Improvement of the Performance of Single Junction a-Si Integrated Mini Modules with Oxide Based Materials

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***Abstract*- We have developed oxide based window layer, buffer layer and n-layer by radio frequency plasma enhanced chemical vapour deposition method for use in the fabrication of single junction amorphous silicon (a-Si) integrated mini modules of size 30 cm × 30 cm. From our earlier study we have observed that higher stabilized efficiency can be obtained using oxide based window and buffer layer. This motivates us to replace conventional n-a-Si:H by n-a-SiO:H to improve the performance of the solar module. The use of this material in a single junction a-Si structure enhances the short circuit current of the module and the conventional efficiency as well. The bandgap of n-a-SiO:H film is much higher and optical absorption is less than that of n-a-Si:H film having the conductivity same. Due to low absorption and wide optical gap of n-oxide layer allows more fraction of light to enter into the cell after reflection from back reflector resulting in increase in short circuit current. The initial module parameters are η = 8.3%, FF = 0.69, V_{oc} = 22.1 V and I_{sc} = 426 mA. Module size is 30 cm × 30 cm. Out of it 10 mm is removed all around to protect from environmental degradation so the aperture area is 784 cm^2. After degradation the stabilized efficiency becomes 7.2%, FF = 0.62, V_{oc} = 22.0V and I_{sc} = 413.8 mA.**

I. INTRODUCTION

In order to increase the stabilized efficiency of a single junction amorphous solar cell researchers made different approaches such as incorporation of nano-crystallites in the intrinsic a-Si:H films [1], improvement of window, buffer and bottom n-layer quality etc. [2-8]. Quality and thickness of the window layers have great importance on improvement of the shorter wavelength quantum efficiency and on the carrier's injection [9]. In order to improve the overall efficiency of solar cells betterment of the individual layers i.e window and intrinsic layer property is important. Apart from that the p/i interface region is also important for reducing bandgap mismatch and thus reducing recombination of charge carriers. In the interface region the recombination centre or trap centre arises from internal electric field distribution due to localized states. Wide gap bottom layer allows more light to reflect back from the back reflector within the absorber layer. The objective of the work is to study the influence of oxide based window and buffer layer on the light induced degradation (LID) of a single junction a-Si solar cell. Now-a-days researchers found that hydrogenated amorphous silicon oxide (a-SiO) is a better photovoltaic material than a-SiC [10-12]. Most of the oxygen atoms are bonded in Si – O – Si form and partly in Si – OH form. It is more electronegative than that of Si or OH. So while this oxygen gets bonded to Si atom the bonding states move deeper in valence band and reduces tail state density and effectively pushes up optical gap. There is two lone pair of electrons around oxygen atom. These lone pair of electrons will have repulsion between them. It will result in antibonding splitting to widen up further from bonding states. Thus bonding and antibonding splitting will increase in silicon oxide alloy materials and optical gap of it will increase due to alloying with oxygen. However, depending on the deposition parameters, incorporation of O into the a-Si:H network, above a certain level, results in a sharp deterioration in electronic properties and restricts its further improvement [10]. Incorporation of O into a-Si:H changes the network from a dense homogeneous to a sparse inhomogeneous and strained one [13]. This phenomenon is common to any alloy material [14]. However, in a-SiO:H the contrast is in the nature of inhomogeneity [15]. There is speculation that Si-rich and O-rich regions of two distinct phases are grown at moderately high level of O-incorporation and their nature of contribution to the optical and the electrical properties of the bulk differs [16].

These superior properties of a-SiO:H film encouraged us to develop a-SiO:H films for p,n and buffer layer. In this paper we have reported the preliminary results relating to the lowering of LID in single junction amorphous mini module using oxide based window, buffer and n-layers.

Preparing your Electronic Paper

Prepare your paper in full-size format, on US letter paper 8 ½ by 11 inches). For A4 paper, use the A4 settings.

Type Sizes and Typefaces: Follow the type sizes specified in Table I. As an aid in gauging type size, 1 point is about 0.35 mm. The size of the lowercase letter 'j' will give the point size. Times New Roman is the preferred font.

1) US Letter Margins: top = 0.75 inches, bottom = 1 inch, side = 0.625 inches. Each column measures 3.5 inches wide, with a 0.25-inch measurement between the columns.

2) *A4 Margins:* top = 19 mm, bottom = 43 mm, side = 13 mm. The A4 column width is 88 mm (3.45 in). The space

between the two columns is 4 mm (0.17 mm). Paragraph indentation is 3.5 mm (0.14 in).

Left- and right-justify your columns. Use tables and figures to adjust column length. On the last page of your paper, adjust the lengths of the columns so that they are equal. Use automatic hyphenation and spell checking. Digitize or paste down figures.

TABLE I
TYPE SIZES FOR PAPERS

Type Size (pts.)	Appearance		
	Regular	Bold	Italic
6	Table captions,[a] table superscripts		
8	Section titles,[a] references, tables, table names,[a] first letters in table captions,[a] figure captions, footnotes, text subscripts, and superscripts		
9		Abstract	
10	Authors' affiliations, main text, equations, first letters in section titles[a]		Subheading
11	Authors' names		
24	Paper title		

[a]Uppercase

Fig. 1. Weibull distribution of 60 Hz breakdown voltages
11 cables $\alpha = 45.9$ kV peak $\beta = 5.08$ Confidence Intervals 95%

II. HELPFUL HINTS

A. *Figures and Tables*

Position figures and tables at the tops and bottoms of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be centered below the figures; table captions should be centered above. Avoid placing figures and tables before their first mention in the text. Use the abbreviation "Fig. 1," even at the beginning of a sentence.

Figure axis labels are often a source of confusion. Use words rather than symbols. For example, write "Magnetization," or "Magnetization (M)" not just "M." Put units in parentheses. Do not label axes only with units. In the example, write "Magnetization (A/m)" or "Magnetization ($A \cdot m^{1}$)." Do not label axes with a ratio of quantities and units. For example, write "Temperature (K)," not "Temperature/K."

Multipliers can be especially confusing. Write "Magnetization (kA/m)" or "Magnetization (10^3 A/m)." Figures labels should legible, about 10-point type.

B. *References*

Number citations consecutively in square brackets [1]. Punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]. Use "Ref.[3]" or "Reference [3]" at the beginning of a sentence: "Reference [3] was the first …"

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the reference list. Use letters for table footnotes (see Table I). *IEEE Transactions* no longer use a journal prefix before the volume number. For example, use "*IEEE Trans. Magn.,* vol. 25," not "vol. MAG-25."

Give all authors' names; use "et al." if there are six authors or more. Papers that have not been published, even if they have been submitted for publication, should be cited as "unpublished" [4]. Papers that have been accepted for publication should be cited as "in press" [5]. In a paper title, capitalize the first word and all other words except for conjunctions, prepositions less than seven letters, and prepositional phrases.

For papers published in translated journals, first give the English citation, then the original foreign-language citation [6].

C. *Abbreviations and Acronyms*

Define abbreviations and acronyms the first time they are used in the text, even if they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title unless they are unavoidable.

D. *Equations*

Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1). To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use an en dash (–) rather than a hyphen for a minus sign. Use parentheses to avoid ambiguities in denominators. Punctuate equations with commas or periods when they are part of a sentence, as in

$$a + b = c. \tag{1}$$

Symbols in your equation should be defined before the equation appears or immediately following. Use "(1)," not "Eq. (1)" or "equation (1)," except at the beginning of a sentence: "Equation (1) is …"

E. *Other Recommendations*

The Roman numerals used to number the section headings are optional. If you do use them do not number ACKNOWLEDGMENT and REFERENCES, and begin Subheadings with letters. Use two spaces after periods (full stops). Hyphenate complex modifiers: "zero-field-cooled magnetization." Avoid dangling participles, such as, "Using (1), the potential was calculated." Write instead, "The potential was calculated using (1)," or "Using (1), we calculated the potential."

Use a zero before decimal points: "0.25," not ".25." Use "cm^3," not "cc." Do not mix complete spellings and abbreviations of units: "Wb/m^2" or "webers per square meter," not "webers/m^2." Spell units when they appear in the text: "…a few henries," not "…a few H." If your native language is not English, try to get a native English-speaking colleague to proofread your paper. Do not add page numbers.

III. UNITS

Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as "3.5-inch disk drive."

Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.

IV. SOME COMMON MISTAKES

The word "data" is plural, not singular. The subscript for the permeability of vacuum$_0$ is zero, not a lower case "o." In American English, periods and commas are within the quotation marks, like "this period." A parenthetical statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical *sentence* is punctuated within the parentheses.) A graph with a graph is an "inset," not an "insert." The word alternatively is preferred to the word "alternately" (unless you mean something that alternates). Do not use the word "essentially" to mean "approximately" or "effectively." Be aware of the different meanings of the homophones "affect" and "effect," "complement" and "compliment," "discreet" and "discrete," "principal" and "principle." Do not confuse "imply" and "infer." The prefix "non" is not a word; it should be joined to the word it modifies, usually without a hyphen. There is no period after the "et" in the Latin abbreviation "et al." The abbreviation "i.e." means "that is," and the abbreviation "e.g." means "for example." An excellent style manual for science writers is [7].

ACKNOWLEDGMENT

The preferred spelling of the word "acknowledgment" in America is without an "e" after the "g." Try to avoid the stilted expression, "One of us (R. B. G.) thanks …" Instead, try "R.B.G. thanks …" Put sponsor acknowledgments in the unnumbered footnotes on the first page.

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