iterative process for finding the optimal material distribution. The design process was performed until the iteration number reached 150 and convergence histories for three wavelength cases and it has been observed that there were many fluctuations in initial stage: however, as the iteration number is
increased, the objectives are converged. The system was composed of the light absorbing Si layer, the back reflector and the top transparent conducting oxide (TCO) layer. The incident beam passes through the Si absorbing layer between the top TCO and the back reflector layer. The silicon-absorbing layer is located in the middle of the top TCO layer and the bottom TCO layer. A thin film metal layer is positioned under the bottom TCO layer to make the wave reflection. The topology optimization based design method for texturing back reflector design was proposed to maximize energy flux efficiency of a thin film solar cell. The suggested method considering different wavelengths simultaneously associated with the scaling weighting factor showed more improved result than the result of single wavelength consideration case or that of multi-objective case using even weighting factor value. The suggested design method combining the topology optimization scheme with the scaling weighting factor concept is valid to design the back reflector structure for the light trapping effect even for considering a specified wavelength range. In future, simple and effective structure design considering the manufacturing feasibility can be obtained [25].

[Michael G. Deceglie, et al., 2013] had presented accounting for localized defects in the optoelectronic design of nanostructure thin film a- Si: H solar cells. Nanostructure of thin film solar cell offers a promising route toward increased efficiency through improved light trapping to optimize device efficiency. The authors approach was based on coupled optical and electrical simulations in which the optical generation rate is calculated from full-wave electromagnetic simulations and taken as input into a finite-element method (FEM) device physics simulation. The region of degraded material represents a recombination active internal surface (RAIS) that is formed during deposition. Such localized regions of low-density low-electronic-quality material quality were known to form during plasma enhanced chemical vapor deposition (PECVD). The introduction of RAIS’s is found to adversely affect performance. When RAISs are included in the electrical simulation, the AM1.5G energy conversion efficiency is reduced from 7.71% to 5.90%, Jsc from 10.69 to 9.79 mA.cm\(^{-2}\), Voc from 0.954 to 0.864 V, and FF from 76.3 to 70.4. After Studying the simulated spectral response of those devices, reveals interactions between the generation profile and the geometry of the device and RAISs themselves. Simulated result shown the EQE as a function of wavelength for three cases: 1) a control in which the a-Si: H is assumed to maintain high quality, with a peak dangling bond density in the intrinsic region of 2\(\times\) 10\(^{17}\) cm\(^{-3}\) · eV\(^{-1}\) 2) a device in which the intrinsic a-Si: H has a uniformly degraded material quality without explicitly considering localized defects.; 3) the peak dangling bond density in the intrinsic region is increased to 1.08 \(\times\) 10\(^{18}\) cm\(^{-3}\).eV\(^{-1}\). Authors demonstrated the use of coupled multidimensional optical and electrical simulations for the study of the optoelectronic device
physics of localized defects that are induced by nanostructures in thin-film solar cells. An empirical study on morphologically dependent material quality for a specific process in order to fully understand and optimize the optoelectronic design of thin-film solar cells had been proposed. Further, more approach provides a framework within which light trapping designs for different photovoltaic material systems, which are governed by different practical limitations, can be optimized[22].

[Ines Massiot, et.al, 2013] had proposed a novel design using multi-resonant absorption to achieve efficient light-trapping in ultra-thin (< 100 nm) solar cells. The proposed design is based on a patterned metallic layer which i) strongly confines light in an ultra-thin and flat absorber layer and ii) plays the role of a front contact combining high optical transparency and good electrical conductivity. Confined light in ultrathin solar cells using a patterned metallic layer is used to achieve multi-resonant absorption while keeping a flat absorber layer. A periodic metallic grating embedded in transparent material made as a front electrode. Designed was proposed with the absorber layer sandwiched between a one-dimensional (1D) or two-dimensional (2D) nanostructured metallic layer (period p, width of the wires w and metal thickness hm) and a back metallic mirror for light trapping. The nano patterned metallic film used as a front contact is coupled to a metallic back mirror in order to confine light and achieve multi-resonant absorption. The geometrical parameters of the metallic grating were chosen to fulfill the following requirements: i) broadband absorption spectrum, ii) no polarization dependence and iii) low angle dependence. The alternative contact allows strongly confined light in ultra-thin and flat absorber layers to reduce parasitic losses in the front electrode of the cell. The design proposed for 2D patterned with metallic front electrode on a 25 nm-thick GaAs layer. Short-circuit current density of 21.6 mA/cm2 had been reached for an ultra-thin GaAs absorber layer sandwiched between a silver 2D nano grid and a silver back mirror. This work can pave the way towards the design of realistic high-efficient ultra-thin GaAs solar cells [14].

[Vikash kumar, et.al, 2014] has developed a computer simulation using technology computer aided design (TCAD) to improve the short circuit current (Isc) and internal quantum efficiency (IQE) without reducing the open circuit voltage (Voc). It is done by introducing a p+ pocket with a high doping density of the magnitude >1018 cm-3 to increase the electric field near the junction to values near 1 mv/cm. By introducing this change, key solar cell parameters like Jsc, Voc, efficiency and quantum efficiency were investigated. The simulation results showed that high doping density of p+ pocket enhances the current density without affecting the voltage and by varying the doping concentration of the p+ pocket from 1018 cm-3 to 9x1018 cm-3. The current density increases from 18mA/cm2 to 32mA/cm2. In
addition, simulation results also show that internal quantum efficiency (IQE) can reach up to 1.89 with very highly doped p+ pocket (9x10^{18} cm^{-3}). In order to study the effect on the solar cell performance, current vs. voltage plot were simulated and plotted. The result shown a sudden increase in current density at low voltage. The abrupt spike in the value of current density at lower voltage was due to the fact that impact ionization is prominent in reverse bias. The output current density increases from 18 mA/cm² to 32mA/cm² when the doping concentration of P+ pocket varied from 1018 cm^{-3} to 9x10^{18} cm^{-3} (with electric field of magnitude was 5.8 x 105 V/m) and IQE was achieved the value of 1.89 for P+ doping density of 9x10^{18} cm^{-3}. In the future, with proper cell design and introduction of the P+ pocket in the absorber layer, the Impact Ionization can be used to increase the output current density of the solar cell without reducing the Voc and hence improve the overall performance of the thin film c-Si solar cell in hardware implementation [32].

[Yusi Chen, et.al 2014] has presented the design, simulation, fabrication and characterization of nanostructured dielectric layer silicon solar cell using SiNx on a high quality planner PN junction Si solar cell. Reflection <10% was achieved over a wide spectral range and incident angle. In addition, 44% improvement of power conversion has been attained compared with a planner Si cell. Justification of the problem was illustrated through optical simulation using finite-difference-time-domain (FDTD) in FDTD solutions from Lumerical, Inc. The nanostructures simulated were an array of pyramids on top of Si with a 600nm × 600nm base and 600nm height, the input refractive index of SiNx was 2.1. A virtual broadband source with wavelengths from 400-1050 nm was used for illumination at normal incidence. The simulations were allowed to run until the wave decays to 10^{-6} of its original intensity. Data monitors placed on top of the simulated array measured the reflected light. Perfectly matched layers were used in the z-direction to minimize unwanted reflections, while boundary conditions in the x and y-directions were periodic. From the simulation result, nanostructured SiNx layer array reduces the reflection from >35% to <5% over a broad spectrum from 400 nm to 1050 nm. The nanostructures could maintain a <5% overall reflection from normal incidence up to 50 degrees off-normal incidence. The Si solar cell was fabricated using reduced pressure chemical vapor deposition (RPCVD) under 1000°C. 700 nm of SiNx was deposited on top of the solar cell using a Plasma-Thermal plasma-enhanced chemical vapor deposition (PECVD) tool under 350°C. The nanostructures were formed using silica nanosphere lithography. Reflection measurements were performed using a standard integrating sphere system. Solar cell current density-voltage (J-V) characteristics were measured under AM 1.5 G normal illumination (1000 W/m², 1sun) at room temperature. Nanostructure dielectric layer on a Si solar cell reduced the reflection to below 10% over a large range of
solar spectrum and at different incident angles. It has also improved the Jsc by 32% and power conversion efficiency by 44%. Such performance enhancement proves that nanostructured dielectric layers can achieve effective light trapping and antireflection. Combining the surface passivation effect of dielectric materials, nanostructured dielectric layer has great potential to produce high efficiency and lost cost nanostructured solar cells [41].

[Kamlesh Kukreti, et.al 2016] This research paper is an attempt to present a concise depth insight of organic solar cells /organic photovoltaic cells (OPVs). Subsequently, this paper also discusses various recent advancements in organic solar cells in terms of material, structures and other performance influencing factors. Furthermore, depth analysis of organic solar cells is included in terms of current density (JSC), fill factor (FF), short-circuit current (ISC), open-circuit voltage (VOC) and efficiency(η). This paper will be very much useful for the beginners of organic solar cells as emerging research area to convert their theoretical fundamental concept into device and circuit realization. This also discusses the small idea towards the different types of organic solar cells, Besides this, solar cell analysis is carried out using 2-D numerical device Atlas simulator, where impact of thickness variation of bulk heterojunction organic solar cells on performance parameter is performed[34].

[Prashanth Kumar Manda, et-al 2017] The built-in potential (Vbi) of an organic diode and solar cell is an important parameter that decides the rectification behavior of organic diodes and affects the open circuit voltage and thereby the efficiency of organic solar cells. In this paper, we propose a physics-based model and an experimental method to extract Vbi from current density–voltage (J–V) characteristics. The proposed model is developed by solving the carrier transport and the continuity equations to obtain the analytic equations for charge carrier profile and current density. The proposed method is thoroughly verified using numerical simulation results. Applicability of this method on experimental results is further validated for poly(3-hexylthiophene):phenyl-C61- butyric acid methyl ester solar cells. Finally, Vbi is extracted from dark J–V characteristics of fabricated devices[48].

[Caterina Stenta, María Pilar Montero-Rama, et.al 2017] A PTB7/PC71BM bulk heterojunction solar cell device where the conventional calcium hole-blocking layer has been replaced by a solution processed bathocuproine (BCP) layer is described. The bathocuproine thin film was deposited via spin coating from a dilute solution of BCP in a mixture of toluene and methanol directly on top of the active layer. The silver cathode was subsequently
deposited via thermal evaporation. The study shows that solar cells devices comprising solution-processed BCP show similar performance than devices made from either calcium or evaporated BCP. Moreover, the devices made from solution processed BCP show superior stability in air than calcium and evaporated BCP-based devices. This is to the best of our knowledge, the first report of the use of solution processed BCP in organic solar cells[51].