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Perovskite, a Solar cell material for the Succeeding Generation

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ABSTRACT: Traditional ways of energy production is harmful to the earth. Still why we are using that approaches? There are so many causes behind it but one of the major roots is less effectiveness of present renewable energy sources. Sun is the biggest renewable energy source. We established so many devices which can convert solar energy into the electrical energy, but the solar cell is the device which can directly convert solar energy into the electrical energy. But still we are not using solar cells that much because it has less power generation capacity, costly materials, space consuming. Perovskites is the leading innovation in Solarcell technology. Perovskites is use as replacement of Silicon to make more inexpensive, thinner and light weight Solarcell. Perovskites has low fabrication cost with good efficiency. This research paper is about the examination of Perovskites and other materials of Solarcell to make batter solar cells in future. This will be transparent, more efficient, chipper, thinner and more conductive. It is about to think about the challenges of solar cell and solve them with respect Perovskite. Perovskites is the material which can reduce the cost of manufacturing and size of the cell with to increasing in efficiency.

KEYWORDS: Perovskite, Solar cell materials, New generation of solar cell, chipper solar cell, Transparent solar cell, breakthrough in solar cell materials, Use of Perovskites, Nano Solarcell.

I. INTRODUCTION

A topic of this paper is that, “The power generation is the biggest need of the present world. But it should not be harmful to the environment also with the good efficiency. For this, Renewable energy sources are the best option. But still we are not using those sources! For that major affecting factor is material. We are conventionally using silicon from last 30 years as solar cell material, which is costly material with low efficiency also having low power generating rate per area. So it is the time to use Nano science and technology in the field of solar energy. So question arise that, what kind of materials we can use as replacement of the silicon and what will be the effect of it?”

Main aim is about to find out the effects of the Perovskite as the solar cell material, how we can increase the effectiveness, efficiency and power generation rate of solar cell. For that we have to know basic things about the solar cell. So in this paper, basic information is available for better understanding of the solar cell and also about the material which we can use or used as solar cell materials. There is description is given about the Perovskite so we can understand the basic phenomena about the Perovskite and how it can be the game changing material for solar cell. Also here we can see what will be the advantages of Perovskite. Photovoltaic cell efficiency record, evolution chart for Perovskite, Efficiency comparison, cost analysis all data given which prove that Perovskite is really a great innovation in the world of solar energy.

Magazines like Science – Dec 2013, The Guardian – March 2014, NREL - August 2014, IEEE spectrum – May 2014, Suddesche Zeitung – August 2014, The Wall Street Journal – September 2014 has amazing information and description about the Perovskite. They try to show that the Perovskite is biggest breakthrough in the world of solar cell technology.

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II. MATERIALS OF SOLAR CELL

- 1) **SILICON BASED:** Two types of silicon based solar cells: Crystalline and Amorphous. More than 80% of solar cells currently manufactured are crystalline silicon solar cells. Nearly all of the other 20% are established as amorphous silicon solar cells. Crystalline silicon solar cells at the commercial level have reached efficiencies of as much as 16%, while experimental expansions have achieved efficiencies of more than 24%. But it has financial drawbacks. The compound processing steps and need for huge amounts of high purity silicon stock have driven the cost of these solar cells up. But recent attention has shifted from wafer-based silicon solar cells to thin-film crystalline silicon. Low temperature depositions from the gas phase permit for the consumption of inexpensive substrates (aluminum for example). The present way of choice for such depositions is PECVD (plasma-enhanced chemical vapor deposition). Unfortunately, the top efficiencies accomplished are just under 10%. In the 1970s, hydrogenated amorphous silicon (Si:H) was familiarized as a possible material for semiconductor devices. Since then, it has become the first thin-film material to arrive large-scale manufacture for solar cells.
- 2) **FURTHER THIN-FILM MATERIALS OF SOLARCELL: CIS RELATED, CDTE AND DYE SENSITIZED:** Copper Indium Diselenide (CIS) and Copper Indium Gallium Diselenide (CIGS) are direct gap polycrystalline p-type semiconductors with great optical absorption. That is, the minimum of the conduction band has the same wave-vector as the maximum of the valence band. CIS and CIGS are used in heterojunctions with n-type layers (ordinarily CdS or ZnO). CIS and CIGS have a curiously high efficiency for polycrystalline thin films, at 18.8% in the laboratory. The addition of Gallium in CIGS increases the band gap and the performance tune by increasing the open-circuit voltage. CIS and CIGS solar cells also show decent steadiness and consistency, except negligible heat and moisture. While commercial production of these solar cells is expected to be expressively inexpensive than for wafer-based crystalline silicon solar cells, it is very likely that full scale fabrication will experience problems with the availability and price of Indium. Another thin-film material similar to CIS and CIGS is CdTe. Typical efficiencies are 16% in the laboratory and 9% commercially Nano crystals in photovoltaic is debated further in the following division. CdTe is a binary compound, and thus easier to produce solar cells with than CIS/CIGS. Typically, a heterojunction is generated on a TCO layered glass substrate using n-type CdS and p-type CdTe.
- 3) **ORGANIC POLYMERS:** Inorganic materials are not the single preference accessible for solar cells, however. About 20 years ago, it was discovered that carbon-based materials could be used in produce photovoltaic. Conducting organic polymer solar cells were publicized to have an efficiency of 2.9%. Recently progresses in the science have ensued in test center results of organic solar cells reaching efficiencies as high as 5%. This illumination leads to the separation of exactions, much like in inorganic semiconductors. Organic photovoltaic are based on the illumination of a supporter and acceptor species. Organic solar cells are created out of various organic polymers, usually entrenched with fullerene (performing as the acceptor). A current polymer being explored is poly 3-hexylthiophene (P3HT).
- 4) **NANO-SCALE MATERIALS:** Importance has been engaged in the use of Nano crystals as a choice for effective and low cost solar cells. It is believed that the size and shape regulator of the Nano crystals will permit aimed at the customization of band gap through preoccupation of light through the entire spectrum. Also, the 3D detention leads to greater impression ionization and results in multiple charge carrier formation from a solo photon. By this property and control of the inter-crystal arrangement, the Nano crystals can be thought of as non-natural atoms that allow for the fine-tuning of detached electronic states via size directive. This control permits for the spectrum of preoccupation to be modified at will Nano crystalline solar cells contain of hugeranges of quantum dots. The efficiency is solitary around 2.5% matched to the theoretical efficiency of 44%.

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III. WORKING

In order for a material to transform sun light into electrical energy, it must fulfill two situations. First, it needs to be capable to absorb incident photons through the elevation of electrons to higher energy stages. Second, it must have an internal electric field that accelerates the promoted electrons in a precise direction, resulting in an electrical current. From the simplest point of view, a photovoltaic cell can be thought of as any device when exposed to light, is reasons for the current to flow in an electrical circuit with a specified load resistance. Sunlight composed in mini scale particle which called as photons, come from sun and impact on Solarcell. It transfers its energy to loose electron, knocking them clean off the atoms. Just like a game of pool. It is just a half work of Solar Cell, It also needs to change electron into Electric Current. This involves the generating an electrical inequity with in cell, which perform like a slop, it help to flow electron in one route. It made possible by the core organization of Silicon, but silicon atoms are organize together bounded structure. By squeezing small quantity of other element into this structure, two dissimilar type of silicon degenerated. N type: Which spare electrons, P type: Which need electrons; it has holes in their places.

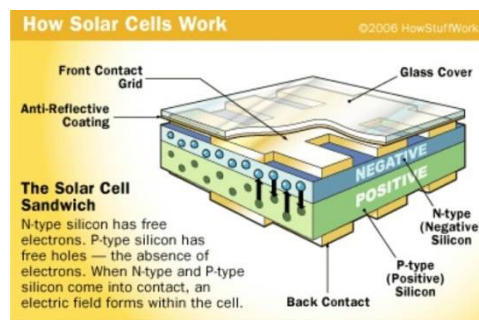


Figure 1: Constructive diagram and working

Now these two materials are located side by side, N-type silicon spare electron to fill the gap of P-type. So P-type becomes Positive charge and N type has Negative charge, which generate field across the cell because silicon is semi-conductor, so it act like an insulator and maintaining this imbalance.

IV. PEROVSKITES: “A INNOVATION IN SOLAR TECHNOLOGY”

It is a crystalline organ metallic. Oxford photovoltaic is doing research about it. They created one prototype as replacement of silicon, which is approx. 15% efficient, but it is just beginning. Perovskites solar cell is a type of solar cell which includes a Perovskites structured composite, most frequently a hybrid organic inorganic led or tinhalde-base material.

V. RESEARCHES ON PEROVSKITES

Perovskites have caught attention far beyond the scientific community:

“Among the 10 science top breakthrough of 2013.”

“Perovskites are the clean tech material development to watch right now.”

“The might be one of the material that is going to change the game.”

“Perovskites Photovoltaic cell have rapidly become one of the hottest areas in energy research over the past few years.”

“The Perovskites crystals let researchers dream of a golden solar age.”

“Perovskites offers shot at cheaper solar energy.”

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VI. PHOTOVOLTAIC CELL EFFICIENCY RECORD

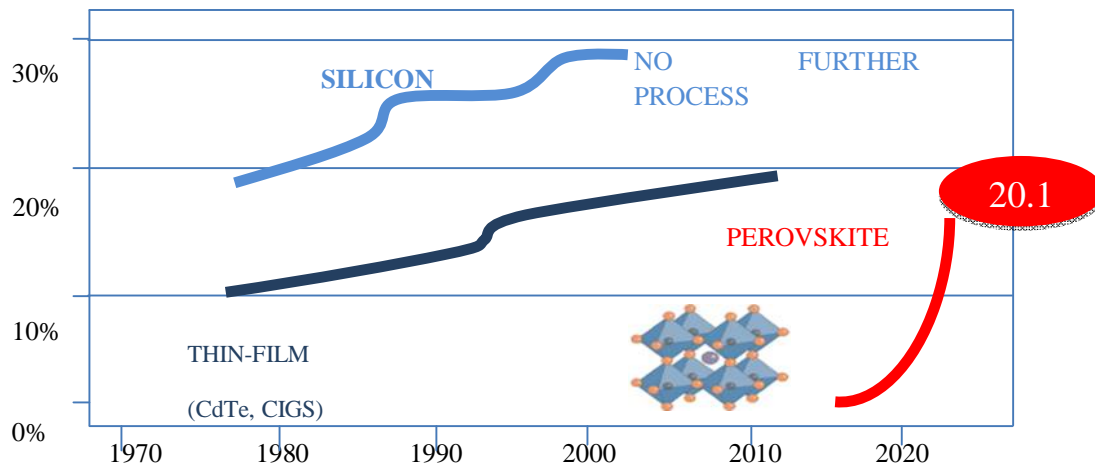


Figure 2: Solarcell evolution and efficiency chart

- 1) Increasing photovoltaic cell efficiency is today's 1st lever for further cost reduction of solar power, but the efficiency of market-dominating crystalline silicon and established thin-film technology has plateau.
- 2) Extremely fast progress in R&D demonstrates game-changing potential.
- 3) Theoretical maximum (>30%) far exceeds silicon for single junction cell.
- 4) Uses abundant, inexpensive, materials, with a modest cell structure, little depletion and small manufacturing cost.
- 5) Printed as a second layer on top of standard PV cells to increase absorption and efficiency

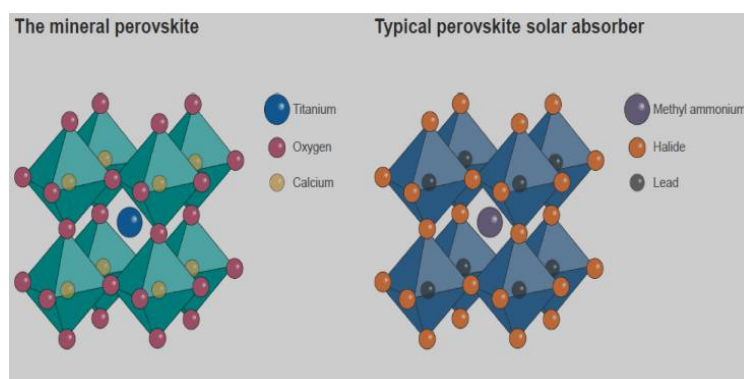


Figure 3: Two basic structures of Perovskites

Here, two basic structures of Perovskites are shown above, which are normally come in use for manufacturing of solar cell. This both structure has different molecules. One has Titanium in core another has Methyl ammonium as a core. In Which, Titanium is rounded by Oxygen and calcium and Methyl ammonium is rounded by Halide and Lead. Both structures are given above.

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VII. EVOLUTION CHART

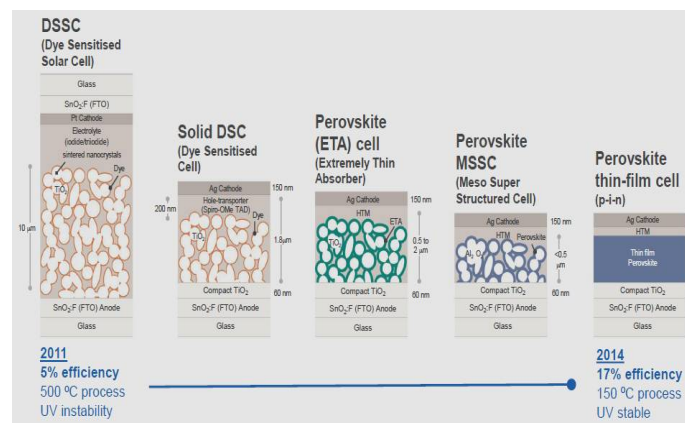


Figure 4: Perovskites evolution chart

Above chart represent evolution of Solar Cell. It shows that how solar cells become more compact and effective from 2011 to 2014. This chart also shows the materials which uses in manufacturing of solar cell. 1st is for DSSC type cell, 2nd is for Solid DSC, 3rd is for Perovskite (ETA) cell, 4th is about Perovskite MSSC and 5th is about Perovskite thin-film Cell. Above figure is about, what improvement accouters in solar cell from 2011 to 2014? In short in 2014 solar cell become more compact and effective.

5Efficiency

Cell Efficiency (%)

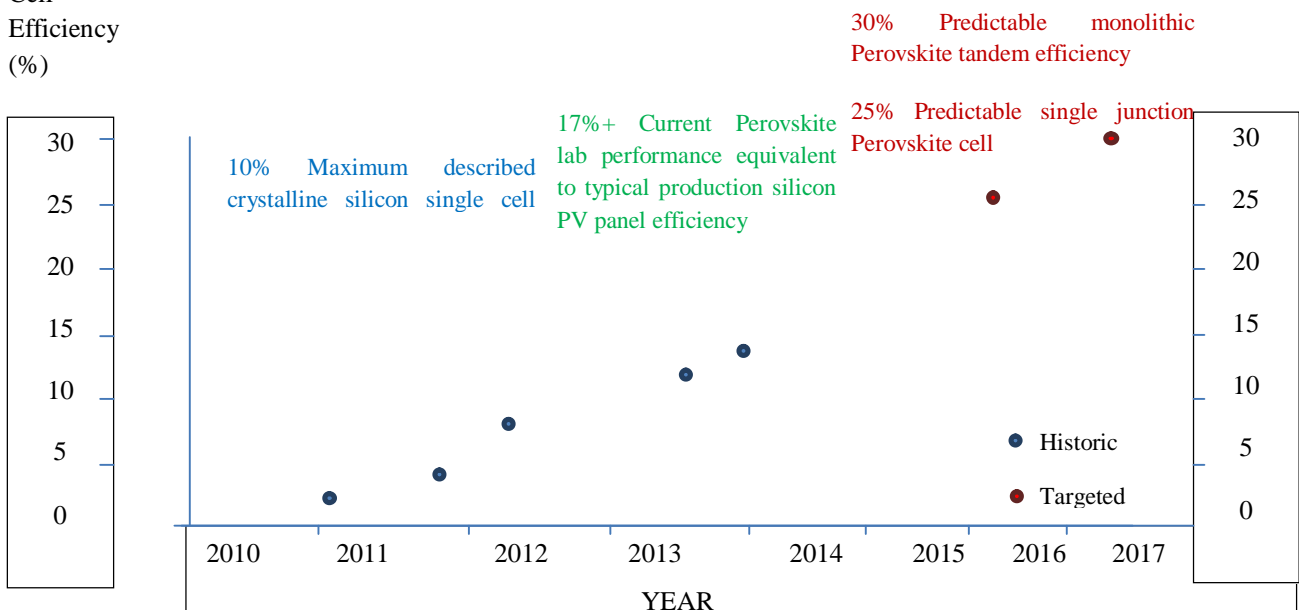


Figure 5 : Efficiency roadmap

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Above details shows the history and target of the Solarcell efficiency from 2010 to 2017. From 2010 to 2012 cell efficiency about 10% because of Silicon Cell, Now, it increases up to 17% because of Perovskite but in future It will be about to 30% Cell efficiency. Above figure shows the Improvement with Cell Efficiency of Solar cell.

VIII. MANUFACTURING

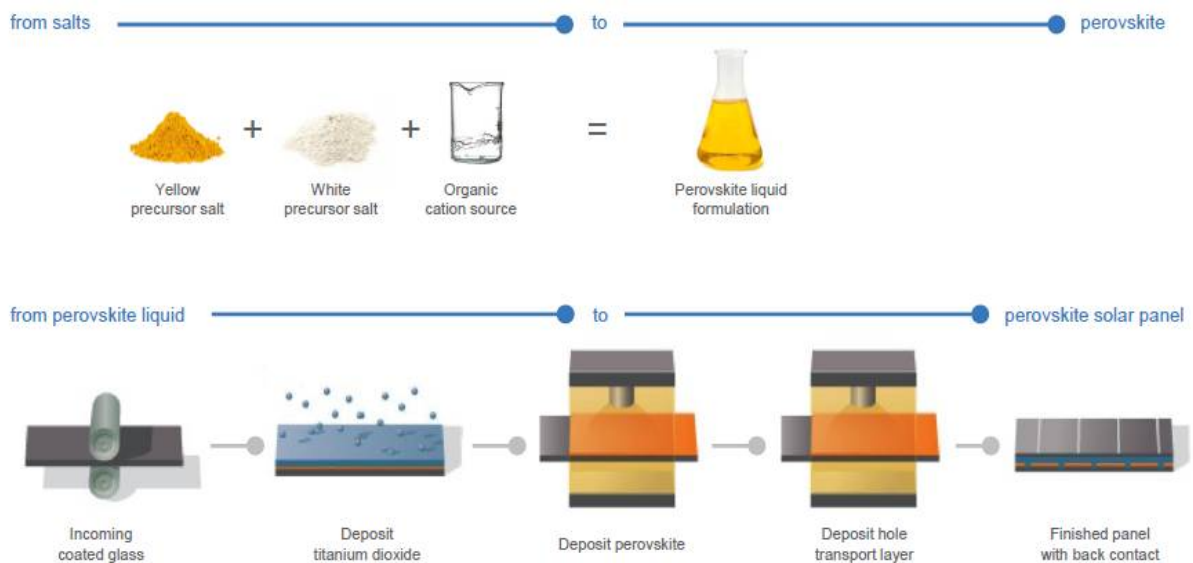


Figure 6: Production process

For production of Perovskites cell, there is requirement of Perovskites liquid formula. Which produce by using of yellow precursor salt, white precursor salt and Organic carbon sources? Upon the FTO glass coating deposit of some titanium dioxide particles take place. After the addition process of that Perovskites deposits in case, just finishing process require.

IX. COST ANALYSIS

Table 1 : Cost analysis

CHARACTERISTIC	CdTe	CIGS	c-Si	Perovskites
FINISHED MATERIAL COST	Low	High	High	Low
FABRICATION COST	Medium	Medium	High	Low
RAW MATERIAL COST	Low	Medium	Low	Low
LCOE	Medium	High	High	Low
ENERGY PAYBACK PERIOD	Medium	High	High	Low
EFFICIENCY	Medium	Medium	High	high

Above details are about the comparative cost of the all material. And it proves that Perovskite is best material for Solarcell.

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X. FUTURE OF SOLARCELL WITH PEROVSKITE

- 1) Solar cell and solar panels of tomorrow will be transparent, light weight, flexible and ultra-efficient.
- 2) We able to coated shingles or skylight or window with them.
- 3) It will be that much cheap as putting up the wallpapers.
- 4) Generated Perovskites solar cell was only size of fingernail and they degrade rapidly in moist atmosphere.

XI. APPENDIX 1: PHOTOVOLTAIC PROPERTIES FOR VARIOUS MATERIALS

Table found from the website for the Key Centre for Photovoltaic Engineering at the University of New South Wales:
<http://www.pv.unsw.edu.au/eff/>

Table 2: Materials

Classification ^a	Effic. ^b (%)	Area ^c (cm ²)	V _{oc} (V)	J _{sc} (mA/cm ²)	FF ^d (%)	Test Centre ^e (and Date)	Description
Silicon Cells							
Si (crystalline)	24.7 ± 0.5	4.00 (da)	0.706	42.2	82.8	Sandia (3/99)	UNSW PERL ²
Si (multicrystalline)	19.8 ± 0.5	1.09 (ap)	0.654	38.1	79.5	Sandia (2/96)	UNSW/EuroSolar ³
Si (supported film)	16.6 ± 0.5	0.98 (ap)	0.608	33.5	81.5	NREL (3/97)	AstroPower (Si-Film) ⁴
III-V Cells							
GaAs (crystalline)	25.1 ± 0.8	3.91 (t)	1.022	28.2	87.1	NREL (3/90)	Kopin, AlGaAs window
GaAs (thin film)	23.3 ± 0.7	4.00 (ap)	1.011	27.6	83.8	NREL (4/90)	Kopin, 5 mm CLEFT ⁵
GaAs (multicrystalline)	18.2 ± 0.5	4.011 (t)	0.994	23.0	79.7	NREL (11/95)	RTI, Ge substrate ⁶
InP (crystalline)	21.9 ± 0.7	4.02 (t)	0.878	29.3	85.4	NREL (4/90)	Spire, epitaxial ⁷
Poly-crystalline Thin Film							
CIGS (cell)	18.4 ± 0.5	1.04(t)	0.669	35.7	77.0	NREL (2/01)	NREL, CIGS on glass ⁸
CIGS (submodule)	16.6 ± 0.4	16.0 (ap)	2.643	8.35	75.1	FhG-ISE (3/00)	U. Uppsala, 4 serial cells ⁹
CdTe (cell)	16.4 ± 0.5	1.131 (ap)	0.848	25.9	74.5	NREL (2/01)	NREL, on glass
CdTe (submodule)	10.6 ± 0.3	63.8(ap)	6.565	2.26	71.4	NREL (2/95)	ANTEC ¹⁰
Amorphous Si							
a-Si (cell) ^f	12.7 ± 0.4	1.0 (da)	0.887	19.4	74.1	JQA (4/92)	Sanyo ¹¹
a-Si (submodule) ^f	12.0 ± 0.4	100 (ap)	12.5	1.3	73.5	JQA (12/82)	Sanyo ¹²
Photochemical							
Nanocrystalline dye	6.5 ± 0.3	1.6(ap)	0.769	13.4	63.0	FhG-ISE (1/97)	INAP
Nanocrystalline dye (submodule)	4.7 ± 0.2	141.4 (ap)	0.795	11.3	59.2	FhG-ISE (2/98)	INAP
Multijunction Cells							
GaInP/GaAs	30.3	4.0 (t)	2.488	14.22	85.6	JQA (4/96)	Japan Energy (monolithic) ¹³
GaInP/GaAs/Ge	28.7 ± 1.4	29.93(t)	2.571	12.95	86.2	NREL (9/99)	Spectrolab (monolithic)
GaAs/CIS (thin film)	25.8 ± 1.3	4.00 (t)	-	-	-	NREL (11/89)	Kopin/Boeing (4 terminal)
a-Si/CIGS (thin film) ^f	14.6 ± 0.7	2.40 (ap)	-	-	-	NREL (6/88)	ARCO (4 terminal) ¹⁴

^aCIGS = CuInGaSe₂; a-Si = amorphous silicon/hydrogen alloy
^bEffic. = efficiency
^c(ap) = aperture area; (t) = total area; (da) = designated illumination area
^dFF = fill factor
^eFhG-ISE = Fraunhofer-Institut für Solare Energiesysteme; JQA = Japan Quality Assurance
^fUnstabilized results

XII. CONCLUSION

Here I conclude that the biggest challenge while use of the solar cell is the selection of the material on the basis of its properties. Solar cell should be more light weight, transparent, flexible and ultra-efficient with Perovskite. We able to coated shingles or skylight or window with them, it will be the stage of next generation of science where transparent window glasses also can generate the electricity without any kind of pollution. It will be that cheaper so people can use Perovskite as the replacement of the wallpaper. Solar cell will be the biggest power generating unit in future and Perovskite will make that happen.

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