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JPL PUBLICATION 78-15. VOLUME VIII

(NASA-CR-162290)CHARACTERIZATION OF SOLARN79-32630CELLS FOR SPACE APPLICATIONS.VOLUME 8:ELECTRICAL CHARACTERISTICS OF SPECTROLABSF. BSR, TEXTURED 290-MICRON SOLAR CELLSUnclas(K7) AS A FUNCTION OF (Jet Propulsion Lab.)G3/4435778

Characterization of Solar Cells for Space Applications

Volume VIII. Electrical Characteristics of Spectrolab BSF, BSR, Textured 290-Micron Solar Cells (K7) as a Function of Intensity, Temperature and Irradiation

B. E. Anspaugh D. M. Beckert R. G. Downing T. F. Miyahira R. S. Wess

September 1, 1979

National Aeronautics and Space Administration

Jet Propulsion Laboratory California Institute of Technology Pasadena, California



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Electrical characteristics of Spectrolab textured, back-surfacefield back-surface-reflector, $2 \times 4 \times 0.029$ cm N/P silicon solar cells (K7) are presented in graphical and tabular format as a function of solar illumination intensity, temperature and irradiation.

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CONTENTS

I.	INTRODUCTION	1
II.	CELL DESCRIPTION	1
III.	TEST PROGRAM	1
1V.	DISCUSSION OF RESULTS	2
BIBLI(OGRAPHY	Ц
APPENI	DIX	A-1

<u>Figures</u>

....

1.	Average	I _{sc} /cm ² as a Function of Temperature	5
2.	Average	V _{oc} as a Function of Temperature	6
3.	Average	I_{mp}/cm^2 as a Function of Temperature	7
4.	Average	V _{mp} as a Function of Temperature	8
5.	Average	P _{max} /cm ² as a Function of Temperature	9
6.	Average	Curve Factor as a Function of Temperature	10
7.	Average	AMO Efficiency as a Function of Temperature	11
8.	Average	I _{sc} /cm ² as a Function of Intensity	12
9.	Average	V _{OC} as a Function of Intensity	13
10.	Average	I_{mp}/cm^2 as a Function of Intensity	14
11.	Average	V _{mp} as a Function of Intensity	15
12.	Average	P _{max} /cm ² as a Function of Intensity	16
13.	Average	Curve Factor as a Function of Intensity	17
14.	Average	AMO Efficiency as a Function of Intensity	18
15.	I _{sc} Temp	perature Coefficient	19

16.	V _{oc} Temperature Coefficient	20
17.	Absolute P _{max} Temperature Coefficient	21
18.	Percent P _{max} Temperature Coefficient	22
19,	Short Circuit Current Density vs 1 MeV Electron Fluence at 135.3 mW/cm ² AMO Illumination, 28°C	23
20.	Open Circuit Voltage vs 1 MeV Electron Fluence at 135.3 mW/cm ² AMO Illumination, 28°C	24
21.	Maximum Power Density vs 1 MeV Electron Fluence at 135.3 mW/cm ² AMO Illumination, 28°C	25
22.	Voltage at Maximum Power vs 1 MeV Electron Fluence at 135.3 mW/cm ² AMO Illumination, 28°C	26
23.	Maximum Power Current Density vs 1 MeV Electron Fluence at 135.3 mW/cm ² AMO Illumination, 28°C	27
A-1.	Solar Cell	A-1
A-2.	Test Plate =	A-2
A-3.	Solar Cell Characterization Facility	A-3
A-4.	Solar Cell Environmental Test Chamber	A-3

<u>Tables</u>

1.	Average	Short-Circuit Current, mA/cm ²	28
2.	Average	Open-Circuit Voltage, mV	29
3.	Average	Maximum Power Current, mA/cm ²	30
4.	Average	Maximum Power Voltage, mV	31
5.	Average	Maximum Power, mW/cm ²	32
6.	Average	Curve Factor	33
7.	Average	AMO Efficiency, Percent	34

SECTION I

INTRODUCTION

A series of reports is being generated to present parametric characterization data on both state-of-the-art and developmental solar cells of interest to the photovoltaic community. These data consist of the electrical characteristics of the candidate solar cell under a wide range of temperature and illumination intensity combinations of the type encountered in typical space applications. This series (JPL Publication 78-15) consists of a number of reports, each report being devoted to a particular type of solar cell and identified by a volume number. Previously published reports with their associated solar cell descriptions are listed in the bibliography. Each report consists primarily of working graphs and tables and does not address itself to interpretive conclusions. The formating of this series of reports is relatively invariant to facilitate comparisons between the characteristics of any of the cell types considered in the series. This report contains a set of parametric data on the Spectrolab textured, back-surface-field, back-surface-reflector solar cell which is a commercially available product.

SECTION II

CELL DESCRIPTION

The cells reported here were manufactured by Spectrolab and are available as off-the-shelf space-qualified solar cells. These cells are fabricated from crucible-grown P-type silicon, boron-doped to a nominal resistivity of 10 ohm-cm. The cell dimensions are $2 \times 4 \times 0.029$ cm (11 mils) thick. A back surface field is added by alloying a layer of evaporated aluminum into the back of the cell. The electrical contact on the top surface consists of solderless Ti-Pd-Ag in a 48-finger grid pattern with a bus bar running the length of the long side. The rear contact is Al-Ti-Pd-Ag. The antireflectance coating is Ta₂O₅. No cover slides were used on this test plate.

SECTION III

TEST PROGRAM

The solar cells were mounted on a copper test plate using RTV 560. The test plate was in turn mounted to a heat sink with provisions for both heating and cooling so that the cells could be maintained at the desired temperature, independent of the solar intensity. All testing was carried out in vacuum at a pressure of less than 1×10^{-6} torr.

The illumination source used was a Spectrclab Model X-25 Mark II Spectrosun filtered solar simulator. This simulator uses an optical integrator lens in the optical system which uniformly distributes a relatively collimated light beam at specific distances from a 2.5-kW short-arc xenon lamp. A system of filters modifies the spectral distribution so that it approximates that of space sunlight. The light beam provides a pattern having a uniformity of $\pm 1\%$ over an area of 225 cm² at the test plane. Illumination intensity is varied by position of the simulator in combination with transmission filters. The solar simulator beam is introduced into the vacuum chamber through a window of 7940 fused silica. The solar intensity and spectral integrity of the solar simulator are constantly monitored and maintained using spacecalibrated standard cells obtained with the NASA/JPL solar cell balloon flight standardization program. Photographs of the solar cell, the assembled plate, and the experimental characterization test facility are shown in Figs. A-1 through A-4 in the appendix.

The temperature range covered in these measurements was -160 to 140°C, while the solar intensity range covered was 5 to 250 mW/cm². The data were taken at each environment point in the matrix in the form of an I-V curve. The appropriate parameters were then read from the I-V curves and punched on cards for the computer analysis and curve plotting functions. The cell temperature was monitored by a thermocouple attached to the surface of a separate cell mounted with the cells under test. Prior, intermediate and post-test ambient measurements were performed daily to insure that the accuracy and stability of the test equipment and the test specimens themselves were maintained within $\pm 2\%$ during the course of the testing program.

After making the solar cell measurements over the above temperature and intensity ranges, the test plate was mounted in the evacuated target chamber of the JPL Dynamitron electron accelerator and irradiated with electron fluences ranging from 5×10^{12} to 2×10^{15} e/cm². During the irradiation the cells were maintained at 28° C. I-V curves of the solar cells were measured in situ before and after each irradiation using an Aerospace Controls Model 302 filtered xenon AMO solar simulator. In addition, after the cumulative fluence reached 10^{14} e/cm², the solar cells were annealed for approximately 16 hours at 60° C after each irradiation, then remeasured. The results of solar cell electrical characteristics, as a function of electron fluence, are shown in Figures 19 through 23. Annealed cell data is used in the plots.

SECTION IV

DISCUSSION OF RESULTS

A computer program computes statistical averages and standard deviations with respect to the measured cells for each intensity-temperature measurement condition. It then produces summary tables, as shown in Tables 1 to 7, that display averages and standard deviations of the cell characteristics in a two-dimensional array format, one dimension representing cell temperature and the second dimension representing

incoming light intensity (AMO spectrum), The program then produces plots of the various electrical parameters of interest, with either incident intensity or cell temperature as the independent variable, as shown in Figs. 1 to 14. Least square fits to the data points are then made automatically to the measured data points using a second-degree polynominal for most parameters. The curve factors, AMO efficiencies, V_{OC} and V_{MP} data points are not fit but interconnected from point to point. In addition, the program calculates the temperature coefficients of the pertinent cell electrical parameters of interest, using the aforementioned curve fits, and plots these as a function of temperature, with intensity as a parameter, as shown in Figs. 15 through 18.

The figures are intended to be working artifacts; that is, they are formatted in such a way that they can supply information of a general nature or may be used to generate predictions, comparisons, computer input data, etc. To facilitate comparisons and inputting, all units are standardized as follows:

- (1) All currents are in units of mA/cm^2 .
- (2) All voltages are in units of mV.
- (3) All power outputs are in units of mW/cm^2 .
- (4) All curve factors are in dimensionless units.
- (5) All efficiencies are in percentages and are based on <u>total</u> cell area.
- (6) All temperatures are in $^{\circ}C$.
- (7) All incoming intensities are in units of mW/cm^2 and are representative of an AMO spectrum.
- (8) All geometric dimensions are in units of cm or μ m (whichever is most convenient conceptually).

The tables included in this report contain complete numerical information with respect to the average values of the following solar cell electrical parameters: I_{SC} , V_{OC} , IP_{MAX} , P_{MAX} , CF, and efficiency at each intensity-temperature combination. For each such parameter at each such intensity-temperature combination, the standard deviation is presented to provide estimates of statistical validity. All efficiency, current, and power output data is on the basis of unit area derived by dividing measured output by total cell area.

The Spectrolab K7 type of solar cell is a commercially available cell which is used for space applications. Other space-qualified solar cells in the K series included such features as polished surfaces, back surface reflectors, and other thicknesses. These other types of K cells will be tested and reported in the future.

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- Volume VII. Electrical Characteristics of Spectrolab HEWAC BSF, Textured, 10Ω -cm, 225-Micron Solar Cells as a Function of Intensity and Temperature, June 1979.



Figure 1. Average I_{sc}/cm^2 as a Function of Temperature



Figure 2. Average V_{OC} as a Function of Temperature



Figure 3. Average $\rm I_{mp}/cm^2$ as a Function of Temperature

Figure 4. Average V_{mp} as a Function of Temperature

Figure 5. Average P_{max}/cm^2 as a Function of Temperature

Figure 6. Average Curve Factor as a Function of Temperature

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Figure 7. Average AMO Efficiency a Function of Temperature

Figure 8. Average I_{sc}/cm^2 as a Function of Intensity

Figure 9. Average $\rm V_{\rm oc}$ as a Function of Intensity

MAXIMUM POWER CURRENT, mA/cm²

.

Figure 11. Average ${\tt V_{mp}}$ as a Function of Intensity

Figure 12. Average P_{max}/cm^2 as a Function of Intensity

Figure 13. Average Curve Factor as a Function of Intensity

Figure 14. Average AMO Efficiency as a Function of Intensity

Figure 15. Isc Temperature Coefficient

Figure 10. V_{oc} Temperature Coefficient

Figure 17. Absolute P_{max} Temperature Coefficient

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Figure 18. Percent Pmax Temperature Coefficient

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23

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Figure 20. Open Circuit Voltage vs 1 MeV Electron Fluence at 135.3 mW/cm² AMO Illumination, 28°C

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Figure 22. Voltage at Maximum Power vs) MeV Electron Fluence at 135.3 mW/cm² AMO Illumination, 28°C

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26

1.2

Figure 23. Maximum Power Current Density vs 1 MeV Electron Fluence at 135.3 mW/cm² AMO Illumination, 28°C

		51	P 10 OHM-	CH CE ST	TCON	•	
		2	- 10 0HH-	CH LE SIL			
		÷.		BACK CON			
				BACK CUP	TACI		
				ATTNC	ici		
			205 AR CO	ATING			
		NU	COVERSEI	DE			
		51	MPLE SIZE		14-4	••	
FLL TEMP.					104++21		
(DEG. C)	5.00	15.00	25.00	50.00	106.00	135.30	251.00
-160.00	1.38	4.15	6.87	13.58	27.65	37.31	70.6
	(.04)	(.10)	(.18)	(.33)	(./5)	(.83)	(1.66)
-140.00	1.41	4.20	6.98	13.87	28.18	38.08	72.3
	(.04)	(.11)	(.20)	(.40)	(.83)	(.93)	(1.75
-120.00	1.45	4.26	/.11	14.14	28.78	38.96	72.6
	(.04)	(.11)	(.21)	(.40)	(.83)	(1.01)	(1.75
-100.00	1.45	4.38	7.24	14.50	29.39	39.62	73.6
	(.04)	(.11)	(.20)	(.38)	(.82)	(.84)	(1.44
-80.00	1.48	4.44	7.39	14.76	29.92	39.87	75.4
the second	(.04)	(.10)	(.18)	(.34)	(.73)	(.82)	(1.51
-60.00	1.50	4.48	7.50	15.00	30.33	40.56	76.4
	(.03)	(. 35)	(.17)	(.32)	(.67)	(.82)	(1.41
-40.00	1.52	4.55	7.58	15.15	30.71	41.26	77.1
	(.03)	(.09)	(.15)	(.29)	(.66)	(.75)	(1.30
-20.00	1.54	4.61	7.66	15.36	31.09	41.73	78.0
	(.03)	(.39)	(.16)	(.28)	(.66)	(.55)	(1.26)
.00	1.55	4.67	7.75	15.64	31.36	42.27	78.9
	(.03)	(.09)	(.16)	(.28)	(.67)	(.66)	(1.17
20.00	1.56	4.71	7.81	15.70	31.69	42.84	79.6
	(.03)	(.10)	(.14)	(.27)	(.66)	(.69)	(1.35
40.00	1.58	4.77	7.86	15.81	32.04	43.13	80.5
	(.03)	(.07)	(.16)	(.28)	(.69)	(.71)	(1.28
60.00	1.59	4.82	7.96	15.98	32.24	43.43	61.01
	(-03)	(.09)	(.16)	(.27)	(.79)	(.73)	(1.32
80.00	1.60	4.85	8.03	16.16	32.51	43.91	81.8
	(.03)	(.99)	(.16)	(.28)	(.70)	(.70)	(1.43
100.00	1.62	4.95	8.09	16-34	32-84	44-12	62.6
	(.03)	(-11)	(-16)	1.27)	(.69)	1.733	(1.42
120.00	1.63	4.99	8.21	16.48	33.21	44.81	83.5
	1.031	1.091	(.15)	1.281	1.701	1.741	11.42
140.00	1.64	5.02	8.25	16.66	33.52	45.37	84.15
	1.033	1.191	(.16)	1.291	1.711	1.721	(1.30)

Table 1. Average Short-Circuit Current, mA/cm2

Table 2. A	verage	Open-Circuit	Voltage,	mV
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		AI T S	X 4 X . CI X 4 X . CI L-TI-PD-AG FI A205 AR CI COVERSL AMPLE SIZI	-CM CG SII 29 CM 5 BACK CON RONT CONT 0 ATING 1 DE 5 F	LICON NTACT ACT		
(DEG. C)	5.00	15.00	25.60	50.00	100.00	135.30	250.0
-160.00	889.62	936.09	944.47	953.50	962.14	966.09	973.2
	(20.70)	(2.90)	(2.20)	(2.10)	(1.98)	(1.62)	(1.93
-14 5.00	858.64	895.66	904.87	915.72	925.49	929.77	938.2
	(13.11)	(4.68)	(3.05)	(2.40)	(2.11)	(1.87)	(1.59
-120.00	821.30	854.43	864.16	875.91	887.89	892.39	912.4
	(8.94)	(4.39)	(3.96)	(3.12)	(2.19)	(2.28)	11.66
-100.00	779.25	811.61	822.19	835.74	848.81	854.29	865.1
	(7.45)	(5.09)	(4.37)	(3.21)	(2.63)	(2.01)	12.10
-85.00	737.09	768.79	779.49	793.64	8 9.22	815.32	827.3
	16.601	(4.60)	14.041	(3.38)	12.311	12.061	12.13
-60.00	692.99	722.89	736.91	752.95	768.80	774.95	769.8
-0	15.611	14.361	13.711	12.611	12.351	11.971	12.17
-44.04	646.55	680.04	603.35	710.55	707.66	715.21	740 0
	15.001	(3.86)	13.221	12.751	12.501	13 361	12.47
-99.00	660.05	634.30	647.50	666.76	6 25 . 34	(01 77	71. 1
	15 121	13.211	14.201	13.00	10.011	12 821	12.07
-0.0	551.96	507.12	611.01	603 31	641 10	651 24	12.01
• • • •	15 175	1 775	603.01	023.31	645.10	651.24	666.5
	(5.13)	(3.33)	(4.13)	13.387	1 3.217	13.281	(4.06
2	503.25	541.80	557.75	578.89	599.19	609.30	628.2
	4.007	14.107	(4.29)	14.037	(3.95)	(3.61)	(3.15
40.00	400.19	494.52	511.00	533.69	336.19	566.1	586.1
	(4./5)	(5.10)	(4.47)	(3.85)	(4.35)	(4.09)	(3.98
60.00	405.14	447.01	464.4	488.51	512.37	522.34	544.0
	(5.19)	(4.96)	(5.00)	(5.02)	(4.87)	(4.60)	14.64
80.00	355.35	398.10	416.64	442.51	467.74	478.45	561.3
	(5.39)	(5.29)	(5.67)	(5.64)	(5.34)	(5.20)	(4.95
100.00	304.97	349.24	367.81	395.21	422.21	433.66	458.0
	(5.96)	(6.44)	(6.38)	(5.94)	(5.96)	(5.77)	15.40
120.03	253.47	299.61	321.20	347.60	376.17	388.31	413.7
	(6.12)	(6.55)	(7.32)	(6.48)	(6.30)	(5.86)	(5.71
140.00	200.77	248.49	269.84	259.45	328.19	341.61	369.7
	(6.76)	(6.95)	(7.01)	(6.83)	(6.22)	(6.37)	(6.10

		SP	ECTROL AB	TEXTURED	BSF. BSF	8	
		N	P 10 0HM-	CM CG SIL	ICON		
		2	X 4 X . 02	9 CM			
		AL	-TI-PD-AG	BACK CON	TACT		
		TI	-PD-AG FR	ONT CONT!	CT		
		TA	205 AR CO	ATING			
		NC	COVERSLI	DE			
		SA	MPLE SIZE	8	TM-	••	
ELL TEMP.		s	OLAR INTE	-	/(#++2)		
(DES. C)	5.00	15.00	25.00	50.00	100.00	135.30	250.00
-160.00	1.16	3.68	6.25	12.79	26.59	35.82	68.7
	(.07)	(.23)	(.31)	(.46)	(.79)	(.87)	(1.63
-140.00	1.18	3.77	6.44	13.17	27.13	36.56	71.3
	(.08)	(.21)	(.29)	1.473	(.80)	(1.03)	(1.83
-120.00	1.21	3.88	6.60	13.47	27.79	37.32	70.3
	(.08)	(.20)	(.28)	(.45)	(.96)	(1.06)	(1.84
-100.00	1.23	4.02	6.77	13.85	28.34	38.09	71.2
	(.08)	(.16)	(.23)	(.40)	(.82)	(.93)	(1.79
-80.00	1.27	4.11	6.93	14.14	28.83	38.29	72.5
	(.07)	(.15)	(.20)	(.37)	(.74)	(.95)	(1.50
-60.00	1.30	4.17	7.07	14.32	29.20	38.89	73.4
	(.06)	(.13)	(.21)	(.34)	(.69)	(.82)	(1.49
-40.00	1.33	4.23	7.11	14.41	29.43	39.45	74.9
	(.05)	(.08)	(.17)	(.32)	(.69)	(.73)	(.99
-20.00	1.33	4.29	7.16	14.55	29.66	39.65	74.3
	(.05)	(.09)	(.16)	: 32)	(.64)	(.68)	(1.10
.00	1.36	4.31	7.20	14.69	29.66	39.84	74.3
	(.04)	(.09)	(.15)	(.28)	(.63)	(.72)	1.87
20.00	1.38	4.33	7.23	14.62	29.74	39.94	74.2
	(.33)	(.09)	(.14)	(.25)	(.68)	1.64)	(1.11
40.00	1.40	4.33	7.23	14.61	29.86	39.91	74.3
	(.03)	(.09)	(.18)	(.24)	(.69)	(.65)	1.79
60.00	1.37	4.33	7.19	14.60	29.66	39.79	73.7
	(.03)	(.11)	(.16)	(.30)	(.60)	(.66)	1.91
80.00	1.37	4.27	7.12	14.52	29.46	39.55	73.7
	(.02)	(.09)	(.15)	(.31)	(.72)	(-52)	1.91
100.00	1.35	4.28	7.04	14.42	27.15	39-15	72.7
	(.03)	(.12)	(.16)	(.28)	1.561	1.533	1.82
120.06	1.32	4.21	6.99	14.14	28.95	38.95	71.9
	(.04)	(.09)	(.14)	(.29)	(.55)	1.600	1.70
140.00	1,25	4.03	6.73	13.95	28.16	38 12	70.00
	(.02)	(-10)	(.14)	(.25)	(.55)	1.381	11.04

Table 3. Average Maximum Power Current, mA/cm2

ELL TEMP. (DEG. C) -160.00 -140.00 -120.00 -00.00 -80.00 -60.00 -40.00 -20.00		N 2 A T T	X 4 X .C: X 4 X .C: L-TI-PD-A 1-PD-AG FI A 205 AR C:	-CM CG SIN 29 CM G BACK CON RONT CONT	TACT		
ELL TEMP. (DEG. C) -160.00 -140.00 -120.00 -100.00 -80.00 -80.00 -40.00 -20.00		2	X 4 X . C: L-TI-PD-A 1-PD-AG FI A 205 AR C	S BACK CON	TACT		
ELL TEMP. (DEG. C) -160.73 -140.60 -120.00 -100.00 -80.00 -60.00 -40.00 -20.00		A T T N	L-TI-PD-A 1-PD-AG FI A 205 AR C	BACK CONT	TACT		
ELL TEMP. (DEG. C) -160.73 -145.60 -120.00 -100.00 -80.00 -60.00 -40.00 -20.60		T	1-PD-AG F	RONT CONT			
ELL TEMP. (DEG. C) -160.03 -145.60 -120.00 -100.00 -80.00 -60.00 -40.00 -20.60		TN	A 205 AR C				
ELL TEMP. (DEG. C) -160.03 -140.60 -120.00 -100.00 -80.00 -60.00 -40.00 -20.00		N	ALOU AN CI	DATING			
ELL TEMP. (DEG. C) -160.03 -140.00 -120.00 -100.00 -80.00 -60.00 -40.00 -20.00			O COVERSI	IDF			
ELL TEMP. (DEG. C) -160.00 -140.00 -120.00 -80.00 -80.00 -60.00 -40.00 -20.00		S	AMPLE SIZE	FR	T#-0	44	
ELL TEMP. (DEG. C) -160.03 -140.60 -120.00 -100.00 -80.00 -60.00 -40.00 -20.00			Anter otte				
CDE G. C) -160.03 -140.60 -120.00 -100.00 -80.00 -60.00 -40.00 -20.00			SOLAR INT		/CH++21		
-160.73 -140.00 -120.00 -100.00 -80.00 -60.00 -40.00 -20.00	5.00	15.00	25.40	50.00	1 00.00	135.30	250.0
-160.00 -140.00 -120.00 -100.00 -80.00 -60.00 -40.00 -20.00	0.00			50.05		103.30	
-140.00 -120.00 -100.00 -80.00 -60.00 -40.00 -20.00	697.62	834.87	875.75	896.25	906.75	912.87	918.3
-140.00 -120.00 -100.00 -80.00 -60.00 -40.00 -20.00	56.85)	(26.10)	(13.56)	(3.99)	(3.33)	(4.09)	14.41
-120.00 -100.00 -80.00 -60.00 -40.00 -20.00	683.50	854.87	833.62	852.00	866.00	869.00	874.8
-120.00 -100.00 -80.00 -60.00 -40.00 -20.00	45.86)	(20.92)	(9.46)	(7.27)	(4.50)	(4.11)	(5.96
-100.00 -80.00 -60.00 -40.00 -20.00	668.75	769.12	792.75	808.25	823.00	825.75	831.6
-100.00 -80.00 -60.00 -40.00 -20.00	37.891	(12.89)	(8.33)	(5.60)	(2.45)	(4.17)	(7.15
-80.00 -60.00 -40.00 -20.00	652.50	730.00	749.62	765.50	779.37	783.12	790.3
-80.00 -60.00 -40.00 -20.00	25.29)	(10.94)	(7.95)	(6.16)	(1.85)	(4.29)	(9.05
-60.00 -40.00 -20.00	620.62	686.87	704.12	717.12	736.50	740.50	747.1
-60.00 -40.00 -20.00	17.37)	(7.02)	(6.73)	(4.91)	(3.16)	(3.12)	18.25
-40.00	586.75	639.50	657.37	675.12	690.75	696.25	701.0
-40.00	11.433	(8.54)	(3.34)	(3.64)	(3.41)	(4.27)	17.13
-20.00	543.62	594.25	610.75	628.37	642.50	651.12	656.1
-20.00	(7.82)	(7.01)	(4.06)	(2.56)	(2.00)	(2.73)	16.60
	502.50	547.62	564.25	583.37	598.50	694.37	611.6
	16.461	16.911	(4.16)	(4.21)	(1.41)	(3.81)	18.48
. 60	459.87	500.75	517.75	537.37	554.75	559.75	567.3
	11.151	(5.12)	(5.06)	(3.34)	(3.85)	(3.58)	18.85
29.60	417.12	453.59	471.75	491.87	510.62	516.37	525.7
	(6.79)	(7.58)	(4.89)	(3.87)	(2.97)	(3.20)	18-48
41.00	354.50	404.75	422.75	444-62	463.87	471.37	479.2
	(5.10)	(3.96)	(3.45)	(3.78)	(3.00)	(3.74)	19.19
63-63	314.97	359.75	376-87	400.00	419.25	426.51	437.7
	(4.52)	(4.50)	(5.00)	(2.14)	(1.83)	14.661	17.44
81.00	269.37	713.37	331.25	354.37	374.50	383.37	192.5
	16.321	(5.26)	(5.75)	(4.63)	(3.30)	(3.17)	19.12
110.00	225.62	268.12	284.5	309.25	129.87	338.00	351.7
	17.42	14.023	14.343	15.623	13.641	14.91	17 50
100.00	179.75	221.07	241.12	265.25	295.50	293.5	304 7
120.00	15.063	15.001	15.511	13.693	14.211	14.345	.7
140.00	110 (2	101 10	197 10	220 00	241 75	251 75	005
140.00	157.62	161.12	15 112	13 051	243.15	201.15	200.0
	10.851	(0.17)	(0.33)	(3.85)	15.607		10.95

Table 4. Average Maximum Power Voltage, mV

.

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CELL TEMP. CDEG. C) -160.00 -140.00 -140.00 -120.00 -100.00 -00.00 -60.00 -40.00 C. -20.00 C. -20.00 C. -20.00 C. -20.00 C. -20.00 C. -20.00 C. -20.00 C. -20.00 C. -20.00 C. -20.00 C. -20.00 C. -20.00 C. -20.00 C. -40.00 C. -40.00 C. -40.00 C. -140.00 C. -140.00 C. -140.00 C. -140.00 C. -120.00 C. -100.00 C. -20.00 C. -20.00 C. -40.00 C. -40.00 C. -40.00 C. -40.00 C. -40.00 C. -40.00 C. -40.00 C. -40.00 C. -40.00 C. -40.00 C. -40.00 C. -40.00 C. -40.00 C. -40.00 C. -40.00 C. -40.00 C. -20.00 C. -	5.00 .81 .10) .81 .09) .80 .09) .80 .07) .79 .06) .76 .05) .72	N/ 2 AL TJ TA NO SA S 15.00 3.08 (.26) 3.04 (.23) 2.98 (.19) 2.93 (.15) 2.93 (.15) 2.82 (.13) 2.66 (.10)	P 10 0HM- x 4 x .02 -TI-PD-AG FR 205 AR CO COVERSLI MPLE SIZE SOLAR INTE 25.00 5.48 (.34) 5.37 (.29) 5.23 (.26) 5.08 (.22) 4.88 (.17) 4.65	CM CG SIN 9 CM PACK CON ONT CONTATING DE 8 NSITY (MM 50.00 11.47 (.45) 11.22 (.47) 10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	TM	44 135.39 32.70 (.88) 31.77 (.97) 30.82 (.94) 29.83 (.67) 28.35 (.65)	250.0 63.1 (1.34 61.5 (1.36 58.5 (1.21 56.3 (.84.2 (.67
ELL TEMP. CDE G. C) -160.00 -140.00 -140.00 -120.00 -100.00 -100.00 -000 -40.00 -20.00 -00 -00 -00 -00 -00 -00 -00	5.00 .81 .10) .81 .09) .81 .09) .80 .07) .79 .06) .76 .05) .72	2 AL TI TA NO SA S 15.00 3.08 (.26) 3.04 (.23) 2.98 (.19) 2.93 (.15) 2.93 (.15) 2.66 (.10)	X 4 X .02 -TI-PD-AG FR 1205 AR CO 0 COVERSLI MPLE SIZE SOLAR INTE 25.66 5.48 (.34) 5.37 (.29) 5.23 (.26) 5.68 (.22) 4.88 (.17) 4.65	9 CM PACK COI ONT CONT ATING DE 8 NSITY (MI 50.00 11.47 (.45) 11.22 (.47) 10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	TH	44 135.30 32.70 (.86) 31.77 (.97) 30.82 (.94) 29.83 (.67) 28.35 (.65)	250.0 63.1 (1.34 61.5 (1.36 58.5 (1.21 56.3 (58.4 2 (.67
ELL TEMP. CDE G. C) -160.00 -140.00 -120.00 -120.00 -100.00 -000 -000 -20.00 -00 -20.00 -00 -00 -00 -00 -00 -00 -00	5.00 .81 .10) .81 .09) .81 .09) .80 .07) .79 .06) .76 .05) .72	AL TI TA NO SA S 15.00 3.08 (.26) 3.04 (.23) 2.98 (.19) 2.93 (.15) 2.82 (.13) 2.66 (.10)	-TI-PD-AG -PD-AG FR 205 AR CO 0 COVERSLI MPLE SIZE SOLAR INTE 25.60 5.48 (.34) 5.37 (.29) 5.23 (.26) 5.68 (.22) 4.88 (.17) 4.65	EACK CON ONT CONT ATING DE 8 NSITY (M) 55.00 11.47 (.45) 11.22 (.47) 10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	TM-4 TM-4	44 135.30 32.70 (.88) 31.77 (.97) 30.82 (.94) 29.83 (.67) 28.35 (.65)	25 0.0 63.1 (1.34 61.5 (1.36 58.5 (1.21 56.3 (.84 54.2 (.67
ELL TEMP. (DE G. C) -160.00 -140.00 -140.00 -120.00 -100.00 -100.00 -00 -00 20.00 40.00	5.00 .81 .10) .81 .09) .81 .09) .80 .07) .79 .06) .76 .05)	TI TA NO SA S 15.00 3.08 (.26) 3.04 (.23) 2.98 (.19) 2.93 (.15) 2.82 (.13) 2.66 (.10)	-PD-AG FR 205 AR CO COVERSLI MPLE SIZE SOLAR INTE 25.00 5.48 (.34) 5.37 (.29) 5.23 (.26) 5.08 (.22) 4.88 (.17) 4.65	CNT CONT ATING DE 8 NSITY (M) 55.00 11.47 (.45) 11.22 (.47) 10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	TH TH	44 135.30 32.70 (.88) 31.77 (.97) 30.82 (.94) 29.83 (.67) 28.35 (.65)	25 5. 0 63.1 (1.34 61.5 (1.36 58.5 (1.21 56.3 (.84.2 54.2 (.67
ELL TEMP. (DEG. C) -160.00 -140.00 -140.00 -120.00 -100.00 -100.00 -000 -000 -20.00 40.00	5.00 .81 .10) .81 .09) .81 .09) .80 .07) .79 .06) .76 .05) .72	TA NO SA 15.00 3.08 (.26) 3.04 (.23) 2.98 (.19) 2.93 (.15) 2.82 (.13) 2.66 (.10)	205 AR CO COVERSLI MPLE SIZE SOLAR INTE 25.60 5.48 (.34) 5.37 (.29) 5.23 (.26) 5.08 (.22) 4.88 (.17) 4.65	ATING DE 8 NSITY (M) 56.00 11.47 (.45) 11.22 (.47) 10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	TH 100.00 24.11 (.73) 23.50 (.79) 22.87 (.82) 22.69 (.66) 21.23 (.56) 20.17	44 135.30 32.70 (.88) 31.77 (.97) 30.82 (.94) 29.83 (.67) 28.35 (.65)	25 5 . 0 63 . 1 (1. 34 61 . 5 (1. 36 58 . 5 (1. 21 56 . 3 (. 84 . 2 (. 67
ELL TEMP. (DEG. C) -160.00 -140.00 -140.00 -120.00 -100.00 -000 -60.00 -40.00 -20.00 40.00	5.00 .81 .10) .81 .09) .81 .09) .80 .07) .79 .06) .76 .05) .72	NO SA S 15.00 3.08 (.26) 3.04 (.23) 2.98 (.19) 2.93 (.15) 2.82 (.13) 2.66 (.10)	COVERSLI MPLE SIZE COLAR INTE 25.60 5.48 (.34) 5.23 (.29) 5.23 (.26) 5.18 (.22) 4.88 (.17) 4.65	DE 8 NSITY (M) 56.00 11.47 (.45) 11.22 (.47) 10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	TM 100.00 24.11 (.73) 23.50 (.79) 22.87 (.82) 22.69 (.66) 21.23 (.56) 20.17	44 135.39 32.70 (.88) 31.77 (.97) 30.82 (.94) 29.83 (.67) 28.35 (.65)	25 5. 4 63.1 (1.3 61.5 (1.3) 58.5 (1.2) 56.3 (1.2) 56.3 (1.2) 56.4 (1.3) 56.4 (1.3) (1.3)
ELL TEMP. (DEG. C) -160.00 -140.00 -140.00 -120.00 -100.00 -00.00 -60.00 -40.00 -20.00 40.00	5.00 .81 .10) .81 .09) .81 .09) .80 .07) .79 .06) .76 .05) .72	SA 15.00 3.08 (.26) 3.04 (.23) 2.98 (.19) 2.93 (.15) 2.82 (.13) 2.66 (.10)	MPLE SIZE SOLAR INTE 25.00 5.48 (.34) 5.37 (.29) 5.23 (.26) 5.08 (.22) 4.88 (.17) 4.65	B NSITY (M) 50.00 11.47 (.45) 11.22 (.47) 10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	TH 100.00 24.11 (.73) 23.50 (.79) 22.87 (.82) 22.69 (.66) 21.23 (.56) 20.17	44 135.30 32.70 (.88) 31.77 (.97) 30.82 (.94) 29.83 (.67) 28.35 (.65)	25 5. 1 63.1 (1.3 61.5 (1.3) 58.5 (1.2) 56.3 (1.2) 56.3 (1.2) 56.4 (1.3)
ELL TEMP. (DEG. C) -160.00 -140.00 -140.00 -120.00 -100.00 -000 -000 -20.00 40.00	5.00 .81 .09 .81 .09 .81 .09 .80 .07 .79 .06 .76 .05 .72	5.00 3.08 (.26) 3.04 (.23) 2.98 (.19) 2.93 (.15) 2.82 (.13) 2.66 (.10)	OLAR INTE 25.66 5.48 (.34) 5.37 (.29) 5.23 (.26) 5.68 (.22) 4.88 (.17) 4.65	NSITY (M) 55.00 11.47 (.45) 11.22 (.47) 10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	24.11 (.73) 23.50 (.79) 22.87 (.82) 22.69 (.66) 21.23 (.56) 20.17	135.39 32.70 (.88) 31.77 (.97) 30.82 (.94) 29.83 (.67) 28.35 (.65)	250.1 63.1 (1.34 61.5 (1.34 58.5 (1.2) 56.3 (1.2) 56.3 (1.2) 56.3 (1.2) 56.3
CDE G. C) 1 -160.00 - -140.00 - -120.00 - -100.00 - -100.00 - -80.00 - -60.00 - -40.00 - .00 - 20.00 - 40.00 -	5.00 .81 .10) .81 .09) .81 .09) .80 .07) .79 .06) .76 .05) .72	15.00 3.08 (.26) 3.04 (.23) 2.98 (.19) 2.93 (.15) 2.82 (.13) 2.66 (.10)	25.00 5.48 (.34) 5.37 (.29) 5.23 (.26) 5.08 (.22) 4.88 (.17) 4.65	50.00 11.47 (.45) 11.22 (.47) 10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	100.00 24.11 (.73) 23.50 (.79) 22.87 (.82) 22.69 (.66) 21.23 (.56) 20.17	135.30 32.70 (.88) 31.77 (.97) 30.82 (.94) 29.83 (.67) 28.35 (.65)	250.0 63.1 (1.34 61.5 (1.36 58.5 (1.21 56.3 (1.84 54.2 (1.67
-160.00 -140.00 -120.00 -120.00 -100.00 -00.00 -60.00 -60.00 -40.00 -20.00 -00 -00 -00 -00 -00 -00 -00	.81 .10) .81 .09) .81 .09) .80 .07) .79 .06) .76 .05) .72	3.08 (.26) 3.04 (.23) 2.98 (.19) 2.93 (.15) 2.82 (.13) 2.66 (.10)	5.48 (.34) 5.37 (.29) 5.23 (.26) 5.08 (.22) 4.88 (.17) 4.65	11.47 (.45) 11.22 (.47) 10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	24.11 (.73) 23.50 (.79) 22.87 (.82) 22.69 (.66) 21.23 (.56) 20.17	32.70 (.86) 31.77 (.97) 30.82 (.94) 29.83 (.67) 28.35 (.65)	63.1 (1.34 61.5 (1.36 58.5 (1.21 56.3 (.84 54.2
-160.00 -140.00 -120.00 -120.00 -100.00 -00.00 -60.00 -40.00 -20.00 -00 -20.00 -00 -00 -00 -00 -00 -00 -00	.81 .10) .81 .09) .81 .09) .80 .07) .79 .06) .76 .05) .72	3.08 (.26) 3.04 (.23) 2.98 (.19) 2.93 (.15) 2.82 (.13) 2.66 (.10)	5.48 (.34) 5.37 (.29) 5.23 (.26) 5.08 (.22) 4.88 (.17) 4.65	11.47 (.45) 11.22 (.47) 10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	24.11 (.73) 23.50 (.79) 22.87 (.82) 22.69 (.66) 21.23 (.56) 20.17	32.70 (.88) 31.77 (.97) 30.82 (.94) 29.83 (.67) 28.35 (.65)	63.1 (1.34 61.5 (1.36 58.5 (1.2) 56.3 (.84 54.2
-140.00 -120.00 -100.00 -00.00 -60.00 -40.00 -20.00 -20.00 -00 -20.00 -00 -00 -00 -00 -00 -00 -00	.10) .81 .09) .81 .09) .80 .07) .79 .06) .76 .05) .72	(.26) 3.04 (.23) 2.98 (.19) 2.93 (.15) 2.82 (.13) 2.66 (.10)	(.34) 5.37 (.29) 5.23 (.26) 5.18 (.22) 4.88 (.17) 4.65	(.45) 11.22 (.47) 10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	(.73) 23.50 (.79) 22.87 (.82) 22.69 (.66) 21.23 (.56) 20.17	(.88) 31.77 (.97) 30.82 (.94) 29.83 (.67) 28.35 (.65)	(1.3) (1.3) (1.3) (1.2) (1.2) (1.2) (1.2) (1.2) (1.2) (1.3)(
-140.00 -120.00 -100.00 -00.00 -60.00 -60.00 -40.00 -20.00 -20.00 -00 -20.00 -00 -00 -00 -00 -00 -00 -00	.81 .09) .81 .09) .80 .07) .79 .06) .79 .06) .76 .05)	3.04 (.23) 2.98 (.19) 2.93 (.15) 2.82 (.13) 2.66 (.10)	5.37 (.29) 5.23 (.26) 5.08 (.22) 4.88 (.17) 4.65	11.22 (.47) 10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	23.50 (.79) 22.87 (.82) 22.69 (.66) 21.23 (.56) 20.17	31.77 (.97) 30.82 (.94) 29.83 (.67) 28.35 (.65)	61.5 (1.3) 58.5 (1.2) 56.3 (.8) 54.2
-120.00 -100.00 -80.00 -60.00 -60.00 -40.00 -20.00 -20.00 -20.00 -00 -20.00 -00 -00 -00 -00 -00 -00 -00	.09) .81 .09) .80 .07) .79 .06) .79 .06) .76	(.23) 2.98 (.19) 2.93 (.15) 2.82 (.13) 2.66 (.10)	(.29) 5.23 (.26) 5.08 (.22) 4.88 (.17) 4.65	(.47) 10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	(.79) 22.87 (.82) 22.69 (.66) 21.23 (.56) 20.17	(.97) 30.82 (.94) 29.83 (.67) 28.35 (.65)	(1.3) 58.5 (1.2) 56.5 (.8) 54.5
-120.00 -100.00 -80.00 -60.00 -60.00 -40.00 -20.00 -20.00 -00 -00 -00 -00 -00 -00 -00	.81 .09) .80 .07) .79 .06) .76 .05) .72	2.98 (.19) 2.93 (.15) 2.82 (.13) 2.66 (.10)	5.23 (.26) 5.08 (.22) 4.88 (.17) 4.65	10.89 (.43) 10.60 (.37) 10.14 (.32) 9.67	22.87 (.82) 22.69 (.66) 21.23 (.56) 20.17	30.82 (.94) 29.83 (.67) 28.35 (.65)	58.5 (1.2) 56.5 (.8) 54.5
-100.00 -80.00 -60.00 -40.00 -20.00 20.00 40.00	.09) .80 .07) .79 .06) .76 .05)	(.19) 2.93 (.15) 2.82 (.13) 2.66 (.10)	(.26) 5.08 (.22) 4.88 (.17) 4.65	(.43) 10.60 (.37) 10.14 (.32) 9.67	(.82) 22.69 (.66) 21.23 (.56) 20.17	(.94) 29.83 (.67) 28.35 (.65)	(1.2) 56.3 (.8 54.3
-100.00 -80.00 -60.00 -40.00 -20.00 20.00 40.00	.80 .07) .79 .06) .76 .05)	2.93 (.15) 2.82 (.13) 2.66 (.10)	5.08 (.22) 4.88 (.17) 4.65	10.60 (.37) 10.14 (.32) 9.67	22.69 (.66) 21.23 (.56)	29.83 (.67) 28.35 (.65)	56.1 (.8 54.1
-80.00 -60.00 -40.00 -20.00 20.00 40.00	.07) .79 .06) .76 .05)	(.15) 2.82 (.13) 2.66 (.10)	(.22) 4.88 (.17) 4.65	(.37) 10.14 (.32) 9.67	(.66) 21.23 (.56)	1.67) 28.35 (.65)	1.8
-80.00 -60.00 -40.00 -20.00 .00 20.00 40.00	.79 .06) .76 .05)	2.82 (.13) 2.66 (.10)	4.88 (.17) 4.65	10.14 (.32) 9.67	21.23	28.35	54.2
-60.00 (. -40.00 (. -20.00 (. 20.00 (. 40.00 (.	.06) .76 .05)	(.13) 2.66 (.10)	(.17) 4.65	(.32) 9.67	(.56)	(.65)	1.6
-60.00 -40.00 -20.00 20.00 40.00	.76	2.66	4.65	9.67	21.17		
-40.00 (. -20.00 (. 20.00 (. 40.00 (.	.051	(.10)	1 15.			21.01	51.4
-40.00 (. -20.00 (. 20.00 (. 40.00 (.	.72			1.261	1.471	1.521	
-20.00 (. .00 (. 20.00 (.		2.52	4.14	9.15	18.91	25.69	
-20.00 (. .00 (. 20.00 (. 40.00 (.		1.071	1.121	1.221	1.411	1.421	
.00 (. 20.00 (. 40.00 (.	.67	2.35	4.04	8.40	17 75	27 84	
.00 20.00 40.00		1.071	1 101		11.15	23.96	
20.00 (.		2.16	1 77	7.00	1.5/1	1.517	
20.00 (.	.03	2010	3.13	1.90	10.45	22.30	42
40.00 (.	.023	(.06)	(.11)	(.17)	(.33)	(.32)	6.54
40.00	.56	1.96	3.40	7.19	15.18	20.63	39.1
40.00	.02)	(.0.)	(.09)	(.17)	(. 32)	(.27)	(.4
	.50	1.75	3.05	6.50	13.85	18.81	35.6
(,	.02)	(.05)	(.09)	(.15)	(.35)	(.25)	1.58
60.00	.43	1.56	2.71	5.84	12.43	16.97	32.2
	.01)	(.05)	(.09)	(.14)	(.25)	(.19)	1.53
80.00	.37	1.34	2.36	5.15	11.03	15.16	28.9
۲.	.01)	(.04)	(.08)	(.14)	(.26)	(.19)	1.6
100.00	.31	1.15	2.00	4.46	9.62	13.23	25.5
· · · ·	. 61)	(.05)	(.07)	(.12)	(.23)	(.22)	1.63
120.00	.24	.93	1.69	3.75	8.27	11.44	22.1
	.017	(.04)	(.07)	(.11)	(.22)	(.19)	1.64
140.00	.17	.73	1.33	3.07	6.86	9.60	18.6
	.01)	(.04)	(.06)	(.10)	(.21)	1.191	1.60

Table 5. Average Maximum Power, mW/cm²

Table 6. Average Curve Factor

			NELLINGLA	BIEXTURE	D. BSF. B	SR	
			2	COR CG S	ILICON		
				129 CM	and the second second		
			11-00-00-	AG BACK C	ONTACT		
			TACCE IS	FRONT CON	TACT		
			TALOS AR	CCATING			
			NO COVERS	LIDE			
			SAMPLE SI	ZE A	TM	-44	
CELL TEMP.							
(DEC. C)	5.00	15	SOLAK IN	TENSITY (MU/CM++2)		
	0.00	10.00	25.00	56.00	100.00	135.30	250.0
-160.00	. 66.09	. 70.25					
	(. 0595)	1.06300	.8443	.8855	.9065	.9072	.918
-140.00	. 66.91		1.3476)	(.0267)	(.0130)	(117)	1.0082
	1.05981	1.05705	.8508	.8831	.9009	.8972	.907
-120.00	- 6877		(.0362)	(.0223)	(.0141)	(.0086)	1.0060
	1.05741		.8517	.8795	.8948	.8864	.8921
-100.00	. 7070	0.04191	(. 1277)	(.0165)	(.0147)	(.0084)	1.01:4
	1.05201	.8261	.8524	.8747	.8854	.8812	.883
-80.00	. 7216		(.0206)	1.0126)	(. 2083)	(.0062)	1.05791
	1.04251	.82/1	.8477	.8658	.8771	.8722	.866
-62.04	7716	(251)	(.0159)	(.0096)	(.0056)	(.0056)	1.61121
		.8221	.8404	.8561	.8649	.8615	.8524
-43.00	7750	(.0225)	(.0136)	(.0095)	(. 3065)	(.005.)	1.0004
	. 0002	.8133	.8259	.8409	.8462	.8469	
-20.00	1.0296)	(. 9174)	(.0123)	(.0083)	(.0053)	(.0065)	1.41401
	. 1216	.8036	.8147	.8285	.8332	.8280	8234
. 0.0	1.0348)	(.0148)	(.0106)	(. 0071)	(.0055)	1.20561	1.11444
	. 1331	•7885	.7981	. 8100	.8159	.8101	
21.00	1.01653	(.0119)	(.0089)	(.0159)	(.0368)	(.0072)	1.01401
e	./120	.7691	.7814	.7912	.7988	.7902	7000
40.00	((.0107)	(.0092)	(.0044)	(.0077)	1.00691	
40.00	. 6920	.7440	.7600	.7703	.7772	.7797	7557
63.00	((.0120)	(.0071)	(.0(55)	(1.00891	
0	.6715	.7226	.7335	.7482	.7528	. 7491	
81.05	(.0123)	(.)098)	(.0089)	(.0056)	(.0086)	1.01101	. 1520
00.00	• 0524	.6932	.7053	.7198	.7256	.7217	
100.00	(. 1107)	(.0356)	(.0052)	(.0148)	(. 1085)	1.11:01	.1053
100.00	.6191	.6643	.6730	.6904	-1.939	6917	(.(234)
100.00	(.0090)	(.0051)	(.0051)	(.0057)	1.00723	. 01261	.6744
120.00	. 5742	.6247	.6392	.6546	.6619	(5126)	(. 0236)
	(.0092)	(.0059)	(.0544)	(.0042)	1.00775		.6389
140.00	. 5285	. 5844	. 5959	.6152	6240		(. 0267)
	1.0065)	(.0112)	(.0230)	(.(055)	(. 1092)	.0195	.5990

		S	PECTROLAB	TEXTURED	BSF. BSI	R	
		N	/P 10 OHM-	CM CG SIL	ICON		
		2	X 4 X . C2	9 CM			
			L-TI-PD-AG	BACK COM	TACT		
		T	1-PD-AG FR	ONT CONT	ACT		
		T	A 205 AR CO	ATING			
		N	O COVERSLI	DE			
		S	AMPLE SIZE	8	TH-	44	
CELL TEMP.			SOLAR INTE	NSITY (M	/(#++2)		
(DEG. C)	5.00	15.00	25.00	50.00	100.00	135.30	250.00
-160.00	16.26	26.53	21.92	22.94	24.11	24.17	25.25
	(1.96)	(1.76)	(1.37)	(.90)	(.73)	(.65)	(.54)
-140.00	16.19	20.27	21.48	22.44	23.50	23.48	24.62
	(1.87)	(1.51)	(1.14)	(.95)	(.79)	(.72)	1.541
-120.00	16.22	19.89	20.93	21.79	22.87	22.78	23.41
	(1.74)	(1.29)	(1.03)	(.86)	(.82)	(.70)	6.48
-100.00	16.04	19.57	20.31	21.21	22.09	22.05	22.53
	(1.50)	(1.00)	(.87)	(.74)	(.66)	(.49)	1.341
-80.00	15.75	18.82	19.53	20.29	21.23	20.95	21.64
	(1.20)	(.84)	(.69)	(.63)	(. 56)	(.48)	1.27
-60.00	15.21	17.76	18.58	19.34	20.17	20.01	20.5
	(.93)	1.651	1.661	1.521	1.471	1.381	1.25
-40.00	14.44	16.77	17.37	18.10	18.91	18.99	19.4
	1.741	1.441	(.49)	(.44)	(.41)	(.31)	1.10
-20.00	13.41	15.68	16.16	16.97	17.75	17.71	10 20
		1.491	1 46 1	1 411	. 175		10.21
	12.54	14.41	14.92	15.70	16 45	16 40	1.21
	1 161		14.72	10.19	10.40	10.48	10.80
20.00	11.01	17 00	17 (0	1.547	((.24)	(.22)
20.00	11.21	13.08	13.62	14.38	15.18	15.24	15.62
			1.575	((.32)	(.20)	(.16)
40.00	9.93	11.69	12.22	13.00	13.85	13.90	14.26
	(.34)	1.34)	(.37)	(.30)	(.35)	(.19)	(.23)
66.00	8.64	10.39	10.85	11.68	12.43	12.54	12.91
	(.28)	(.33)	(.37)	(.28)	(.25)	(.14)	(.21)
80.00	7.41	8.93	9.44	10.30	11.03	11.21	11.5
	(.27)	(.29)	(.32)	(.28)	(.26)	(.14)	(.24)
100.00	6.11	7.66	8.01	8.92	9.62	9.78	10.21
	(.26)	(.31)	(.28)	(.24)	(.23)	(.16)	(.25)
120.00	4.73	6.23	6.75	7.50	8.27	8.45	8.83
	(.22)	(.27)	(.28)	(.23)	(.22)	(.14)	(.26)
140.00	3.49	4.86	5.31	6.14	6.86	7.09	7.45
	(.19)	(.26)	(.24)	(.21)	(.21)	(.14)	1.281

Table 7. Average AMO Efficiency, Percent

OF POOR QUALITY

APPENDIX

Figure A-1. Solar Cell

ORIGINAL PAGE IS

Figure A-2. Test Plate

Figure A-3. Solar Cell Characterization Facility

POOR QUALITY

Figure A-4. Solar Cell Environmental Test Chamber

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