

Paper Printed Solar Photovoltaic Cells: A Review

Ajay Singh Meena¹, Dr. Virendra Sangtani²

Department of Electrical Engineering

^{1,2}Poomima College of Engineering (RTU, Kota) Jaipur, India

Abstract- *There is a developing requirement for sustainable power sources, and sunlight based power is a decent alternative in numerous cases. Photovoltaic sun powered boards are currently being produced by means of different techniques, and unique printing forms are being fused into the assembling procedure. Screen printing has been utilized most pervasively in the printing procedure to make sun oriented cells, yet a few organizations have utilized the balanced web press type techniques to put material onto foil; they additionally have made sun powered cells with inkjet printing. The printing of sun oriented cells has decreased assembling costs much of the time, and it additionally has expanded the different applications in which sun based power both is and can be utilized. A lot more alternatives for photovoltaic sun based boards are accessible, what's more, not just the customary ones that are frequently put on housetops. Such an assortment of sun based boards are mostly to the consequence of the execution of appropriate printing forms amid the creation of these cells.*

Keywords- Photovoltaic Power, Printing Solar Cells, Screen printing, Ink jet printing, Web Printing

I. INTRODUCTION

With the regularly expanding political and financial oil clashes just as environmental change, a developing requirement for sustainable power source that originates from common assets, for example, daylight, wind, downpour, tides, and geothermal warmth, is justified. Wars have been caused to a limited extent to secure oil supplies, and a great many huge amounts of poisons and ozone harming substances are produced into the environment consistently because of the consuming of petroleum products to make vitality. There is no other zone of innovation than sustainable power source advances that can both "address the difficulties of environmental change and secure a vitality supply in a clever way". Various choices for new innovations of sustainable power source exist, that is, from geothermal to twist to hydrogen power devices to hydropower; in any case, a standout amongst the most open and generally utilized advances is sun powered vitality. Sun powered power does not make any clamor when it is working, "is non-dirtying, does not create ozone harming substances, and makes no waste items, which is likewise why it is an undeniably favored sustainable power source. Moreover, the potential for sun

powered power is tremendous. The vitality from the daylight that strikes the earth for just forty minutes is equivalent to the worldwide vitality utilization for a whole year. The majority of that vitality is of no utilization, except if it very well may be caught. A decent strategy to saddle this gigantic measure of vitality and along these lines to in the end use it as power is using photovoltaic (PV) vitality framework.

II. PHOTOVOLTAIC POWER

According to the U.S. Branch of Energy (2010, p. 1), "the assorted variety, versatility, and seclusion of photovoltaic innovation make it unmistakable from other sustainable assets. "Photovoltaic power obtained from solar is amazingly helpful in light of the fact that it tends to be delivered in various ways from an assortment of materials, and it tends to be utilized for various purposes. Photovoltaic cells are usable for anything (e.g., from a little strip that is capable of controlling a straightforward number cruncher to individual boards on homes to bigger business strategies and sun oriented homesteads that have been spread out over immense regions of land). These modules are additionally helpful since they have inconsiderable upkeep costs and are amazingly dependable; a few makers offer up to 25-year warranties. Photovoltaic frameworks were the biggest maker of power specifically from sunlight based vitality on the planet in 2008, regarding kWh created every year.

The PV cell utilizes semiconducting materials to change over the vitality in daylight into power that can be used. The term photovoltaic can be interpreted as "Electrical vitality from light". The phones exchange the vitality of the photons infiltrating the sun powered boards to electrons that are "directed into an outer circuit for driving an electrical burden". A PV board consists of various photovoltaic cells, in between the range of 50 to 120, associated together in an electrical circuit that can be connected to an outside circuit at a solitary point.

III. PRINTING SOLAR CELLS

In order to make the usage of sun arranged power a possible alternative rather than oil subsidiaries, it ought to be monetarily equivalent to standard imperativeness sources like coal, combustible gas, and oil. This matter of cost is the

greatest issue standing up to the accomplishment of photovoltaic sun fueled board use. Efficiency of daylight based cells is the rate that they are viable at "changing over the radiation from the sun into power for the zone of the dynamic bit of the module". Profitability is possibly the most imperative factor while choosing the general use and nature of a daylight based cell, and it can accept a broad employment in reducing all in all costs. The two principle techniques to decrease the expense of intensity creation in photovoltaic gadgets are to expand proficiency and to bring down generation expenses of the beginning materials. Executing differing printing shapes all through explicit steps of amassing has starting late accomplished both capability and lower costs. Certain printing shapes like screen printing, inkjet printing, and even web press balance printing credit themselves to being actually what is relied upon to make diverse sorts of daylight based cells. These procedures are turning into an extensive piece of sunlight based cell producing for various types of photovoltaic sun based vitality, each with its very own advantages and disadvantages. It is basic to understand the unmistakable sorts of sun based cells and materials that are used to impact them in order to fathom where these printing strategies can fit in.

IV. CONVENTIONAL PV MATERIALS

Conventional sun controlled cells are created utilizing silicon, are level plated and unyielding, and generally have the most important efficiencies. C-Si is the most comprehensively used and most capable material devoured in the production of photovoltaic sun situated cells, with business efficiencies on occasion accomplishing 20%. C-Si is basically used to make 80% of all photovoltaic sun fueled sheets, and this material is especially significant since it has seemed whole deal execution and resolute quality. These cells are delivered utilizing silicon wafers that can be either single-crystal or multi-crystal in structures, depending upon what is available or what is required for that particular strategy. All structures using unadulterated silicon will face insufficiencies, especially since the material is used in other semiconductor adventures similarly as in sun arranged PV. Silicon is an inexhaustible segment on the planet's structure, anyway its dominant part occurs in increases that would be costly to isolate the unadulterated silicon from them. Crystalline silicon has been the go-to material to make profitable sun based sheets; in any case, because of lacks and the general astonishing costs of silicon, distinctive decisions have been made with various materials or smaller proportions of silicon.

V. SLENDER FILM PV MATERIALS

Thin film daylight based cells offer the best option with respect to conveying sun arranged cells. Thin film sun controlled cells require less semiconductor material, so material costs are impressively lessened. The adaptability of uses with shaky film could in like manner colossally increase the use of sun arranged power. While different various materials have been used for thin film, the most by and large used at present are ill defined silicon, common polymers, and a mix of conductive metals including blends of copper, indium, diselenide, and now and again gallium.

With respect to increasingly standard materials, ill-defined silicon (a-Si) can be mass made more adequately than crystalline silicon, and it will in general be very shaky, even to the point of being versatile, so significantly more diminutive entireties are required. Since the atoms are not organized in a particular demand, as in a crystalline structure, there is more prominent versatility with what can be made with ill-defined silicon. The material is overflowing with blemishes ordinarily so contaminating impacts are not an issue, and it will in general be associated reliably over outstandingly immense surfaces, making it more usable than crystalline silicon. Undefined silicon does not have unclear nature of electrical properties from crystalline silicon, anyway the opening has been closed starting late. A couple of mixes of conductive and semi conductive metals and blends can be used to make sun situated cells, anyway the most acclaimed and most typical is apparently one involving copper indium diselenide, generally called CIS. As in front of timetable as 1978, high efficiencies without corruption were watched, which made this a basic material in the thin film sun arranged industry. Starting late, a practically identical anyway extensively progressively profitable blend of copper, indium, selenium, and gallium, generally called CIGS, has been used. These materials help to make the vast scale assembling of daylight based cells to a more prominent degree a reality, and since CIGS can possibly have relative efficiencies to ordinary cells, about 19.5%, this is a champion among the most reassuring new PV propels. An association called Konarka Technologies has developed thin film sun arranged PV cells from normal polymers as "Power Plastic." These common photovoltaics are a third-age sort of sun situated power that uses a photo responsive polymer that can be joined with a couple of other dainty layers to be used in different things. The Power Plastic can be engraved on broad moves of versatile substrates, is created utilizing recyclable materials, and changes over light to essentialness both outside from the sun and inside from a light. Another utilization of common polymers is seen when it is used as a shading that is a blend of nanoparticles that convert light to control. Both of these uses of common polymers immensely help lessen the cost of collecting sun based cells, anyway they are not as

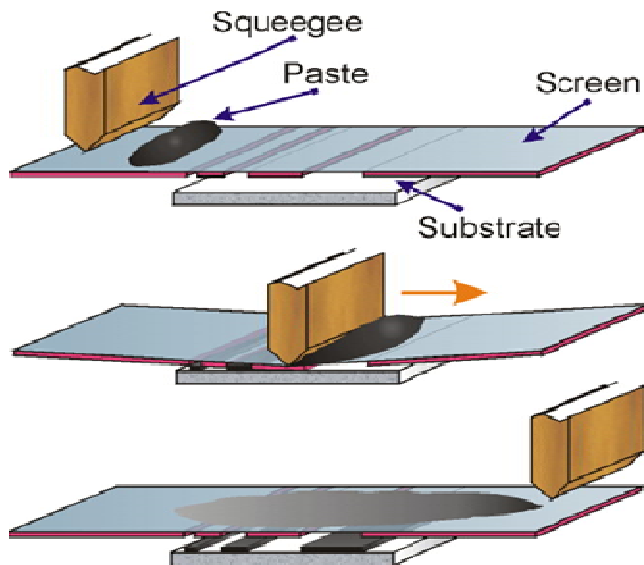
viable as silicon based cells, and the life expectancy isn't thought about these new cells.

VI. SCREEN PRINTING

Principal rule of the system of screen printing is basically the use of a stencil to rehash a comparative picture again and again. This is at present customarily completed with the use of a work screen secured with light-tricky admixture that is then displayed to light with the perfect positive picture blocked, and after that washed out to make the work stencil. There are diverse ways to deal with make the stencil, anyway the use of photographic admixture is commonly typical. The ink is associated with the screen and forced through with a squeegee the ink on the open picture zone to the perfect substrate. This strategy can be repeated indistinguishable number of times from the screen materials will last. Screen printing is a champion among the most adaptable printing frames in light of the way that almost anything from glass to paper to surface to plastic can be engraved on, and an amazingly thick proportion of ink can be set down, not in any way like in other printing shapes. Different factors should be seen as when screen printing is used, dependent upon the kind of materials and pictures that are being printed. Factors including system check, screen edge, admixture on-work thickness, stencil surface smoothness, ink type, how point by point the image is, the thing that number of impressions the screen can last, and squeegee weight would all have the capacity to impact the general idea of the thing that is being printed. This screen-printing process has been used as a part of the technique to make normal silicon sun controlled cells in light of its adaptable nature. "Screen printing photovoltaic cells is the most reliable technique and snappiest creating application in present day printing". Screen printing is furthermore the most conventionally and routinely used printing process all through the gathering of photovoltaic sun fueled cells. Without a doubt, over 90% of all crystalline silicon modules are created using screen printing, and about 60% of versatile unstable film modules use screen engraving in the gathering system.

The way in which that screen printing is used amid the time spent making sun fueled cells is that PV sun situated cells are consistently metalized through a screen-printing process. This is the utilization of three particular sorts of metallization pastes onto the c-Si cell. The primary paste is the front-side silver used as a bit of hindsight going up against the sun; it makes up the gatherer gridlines and the silver transport bars, and the second is the rear choosing silver or silver-aluminum, and the third is the posterior aluminum stick that truly reacts with the silicon to make the back surface field. The screen-printing process is especially significant in

applying these pastes since consistency in each application similarly as the ability to set down different thicknesses for the unmistakable sorts of pastes are both basic. In any case, as demonstrated by Brenner (2010), like screen printing anything, different elements connected with screen-printing photovoltaics must be watched: ink plan (solid substance, consistency, rheology, evaporating rate, dissipating), press setup (squeegee durometer and shape, strike point, squeegee weight, print speed, snap off, enlistment control), screen/stencil (work count, wire remove over, percent of open region, emulsion thickness, work strain), and nature (room temperature, sogginess, air unsettling influence, tidiness, substrate surface, time length of ease of use of ink and screens). All of these variables is generally something that should be considered in a screen printing, anyway it is especially basic with printing PV modules due to the possibility of the materials and the precision that is required. Another way that screen printing is utilized in the generation of sun fueled sheets is utilizing common shading, a blend of nanoparticles, which fills in as a semiconductor to change over sunlight to essentialness. The adaptability of this shading thinks about particular tints and plans to be printed, making this a phenomenal choice to be composed into the façade of a structure or to fill in as an elaborate segment. These sheets could be composed into windows and convert light to control just as fill in as a sunshade to within the structure, saving additional essentialness. In spite of the way that screen-printing this shading onto glass settles on it a dumbfounding choice for structure compromise, the cells simply have a viability of about 4%, so they are not yet centered with conventional silicon sheets. The life expectancy of this development is yet to be settled, anyway it appeared to perform well in starting tests. To be sure, even with these burdens, this regular shading could be an outstanding choice by customers as a result of its everything the more stunningly fulfilling qualities and buyers' choices to have whatever structure or shading they need.



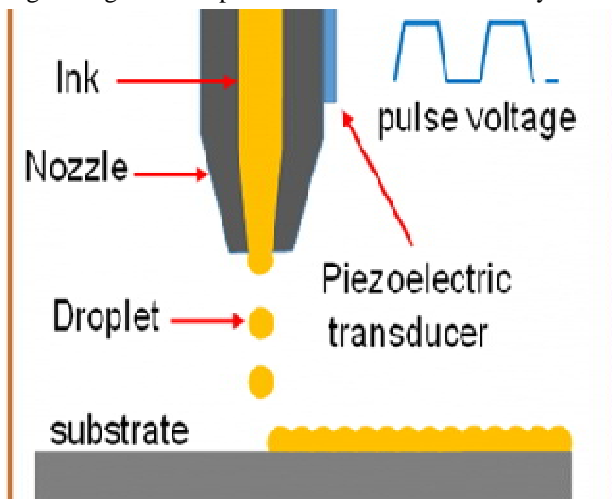
VII. INKJET PRINTING

This type of printing is one of the freshest and most exploratory techniques which makes daylight based cells, and it may have a very tremendous activity in making sun based sheets open to everyone. The most notable kind of computer printers uses inkjet advancement, and it is also used for the most part in current applications as well as purposes, for instance, the formation of different moment things, the improvement of conductive pursues for circuits, and the generation of shading diverts in LCD and plasma appears. Inkjet printing is a non-influence printing that uses different spouts to shower ink dabs direct onto the paper. This basic guideline makes this printing amazingly significant in that not only would it have the capacity to shower onto different assorted surfaces, yet furthermore it can sprinkle onto different materials. It isn't simply ordinary printing ink that can be sprinkled. Inkjet printing starting late has been used in the formation of both versatile slight film sun controlled cells similarly as dynamically normal unyielding silicon cells. Using inkjet printing to apply semi conductive material onto versatile substrates that could result in the course of action of an unstable film PV sun based cell can end up open to any person who has an inkjet printer. While this isn't the circumstance yet, various spots are using inkjet printing to diminish creating costs and endeavoring to construct efficiencies of pitiful film sun fueled cells. Konarka Technologies is using inkjet printing as an element of the age strategy of their Power Plastic thin film sun situated cells, which are made of regular polymers. This material has been in progress and improvement for two or three years, and in 2008, inkjet printing was used, making the system significantly more affordable than it as of late had been. This paper dainty plastic has unbounded conceivable outcomes and can be related with any flexible surface, for example, tents, umbrellas, and satchels, anyway there are two or three drawbacks. The

profitability of this inkjet printed material is only 3-5%, so to go wherever near the proportion of essentialness a standard silicon daylight based cell can get, there would ought to be a considerable domain available to set out this Power Plastic. These cells also simply last around a few years, rather than decades that customary cells last. Such weaknesses right currently limit the use of the thing, yet the points of interest are still astoundingly unimaginable since possibly anyone could print these cells. That may be a few years away, anyway the flexibility and tremendous proportion of spots this plastic could be used are not to be disturbed. Inkjet printing has accepted a basic employment in getting this moving.

Printing using inkjet method is also used now a days rather than screen printing to make electrical relationship in the midst of the path toward making progressively normal crystalline silicon sun arranged modules. The printing done via inkjet method has a procedure which is more accurate than past techniques, and since the heads of printing don't achieve the silicon, an increasingly thin, logically fragile piece can be used. Customary screen printing procedures need to use silicon wafers that are no under 200 um thick in light of the fact that any increasingly slim wafer will likely break. It is surveyed that 100 um of Si can be used with this inkjet methodology, and since Si can represent to 75% of the full scale cost of materials and creation, this may fundamentally diminish overall costs. The inkjet printing can be used for printing silver gridlines and a more conductive ink is used. Markel van Hest, a specialist at the National Renewable Energy Laboratory, noted progressively definite lines of 35 to 40 um wide, appeared differently in relation to 100 with 125 um wide with screen printing can in like manner be printed. This finally infers not as significantly silver ought to be used, saving additional money and resources. The more slim lines in like manner can square less of the sun based assembling material, with the objective that the sun's radiation can hit a more prominent measure of the surfaces that are truly assembling it, instead of avoiding off because of the thicker silver lines. These progressively slim lines make the cells progressively gainful, disregarding the way that correct now the proportion of extended adequacy is dark. Notwithstanding what application inkjet printing is being used in, the strategy is ended up being a basic bit of making photovoltaic sun situated cells dynamically judicious and progressively open. While at present it is simply used in expansive scale producing, the ability of having the ability to print on an individual printer is absolutely a huge favored angle that this system has over any of the others. Not solely is inkjet printing improving successfully made PV creating shapes, anyway it is moreover a key section to an absolutely new sort of dainty film that could be used for any number of tasks. Such printing is reducing costs of gathering and augmentation the adequacy

and availability of sun controlled cells, which are at present urgent targets of the photovoltaic sun based industry.



VIII. WEB PRINTING

Regardless of the way that not really using the rule of equalization lithographic printing, there are associations using web press applications to coat semiconducting materials onto versatile substrates. The substrates that are at present being used are plastics and metal foils. Equalization printing is a sort of planography, in light of the fact that the plates used in the midst of printing are absolutely level. The rule of balance lithography is that the oil-based ink just clings to the hydrophobic picture area on the plate, which is traded to a spread, and thereafter traded onto the substrate. Web offset printing is an unending method that prints on moves of substrates, anyway it is up 'til now a circuitous strategy due to adjust lithographic printing. Papers, for instance, are as often as possible printed by an offset press and a short time later hacked down into the major sheets. With the collecting of sun based cells, certain benchmarks of web balance printing are associated, and they are appeared to altogether reduce costs and addition creation limits. Nano solar is an association that prints the semi conductive compound of copper, indium, gallium, and selenium (CIGS) onto thin foil. The association uses a web press application and "can convey a hundred feet of endlessly moved sun situated cell each minute". Their nanoparticle ink mix, including CIGS and the crucial parts for genuine dissipating, is secured onto "a remarkably orchestrated selective amalgam of metal foil using high-throughput covering/printing methodology". This system for printing has displaced the standard methodology of high-vacuum affirmation, which is considerably progressively repetitive. Nano solar has taken the money related issues and methods of printing and associated them to the course of action of sun arranged cells and seems to have done in that capacity all around viably. Their methodology should make this kind of sun based cell control as humble as the stream

control expelled the cross section. The National Renewable Energies Laboratory affirms that their sun situated cells have up to a 15.3% efficiency, which is identical to standard crystalline silicon cells. The thing itself is moreover slim and versatile, which could be useful in different applications. Nano solar's slim film cells are significantly more moderate than standard silicon cells, and they can be mass-made in all regards quickly due to the usage of a printing methodology. Konarka's Power Plastic uses inkjet printing just as a web press application in specific events. they use a sort of covering process that is always moved to get the right substrate mix of usable photographic film and common polymers. Regardless of the way that not really a printing strategy, this application is without a doubt awakened by standard web printing, and this is a basic bit of the system of the amassing of Power Plastic. Web press applications are truly new to the photovoltaic sun based cell industry, anyway they are expecting a basic occupation in the limit of the business to use vast scale fabricating shapes. This finally makes the phones dynamically productive, and by virtue of Nano solar, the phones are really for all intents and purposes indistinguishable in viability. The usage of web printing is certainly a help for the sun fueled cell industry.

IX. CONCLUSIONS

In this period of uncertain essentialness sources and with the impacts that they are having on the atmosphere, flawless, endless sun arranged imperativeness is a better than average choice. In any case, it is still more expensive than methods used starting at now by customers, and lodging solicitation to be a sensible decision, it must be attainable and moderate. With the use of different materials and slim film developments, the usage of photovoltaic sun controlled essentialness for the typical individual is ending up to a more prominent degree a reality. Printing shapes have helped the photovoltaic sun fueled industry by giving profitable responses for diminishing manufacturing costs and addition the openness of these progressions to customers. Screen printing has been used for a significant long time as a good option for metallization while conveying ordinary crystalline silicon sun situated cells, and it has even more starting late been used as the strategies for applying regular semiconducting shading to make photovoltaic sun based cells. Inkjet printing is profitable in the age of sun controlled cells as both another substitution for the screen-printing metallization and in the collecting of slight film sun arranged cells. To be sure, even web balance printing has impelled a segment of the systems used to make thin film daylight based cells, and it is a practical strategy to mass-produce these cells quickly. All of these methodology has made daylight based cells continuously sensible and plausible.

Meager film sun based cells would not be as broadly delivered and inquired about in the event that it were not for the printing forms that helped make them as valuable as they right now have progressed toward becoming. Customary crystalline silicon sun based cells are proficient and have extraordinary life span, however they can't be utilized wherever since they are inflexible; they additionally are over the top expensive and asset escalated to deliver. Dainty movie is by all accounts the bearing that the general population who make sun based cells are going, and on the off chance that they can get equivalent efficiencies, at that point there is no motivation behind why these phones ought not be utilized as substitutions for customary vitality strategies. Flimsy film cells additionally can be utilized on rooftops, yet they can likewise be put simply above anyplace and are all the more stylishly satisfying, which would make them more attractive than regular sun oriented boards. There are various new improvements in the photovoltaic sun oriented industry, and with the assistance of procedures roused by the printing business, this industry will proceed to create, and in the long run PV cells will be an exceptionally looked for after vitality source.

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