Stability Analysis of CdS/CdTe Solar Cells under illumination

Objective:

- To study and analysis of CdS/CdTe Solar cells for their stability performance under light soaking

- Standardize the stability testing procedure

- To investigate degradation mechanisms involved in the cell performance.

Experimental

Device Measurement

- One Half of Sample substrate is mounted inside the oven and stressed under one sun intensity simulated using Halogen lamps and other half remain unstressed.

- Day and Night cycle is done by turning on and off the lights at 4 Hour interval.

- The samples are maintained at desired temperature zone using water cooling technique.(Now it is maintained below 45 deg C)

- Characterization techniques such as IV, CV, Color IV and CF Measurements are used to analyze the degradation mechanisms involved.

- Light and Dark IV Measurements are made frequent intervals, keeping samples stressed inside the oven.

- The samples are maintained at UHP N_2 ambient.

Set III Samples under light soaking

- Annealing Temperature after $CdCl_2$ treatment

  360,370,380,390 and 400 deg C

- Various CBD CdS Deposition Time

  60,70,80 minutes

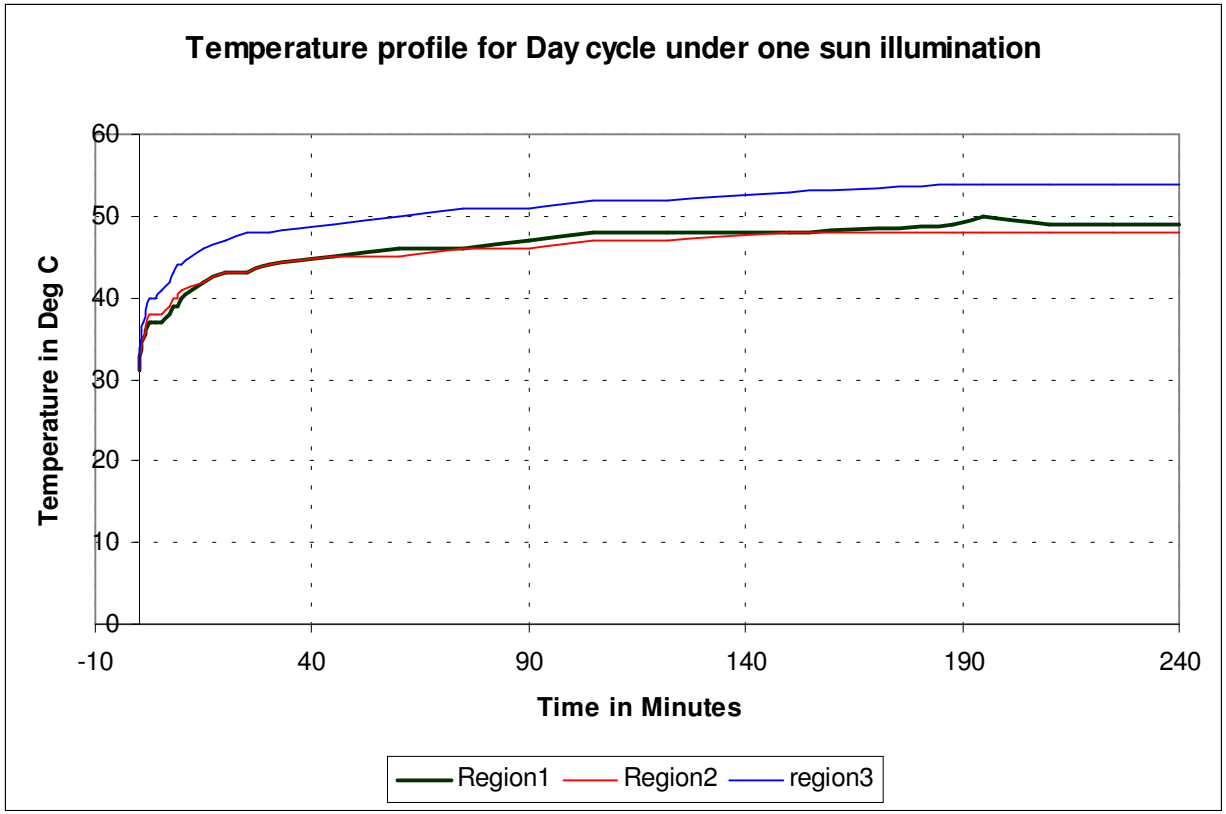
- CdTe only samples without Back contacts to see the effect of back contacts in degradation process

- Samples with $CuCl_2$ treatment on CdS.

Note:

Samples are tested under Open Circuit and Short Circuit Condition.

Temperature Profile inside the oven

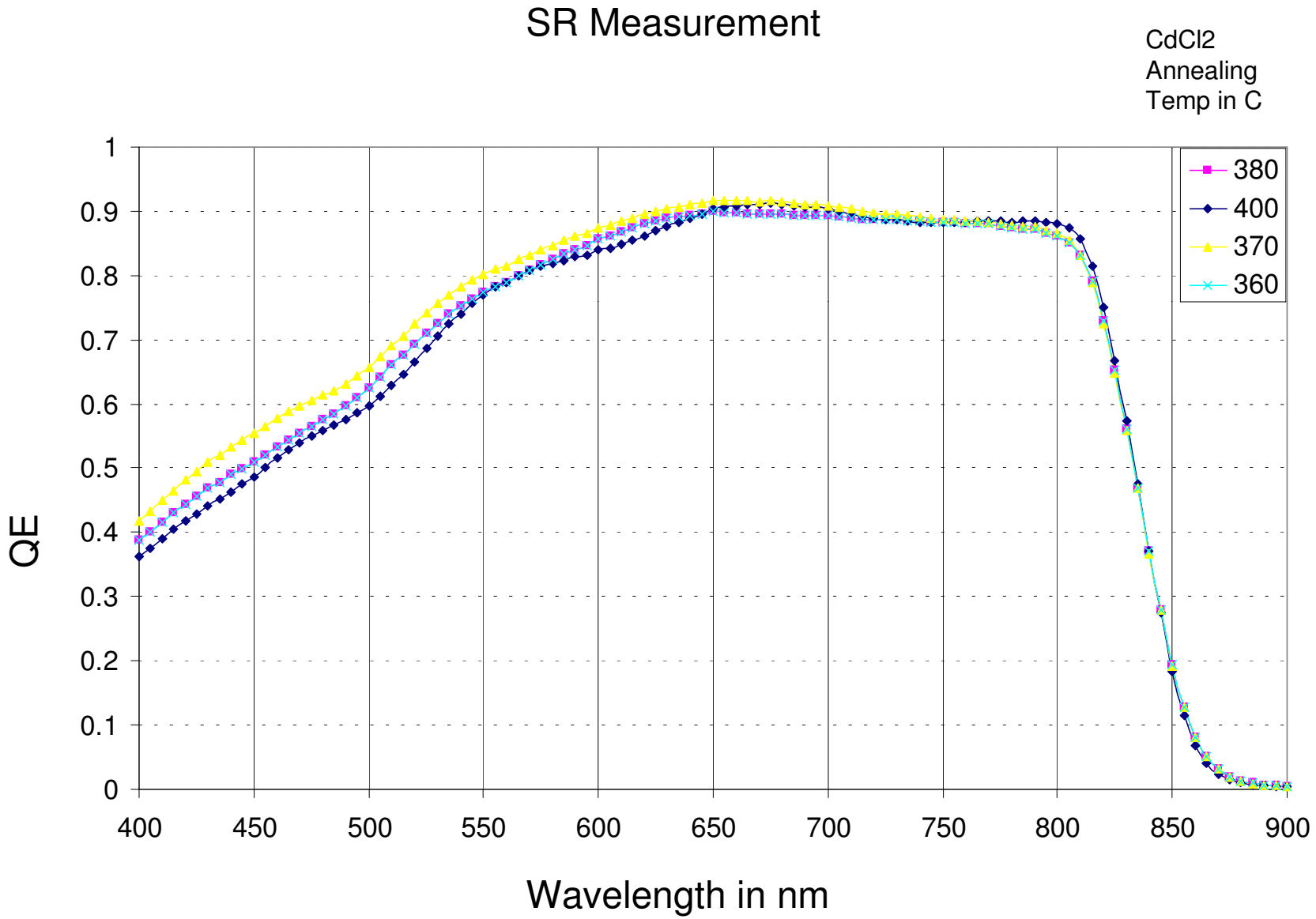


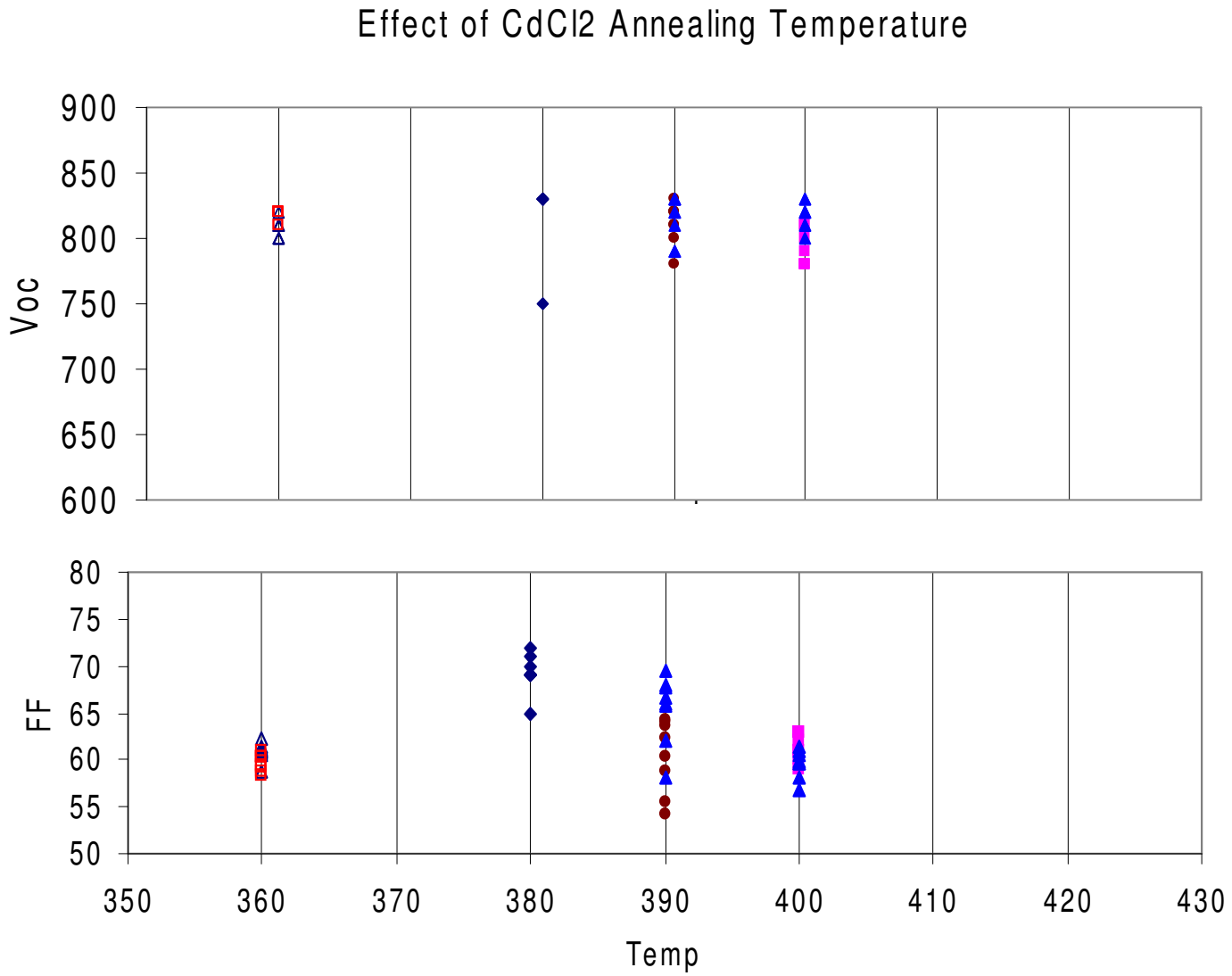
Set point for water flow control 35 deg C

1 2 3

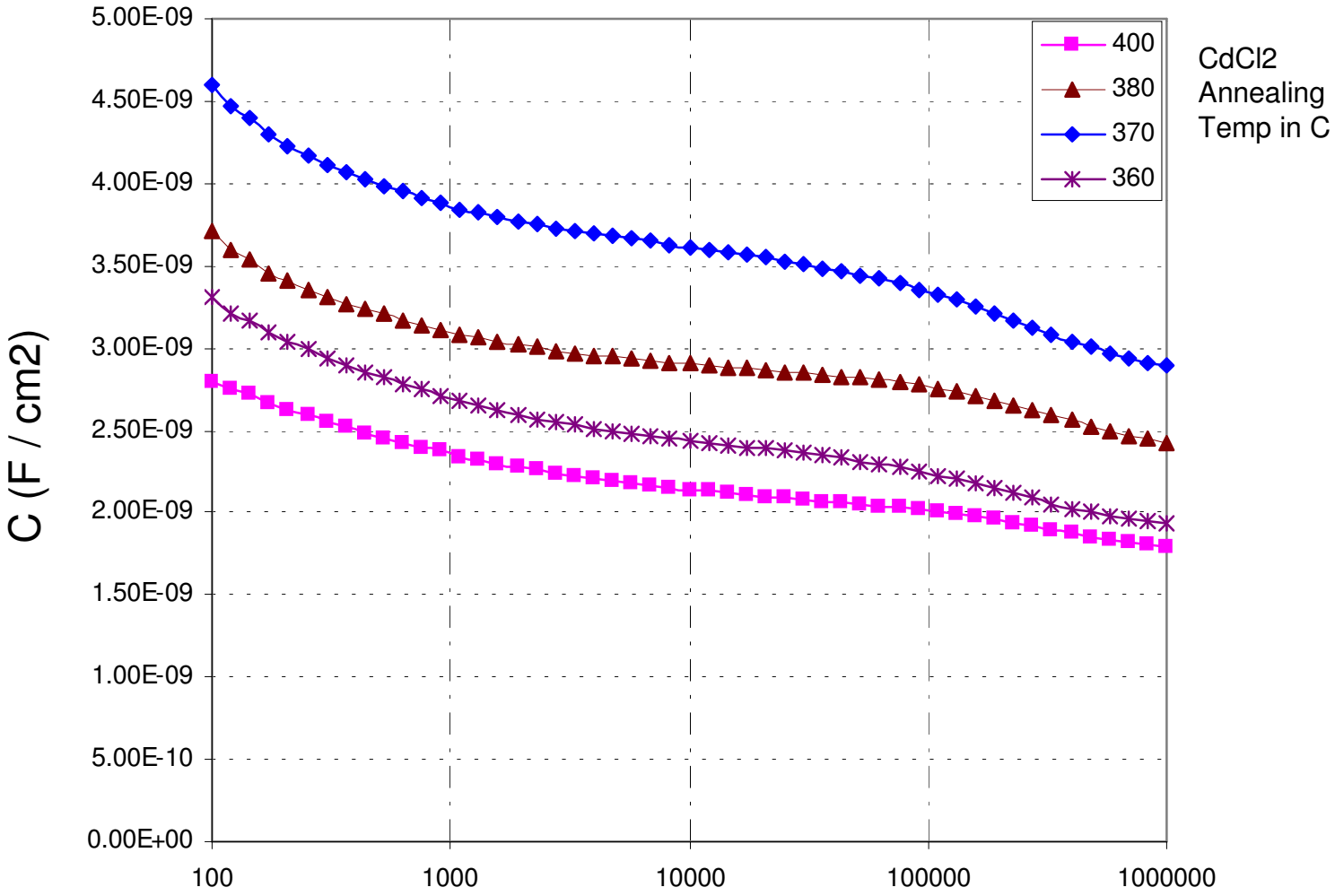
sub Region

Front Row


SR Measurement
CdCl2
Annealing
Temp in C
380
400
370
360
QE
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
400
450
500
550
600
650
700
750
800
850
900
Wavelength in nm


Effect of CdCl2 Annealing Temperature
Voc
900
850
800
750
700
650
600
FF
80
75
70
65
60
55
50
350
360
370
380
390
400
410
420
430
Temp

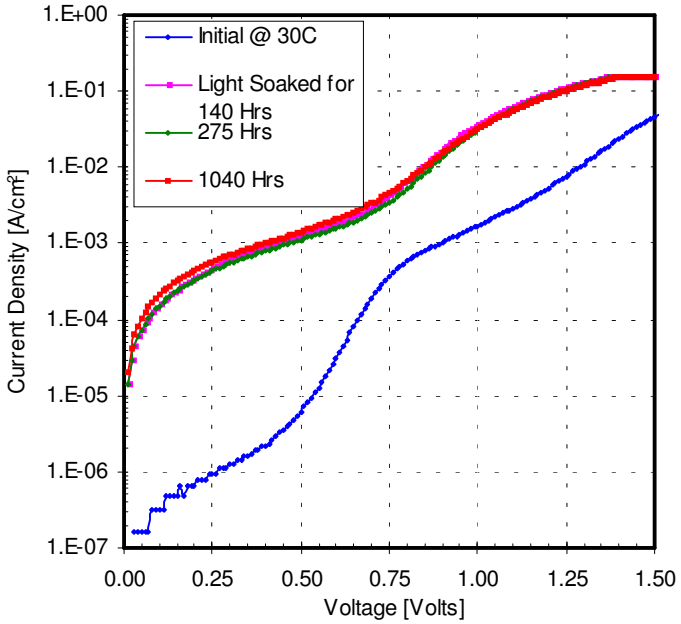
CF Measurement at Room Temperature



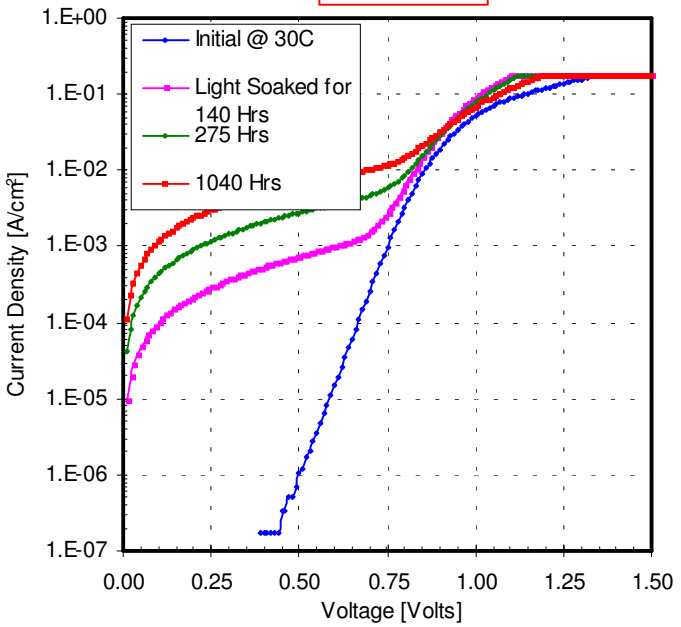
Stability Analysis of CdS/CdTe Solar cells
Ashok Rangaswamy

Post Annealing Effect on device stability

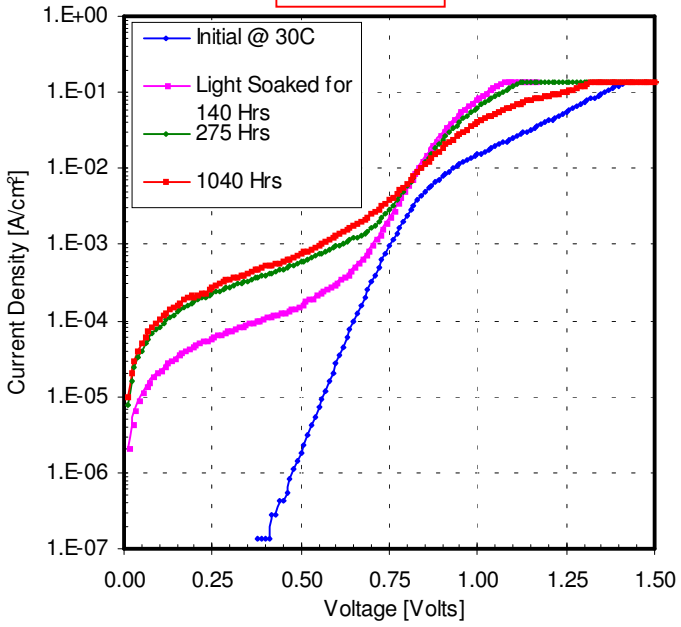
360 ^{0} C



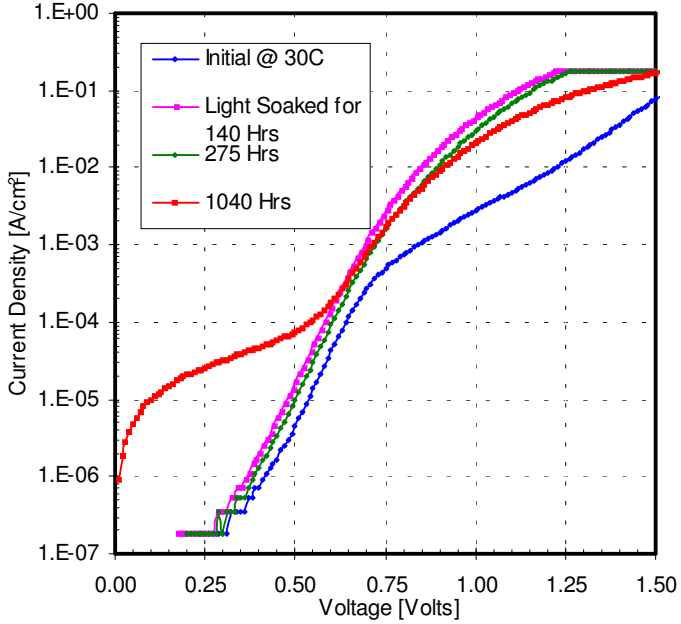
390 ^{0} C

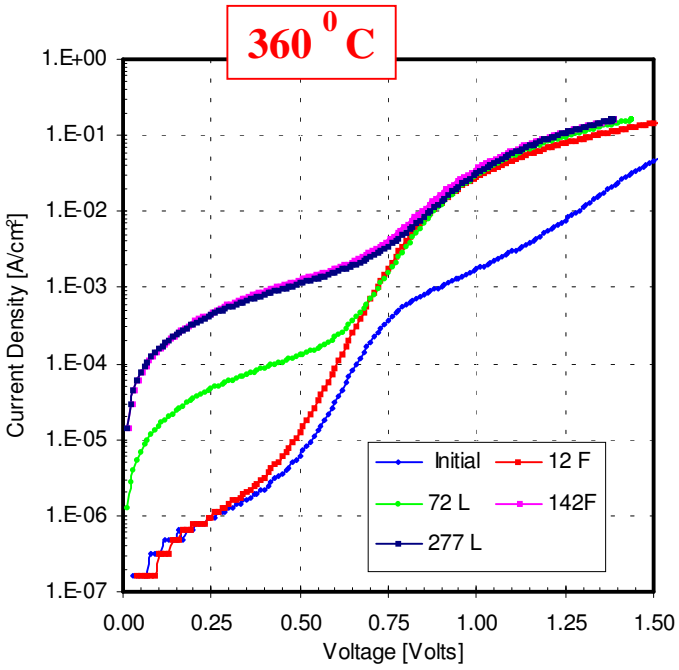


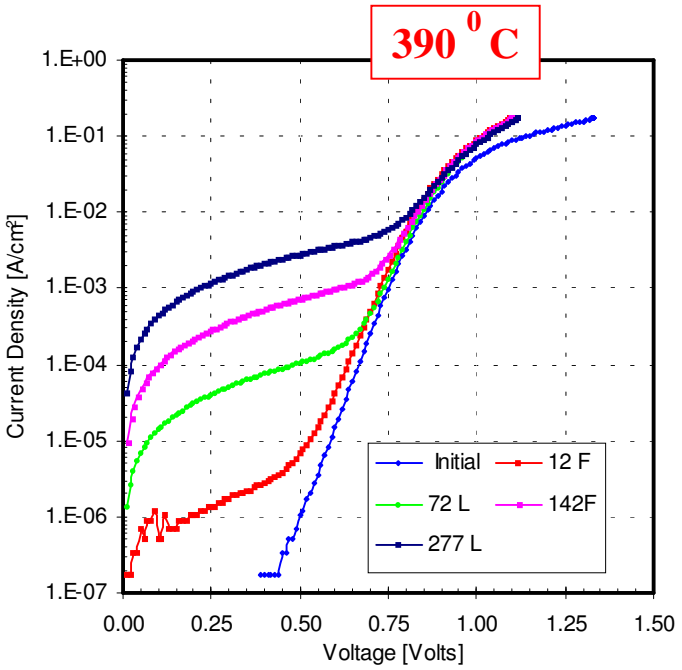
380 ^{0} C

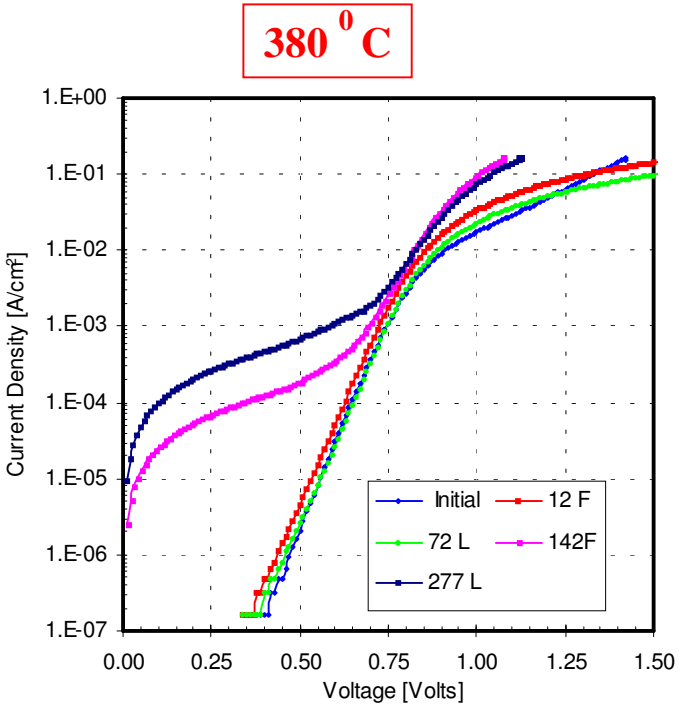


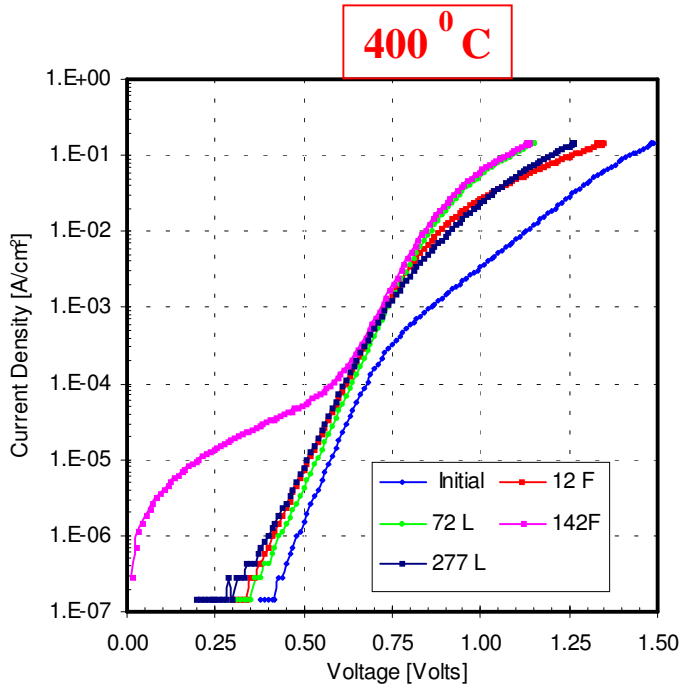
400 ^{0} C

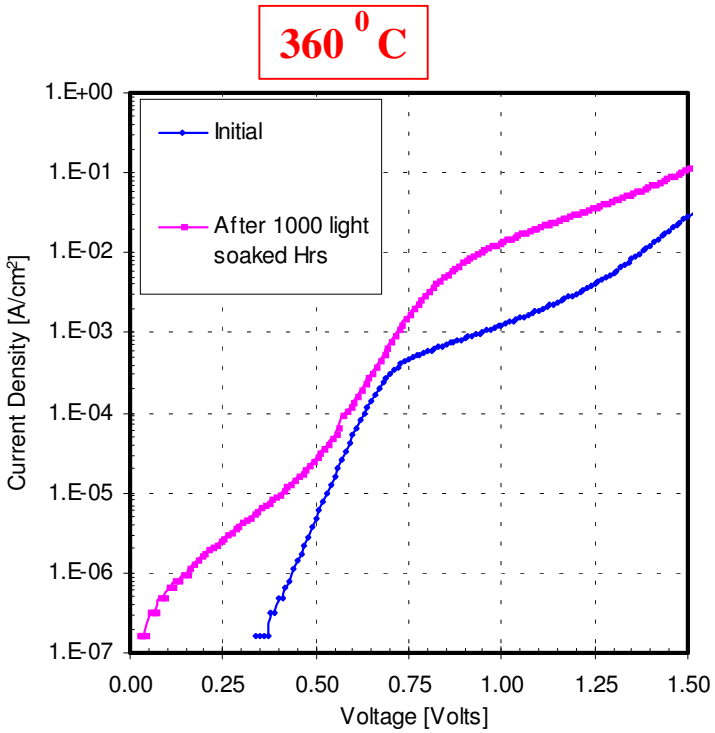


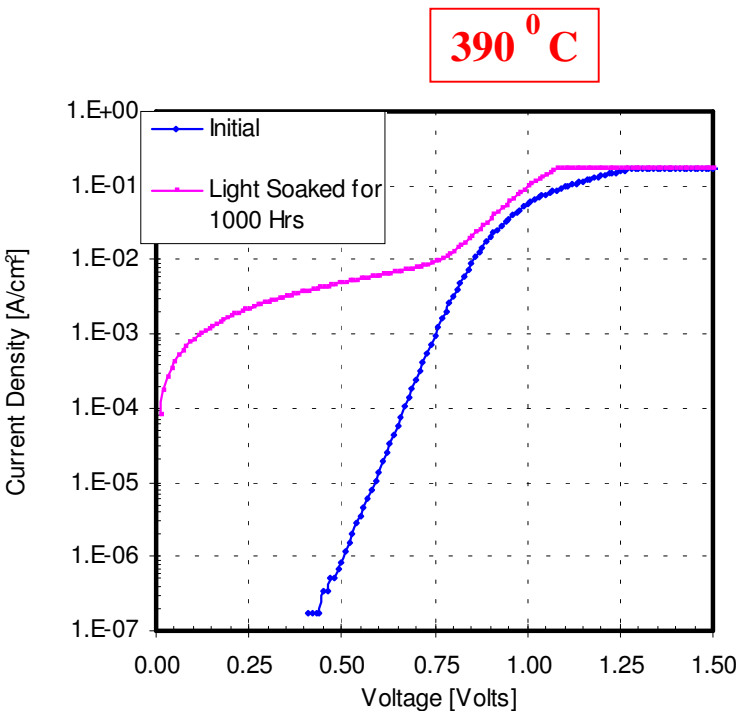

360 0 C
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
Current Density [A/cm²]
0.00
0.25
0.50
0.75
1.00
1.25
1.50
Voltage [Volts]
Initial
12 F
72 L
142F
277 L

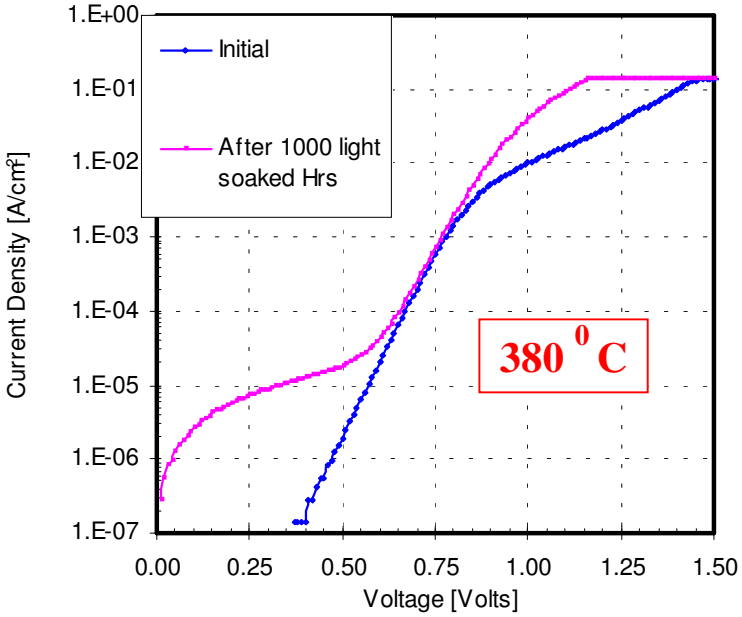

390 0 C
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
Current Density [A/cm²]
0.00
0.25
0.50
0.75
1.00
1.25
1.50
Voltage [Volts]
Initial
12 F
72 L
142F
277 L

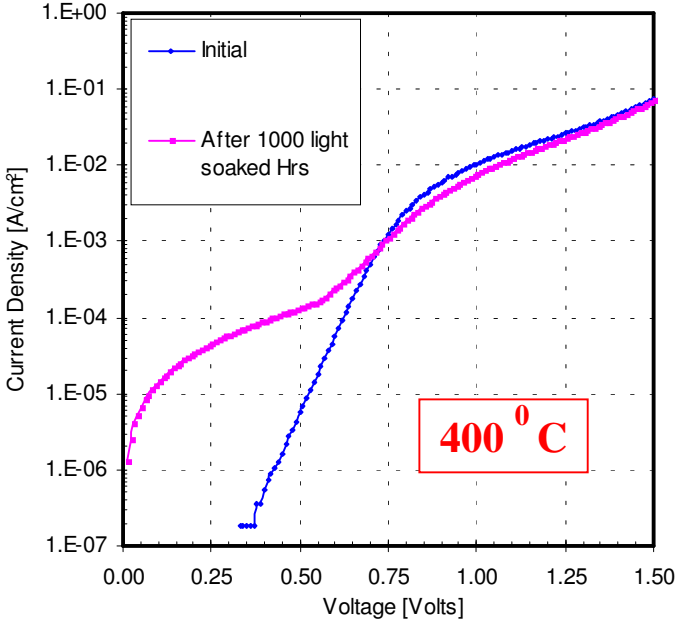

380 0 C
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
Current Density [A/cm²]
0.00
0.25
0.50
0.75
1.00
1.25
1.50
Voltage [Volts]
Initial
12 F
72 L
142F
277 L


400 0 C
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
Current Density [A/cm²]
0.00
0.25
0.50
0.75
1.00
1.25
1.50
Voltage [Volts]
Initial
12 F
72 L
142F
277 L

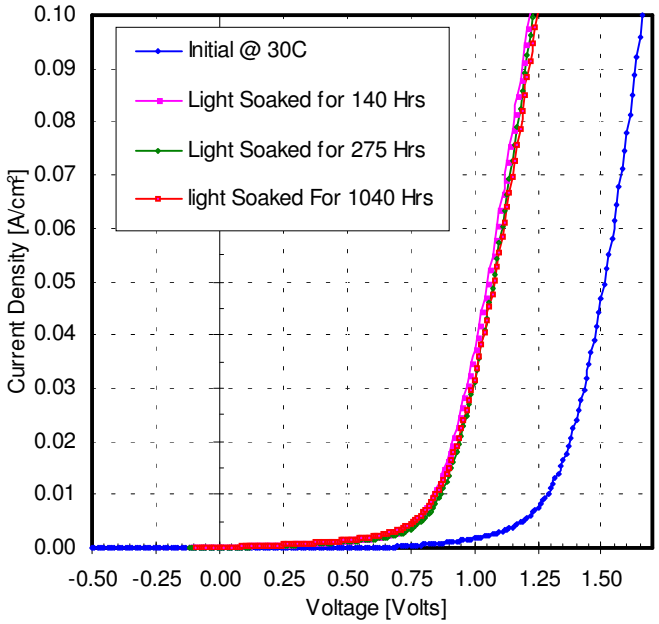

360 0 C
Initial
After 1000 light soaked Hrs
Current Density [A/cm2]
Voltage [Volts]
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
0.00
0.25
0.50
0.75
1.00
1.25
1.50


390 0 C
Initial
Light Soaked for 1000 Hrs
Current Density [A/cm2]
Voltage [Volts]
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
0.00
0.25
0.50
0.75
1.00
1.25
1.50

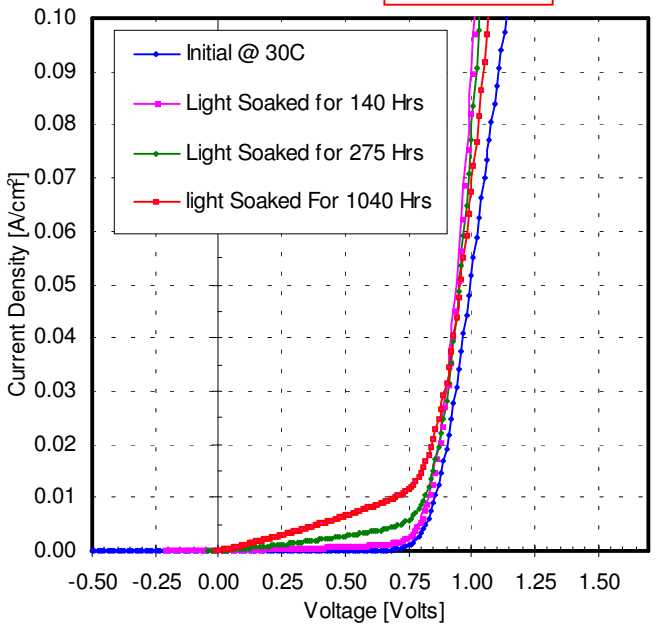

Initial
After 1000 light soaked Hrs
380 0 C
Current Density [A/cm2]
Voltage [Volts]
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
0.00
0.25
0.50
0.75
1.00
1.25
1.50


Initial
After 1000 light soaked Hrs
400 0 C
Current Density [A/cm2]
Voltage [Volts]
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
0.00
0.25
0.50
0.75
1.00
1.25
1.50

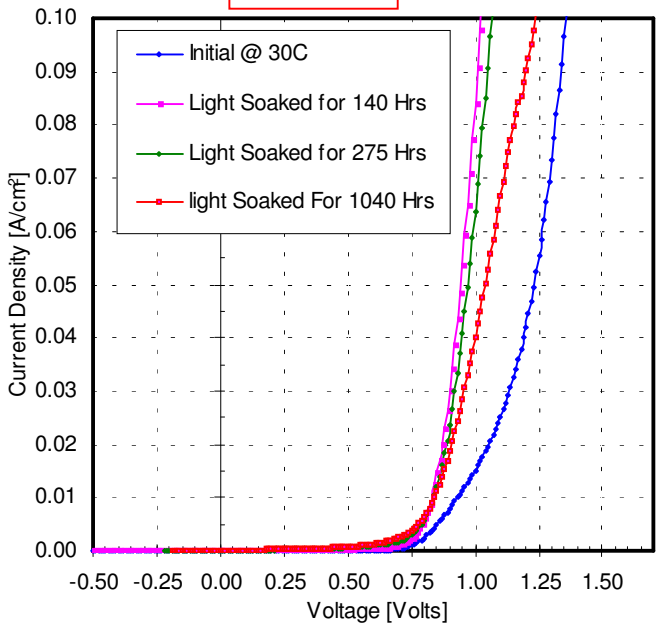
360 ^{0} C



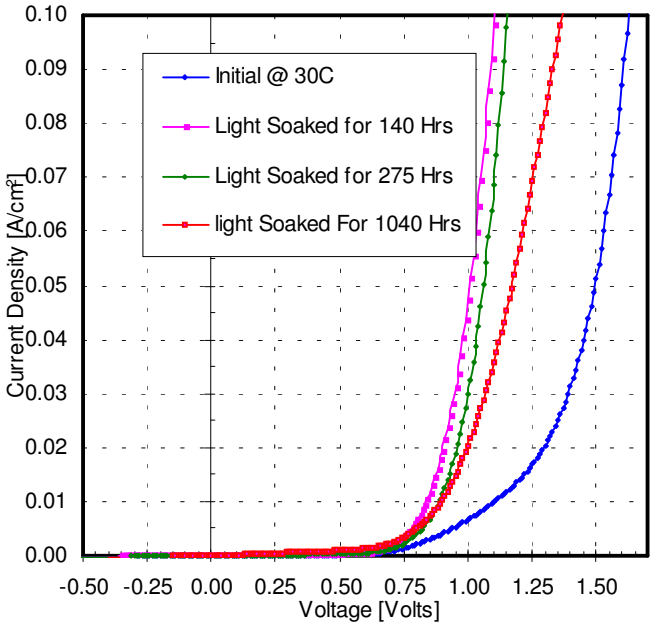
390 ^{0} C



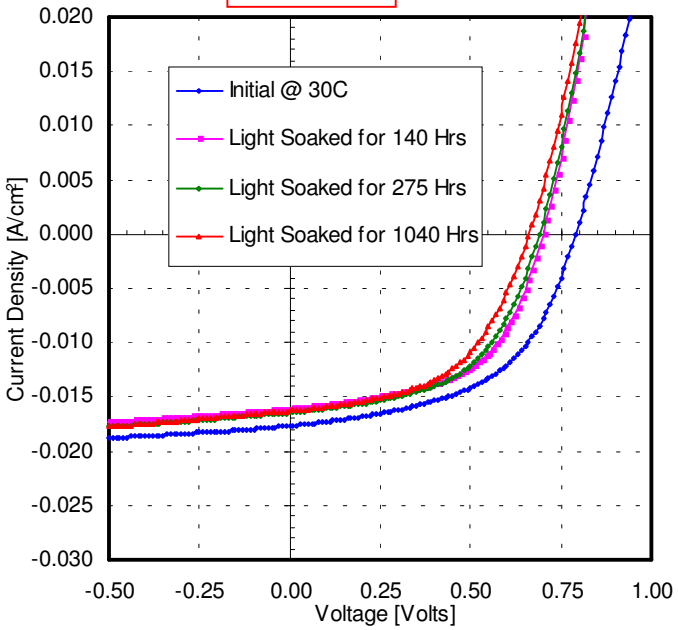
380 ^{0} C



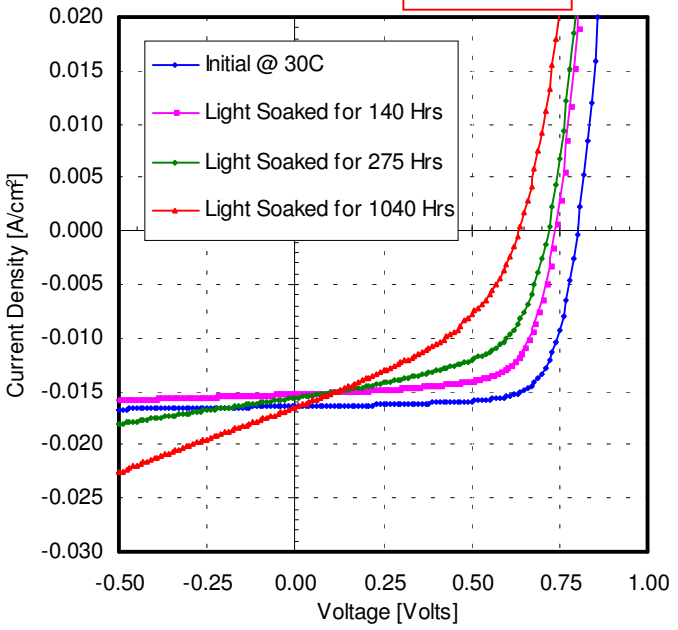
400 ^{0} C



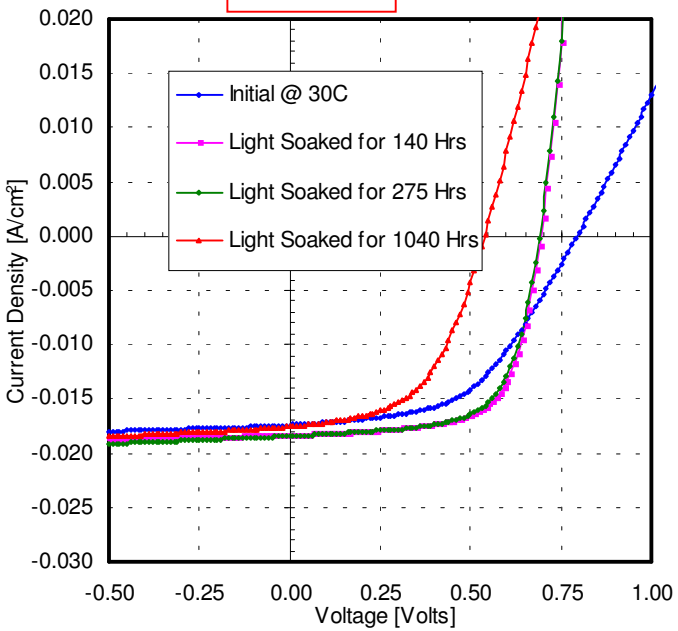
360 ^{0} C



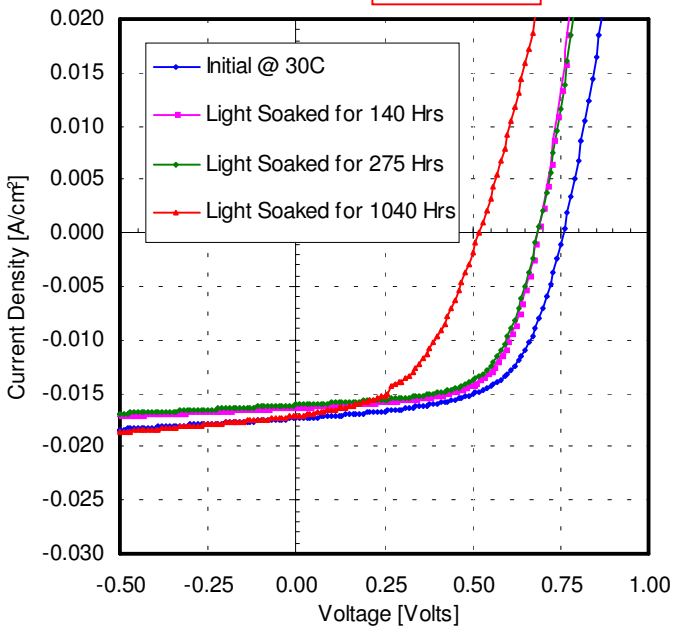
390 ^{0} C

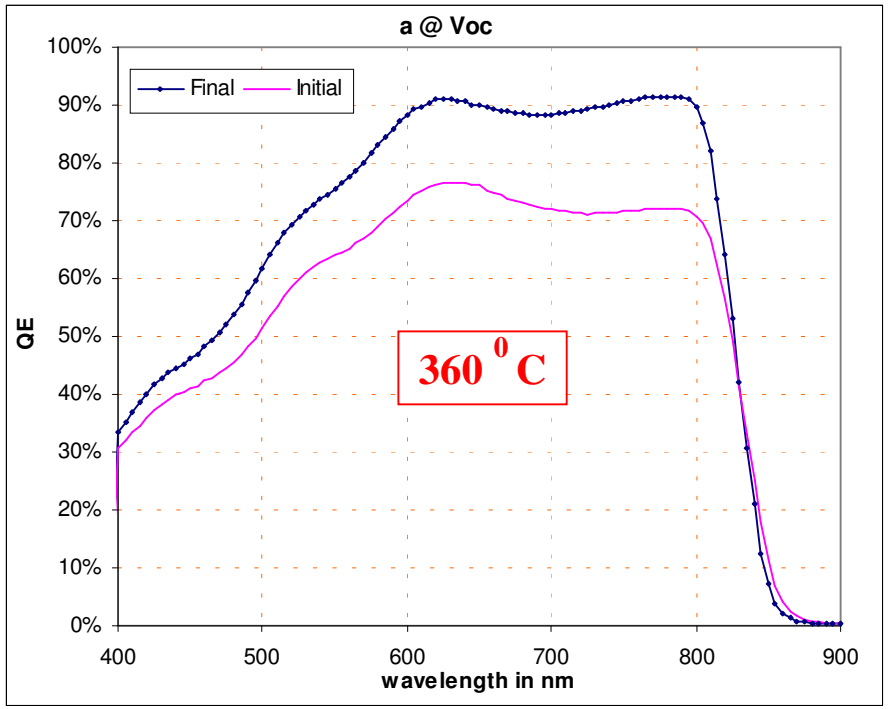


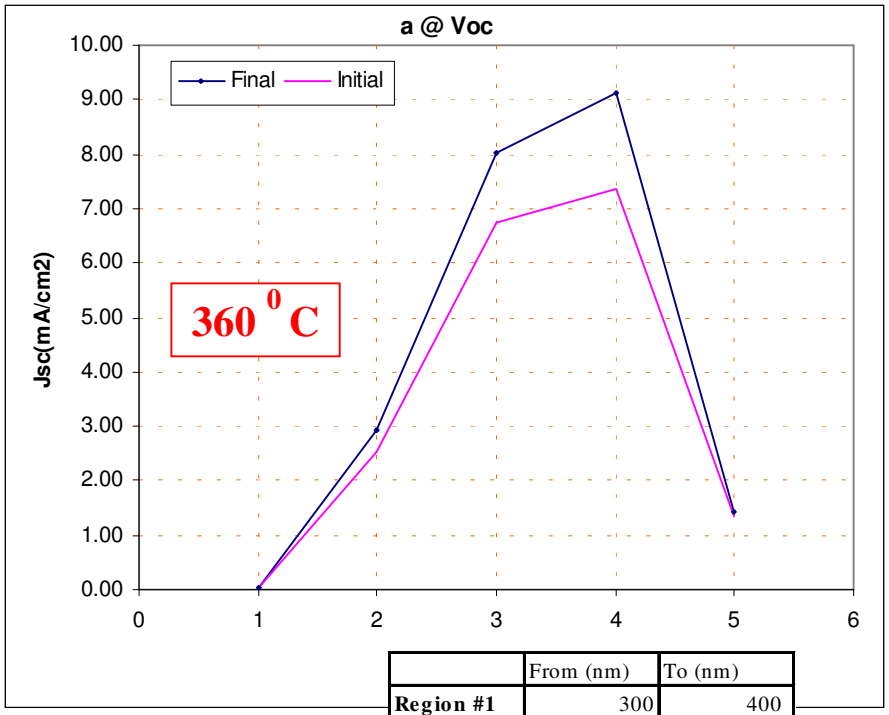
380 ^{0} C



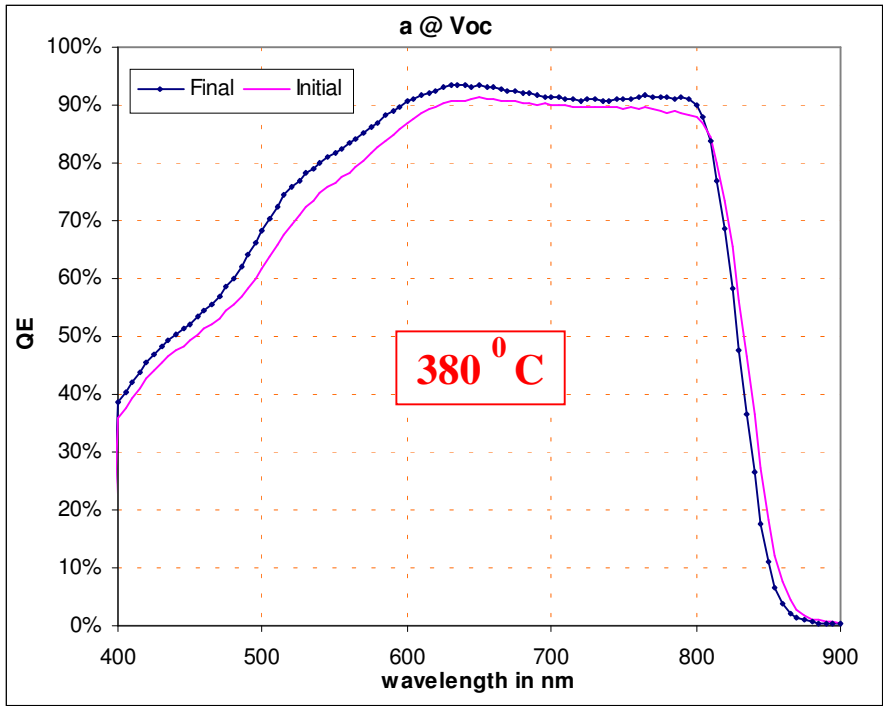
400 ^{0} C

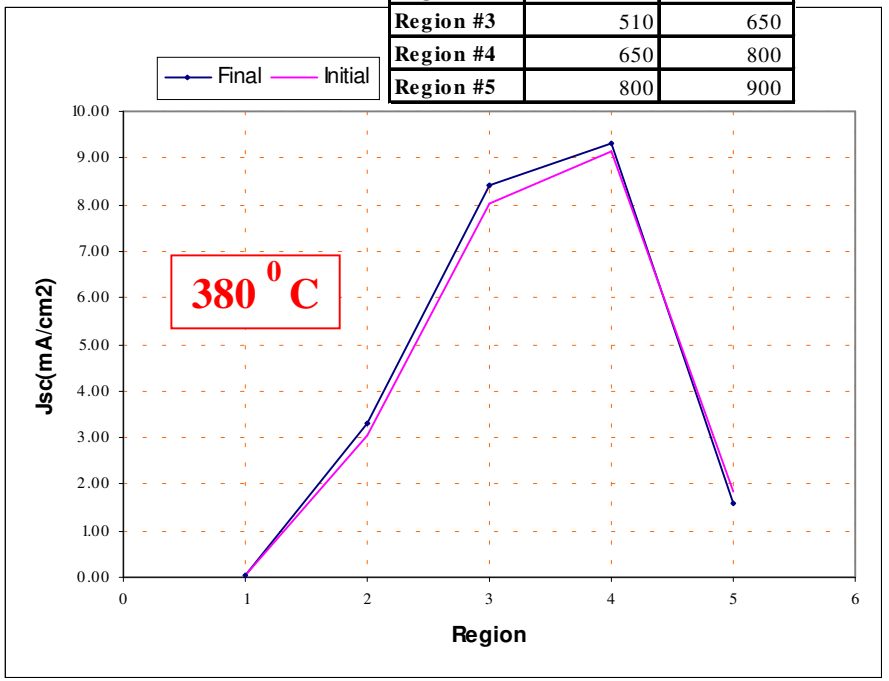


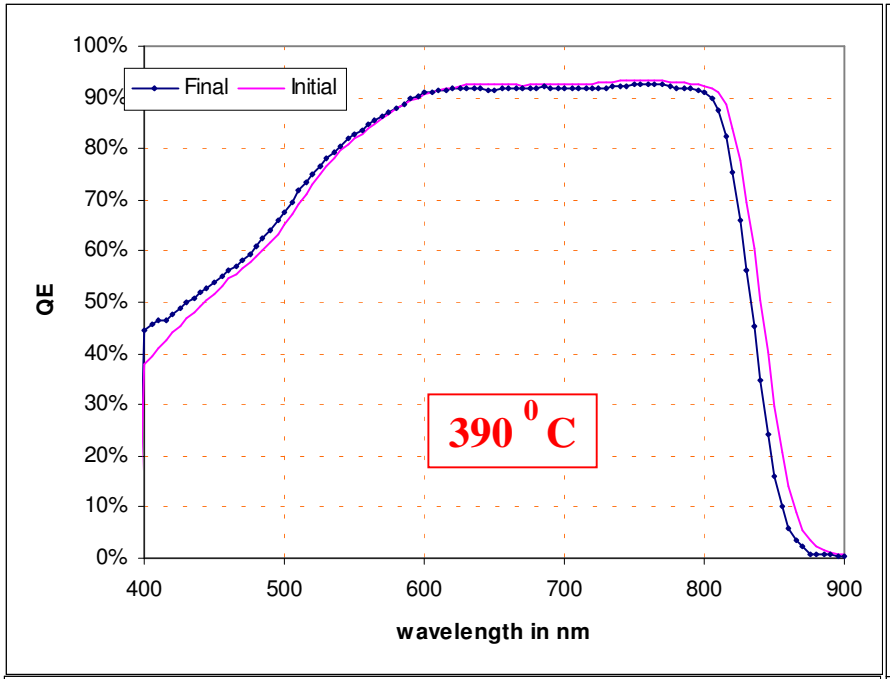


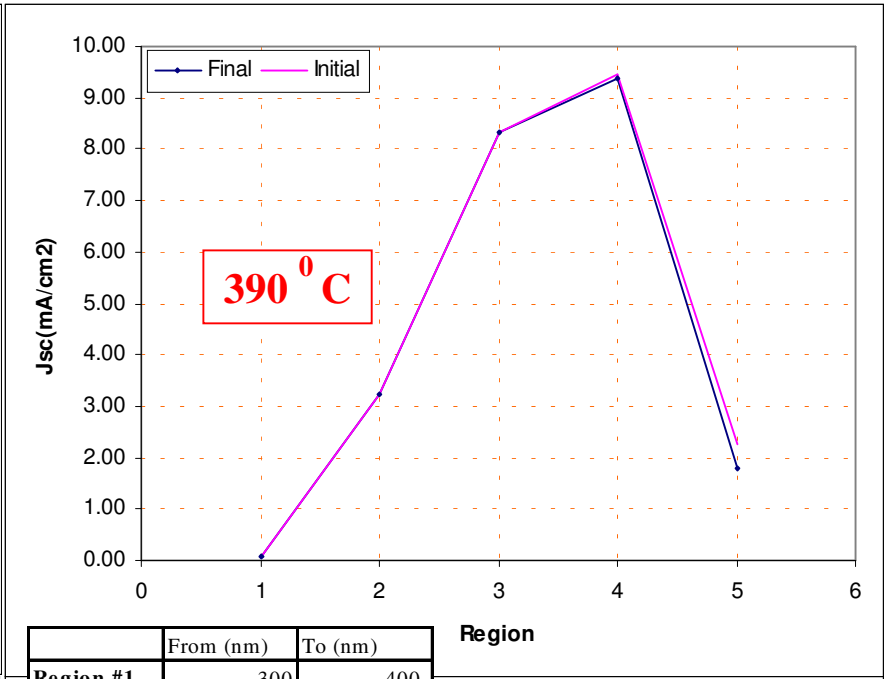


	From (nm)	To (nm)
Region #1	300	400
Region #2	400	510
Region #3	510	650
Region #4	650	800
Region #5	800	900

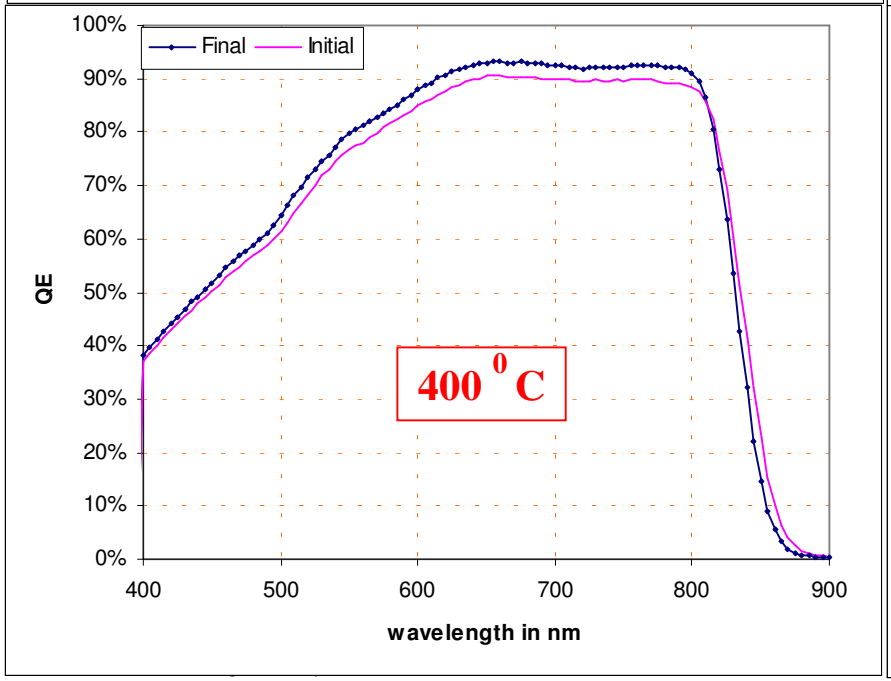


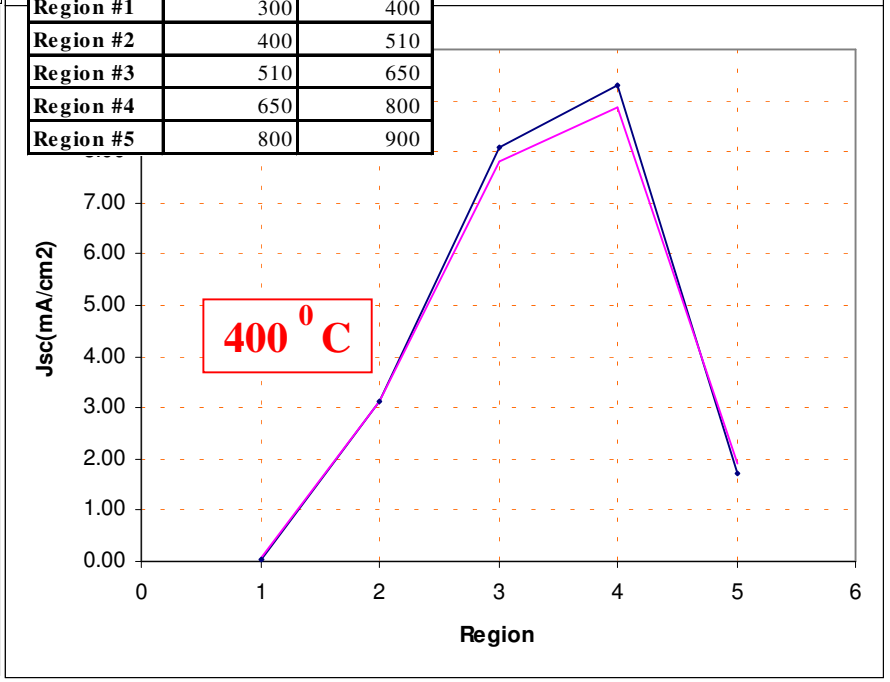






	From (nm)	To (nm)
Region #1	300	400
Region #2	400	510
Region #3	510	650
Region #4	650	800
Region #5	800	900

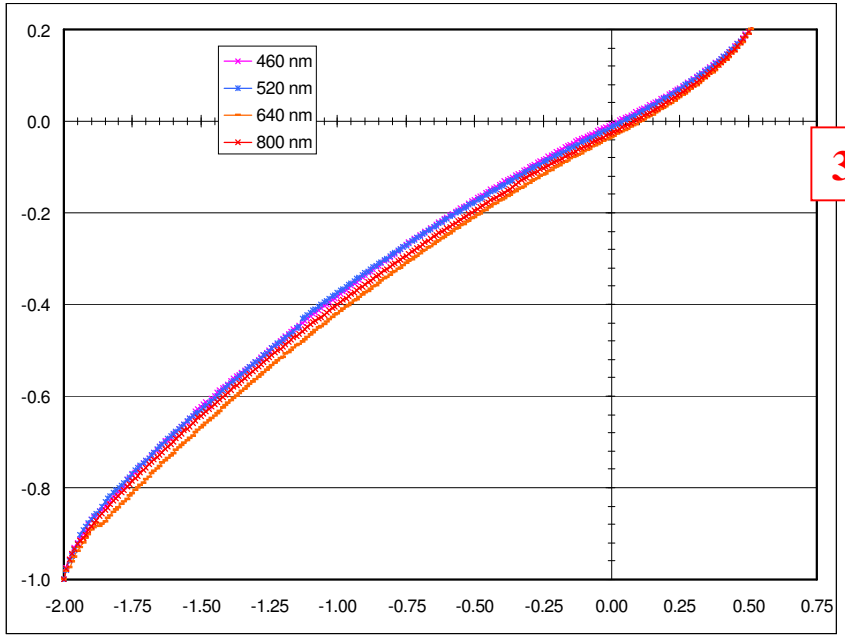




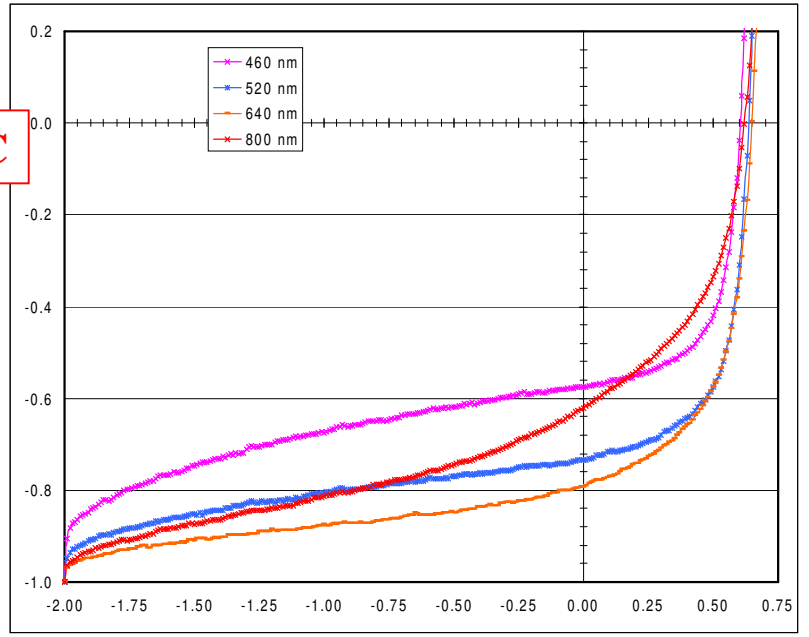
After 1000 Hrs

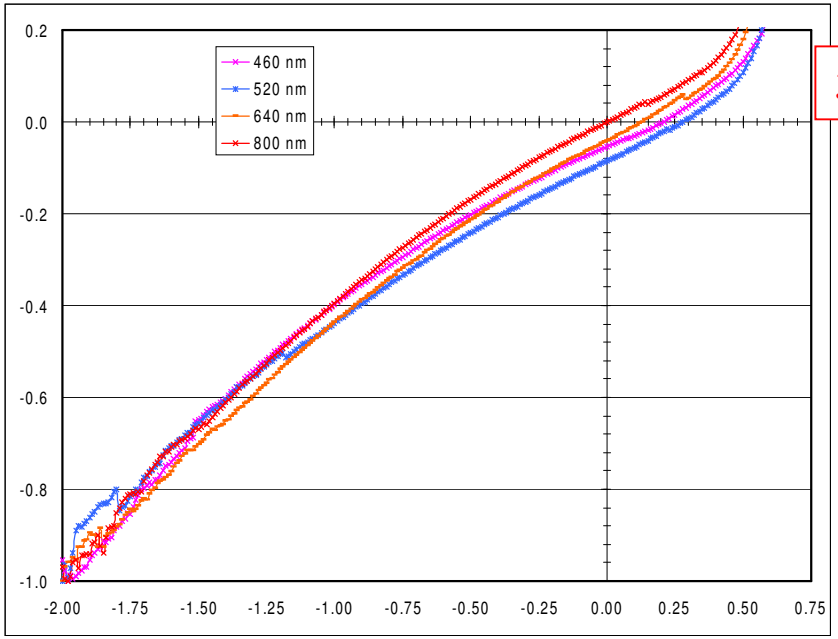
Color JV

Initial

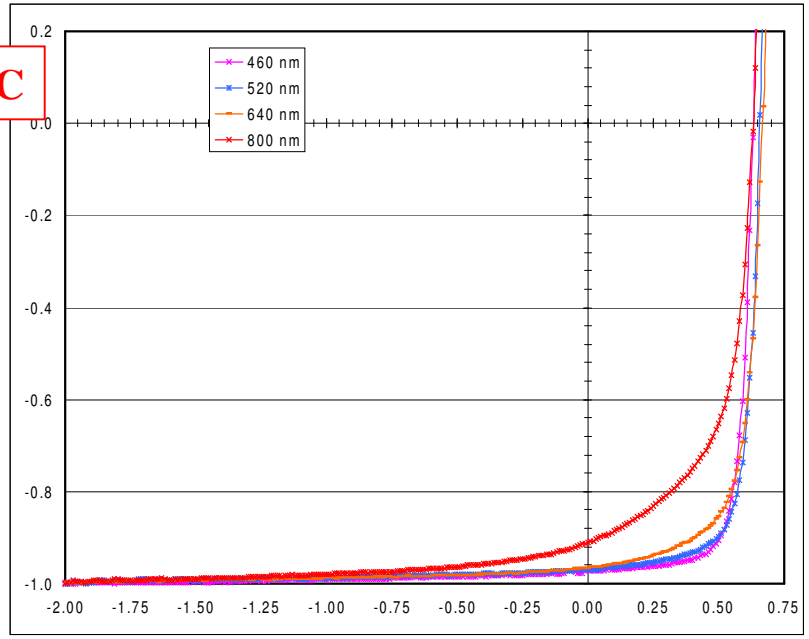


360 ^{0}C

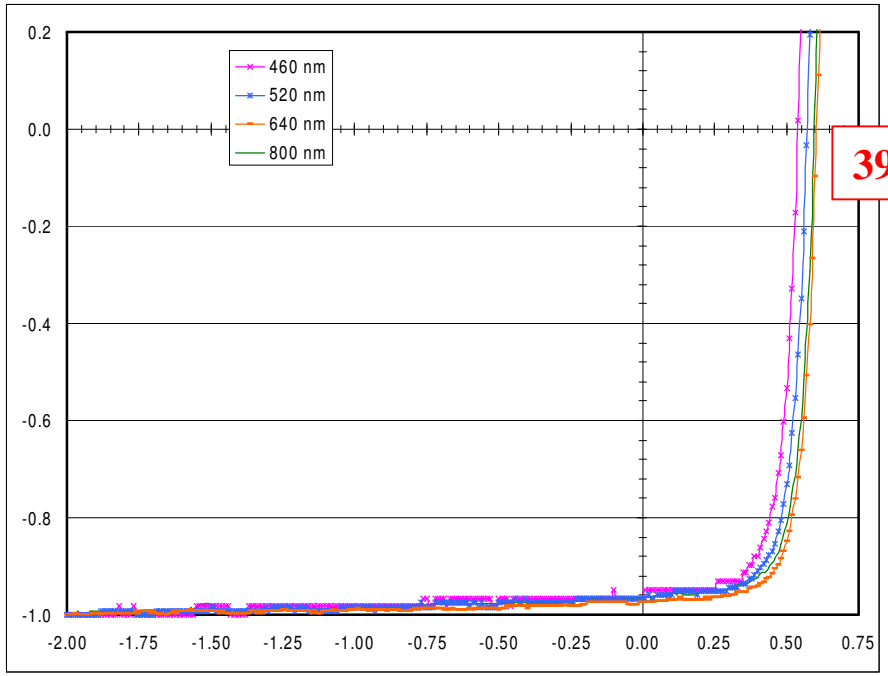




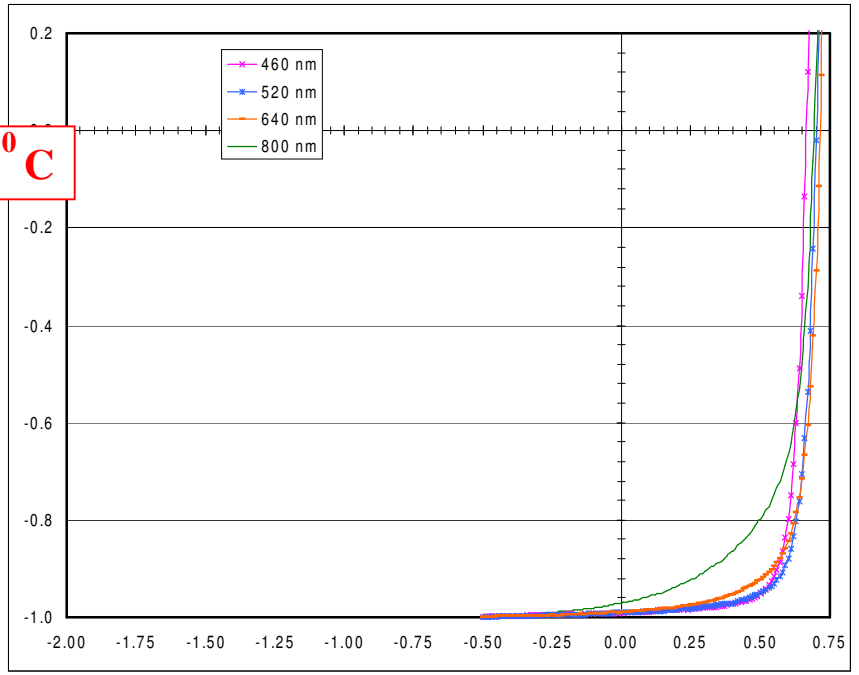
380 ^{0}C

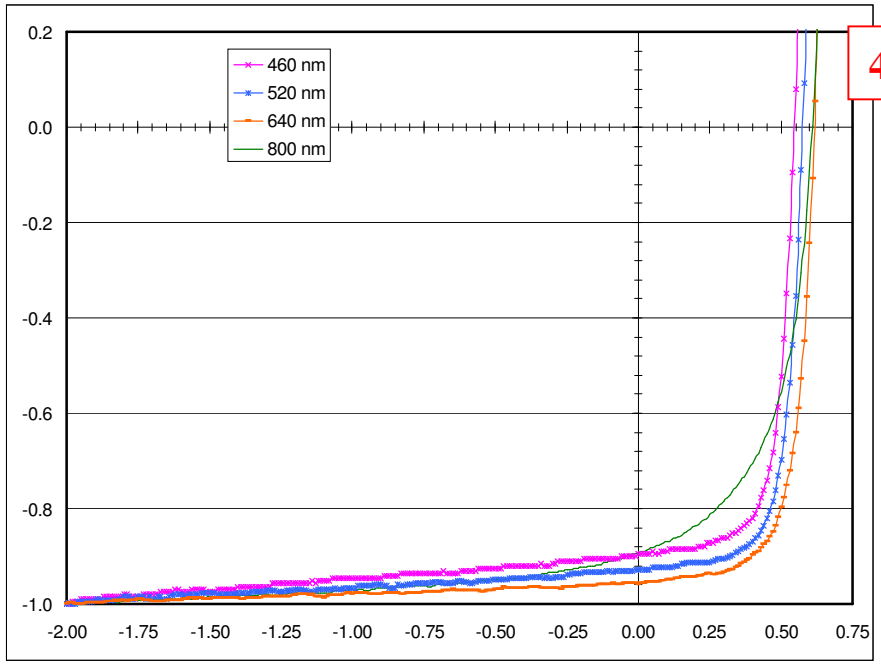


After 1000 Hrs | **Color JV** | **Initial**

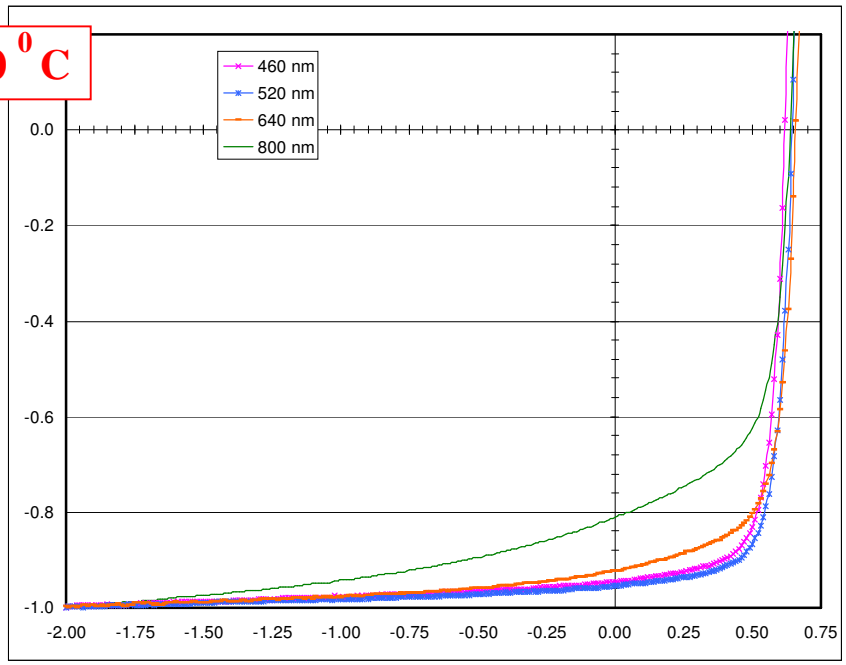


390 ^{0}C

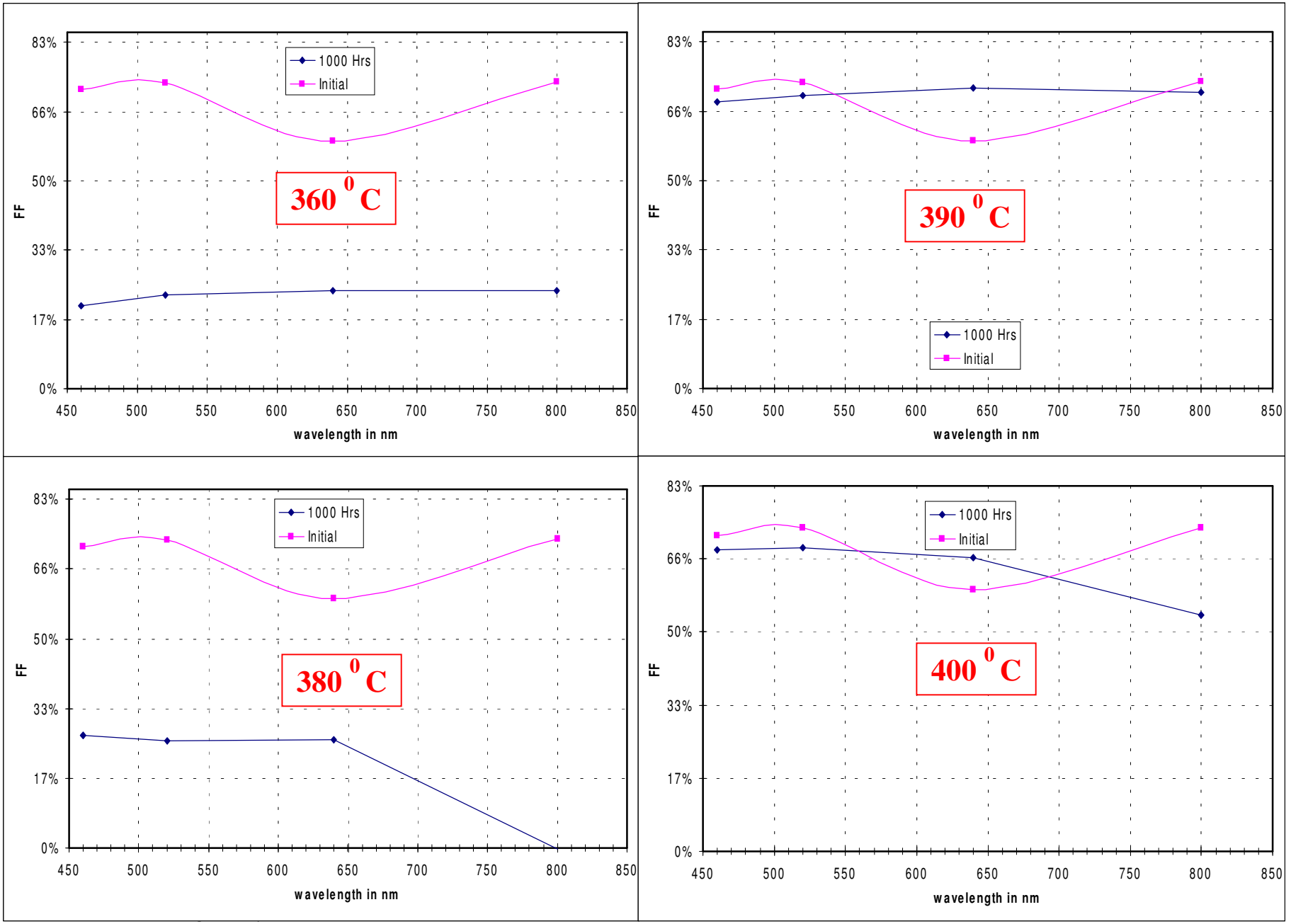


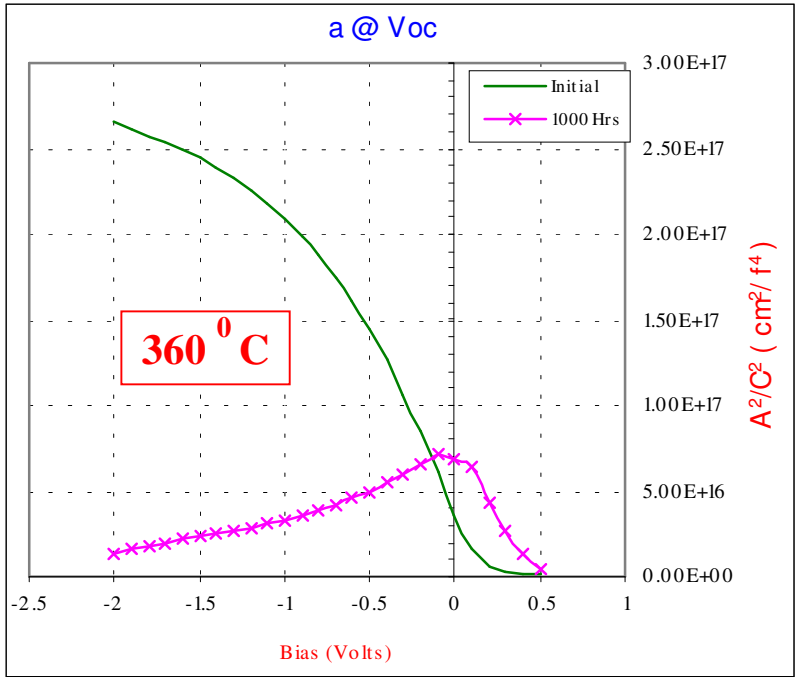


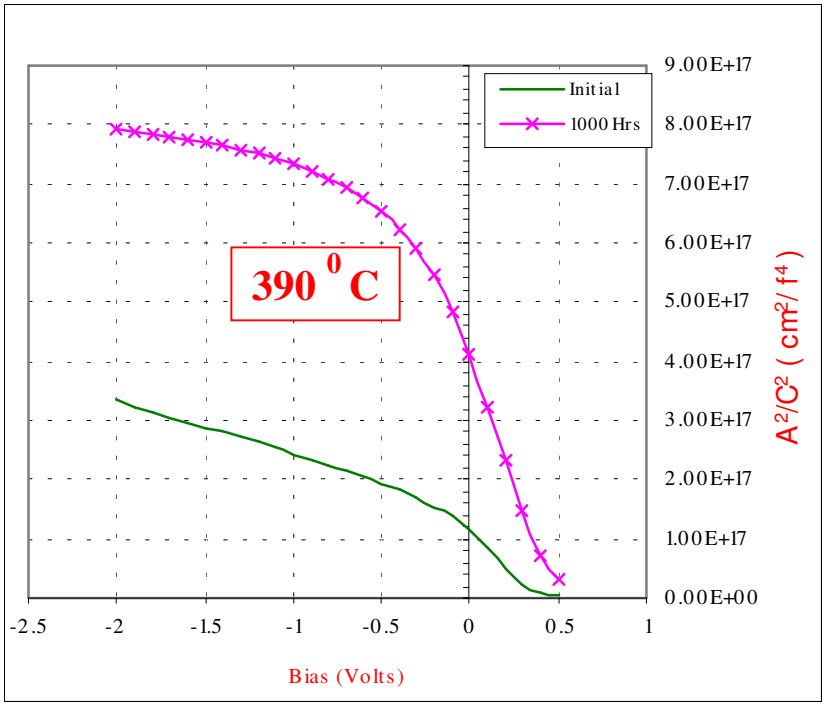
400 ^{0}C

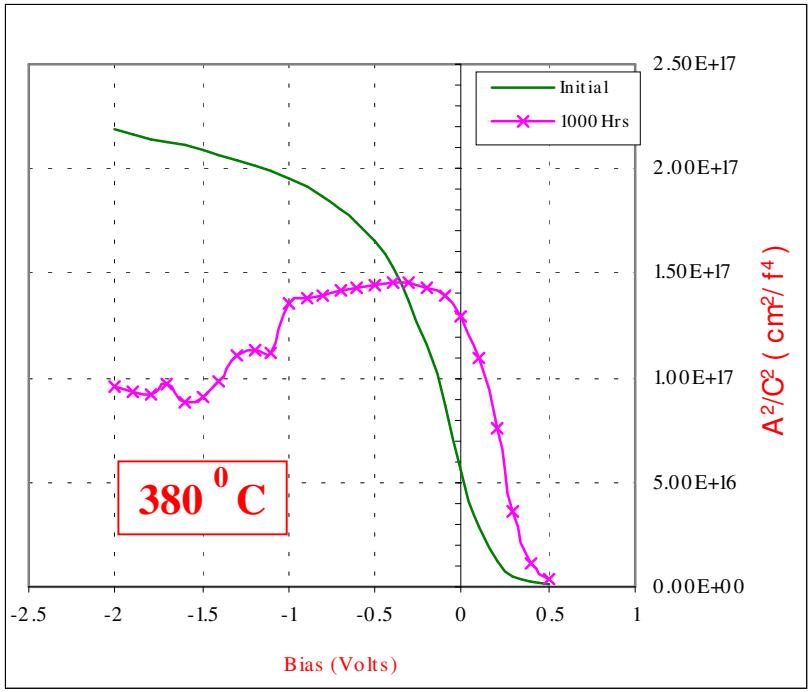


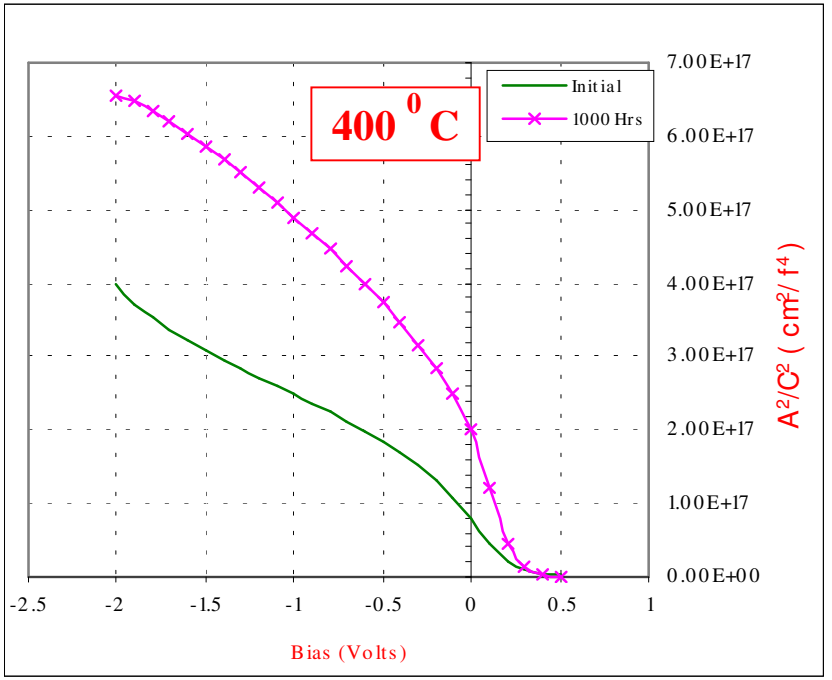
Change in FF in Color JV

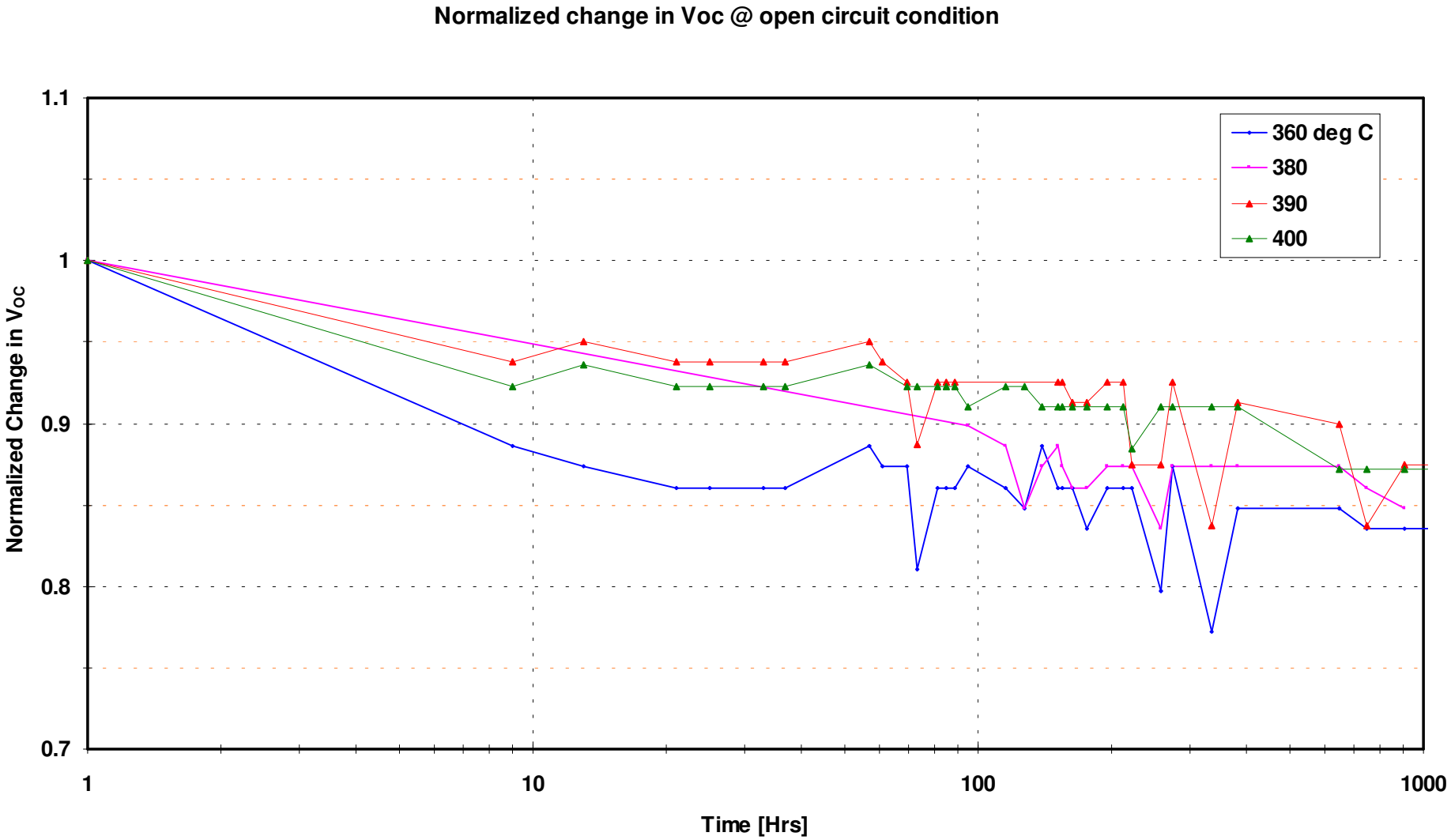



a @ Voc
Initial
1000 Hrs
360 0 C
3.00E+17
2.50E+17
2.00E+17
1.50E+17
1.00E+17
5.00E+16
0.00E+00
A2/C2 (cm2/ f4)
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
Bias (Volts)

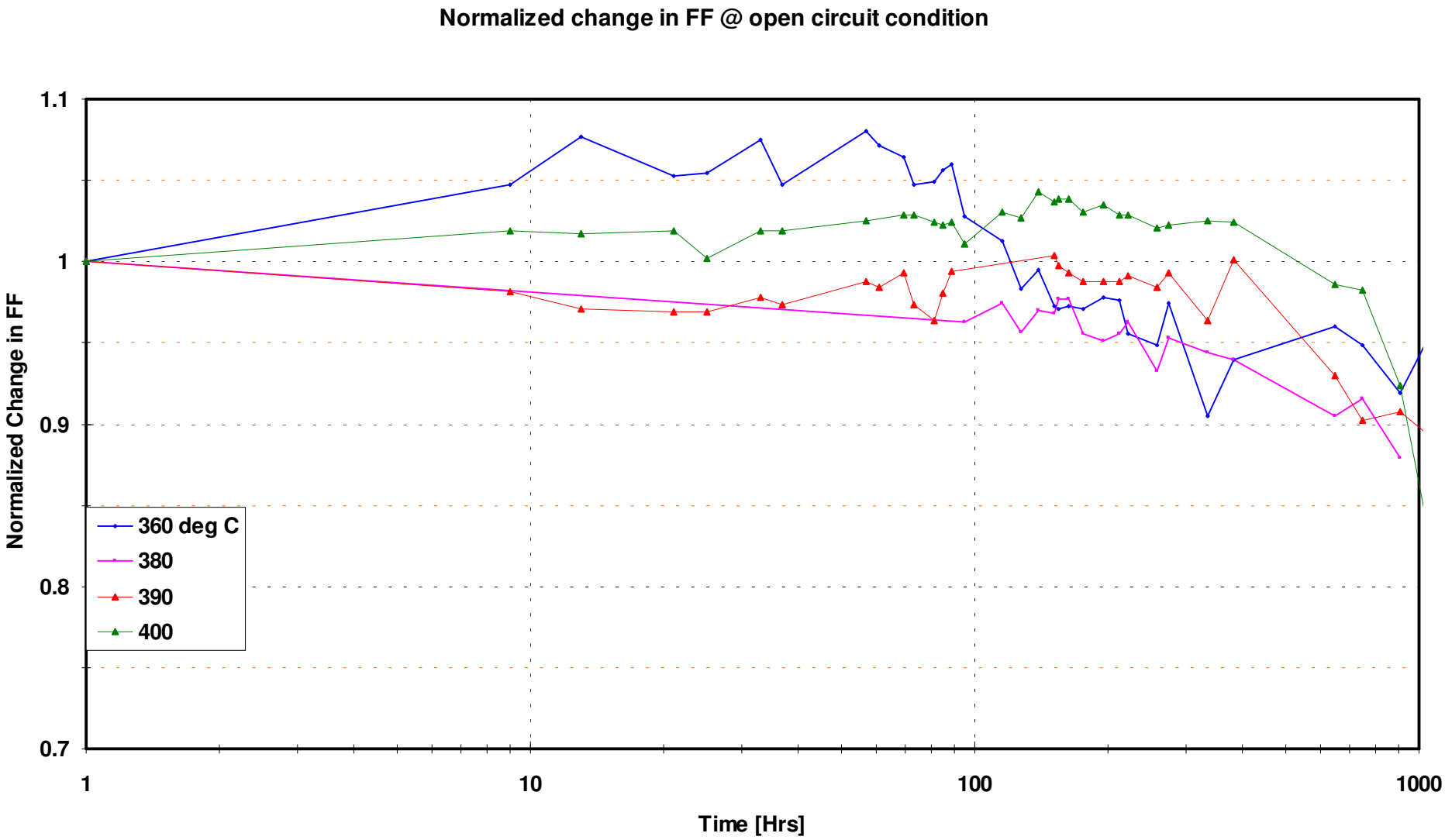

Initial
1000 Hrs
390 0 C
9.00E+17
8.00E+17
7.00E+17
6.00E+17
5.00E+17
4.00E+17
3.00E+17
2.00E+17
1.00E+17
0.00E+00
A2/C2 (cm2/ f4)
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
Bias (Volts)


Initial
1000 Hrs
380 0 C
2.50E+17
2.00E+17
1.50E+17
1.00E+17
5.00E+16
0.00E+00
A2/C2 (cm2/ f4)
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
Bias (Volts)


Initial
1000 Hrs
400 0 C
7.00E+17
6.00E+17
5.00E+17
4.00E+17
3.00E+17
2.00E+17
1.00E+17
0.00E+00
A2/C2 (cm2/ f4)
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
Bias (Volts)

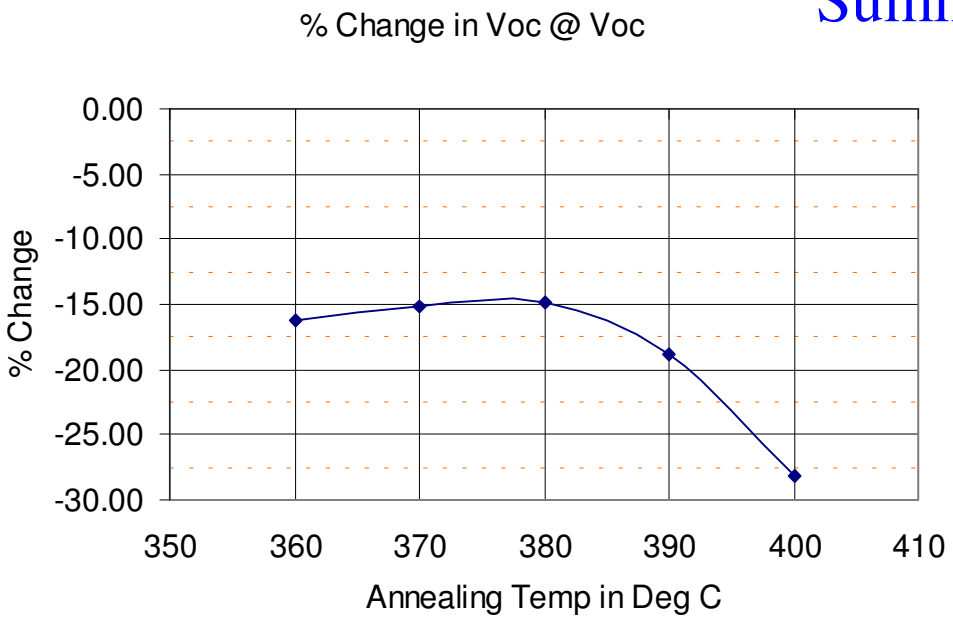


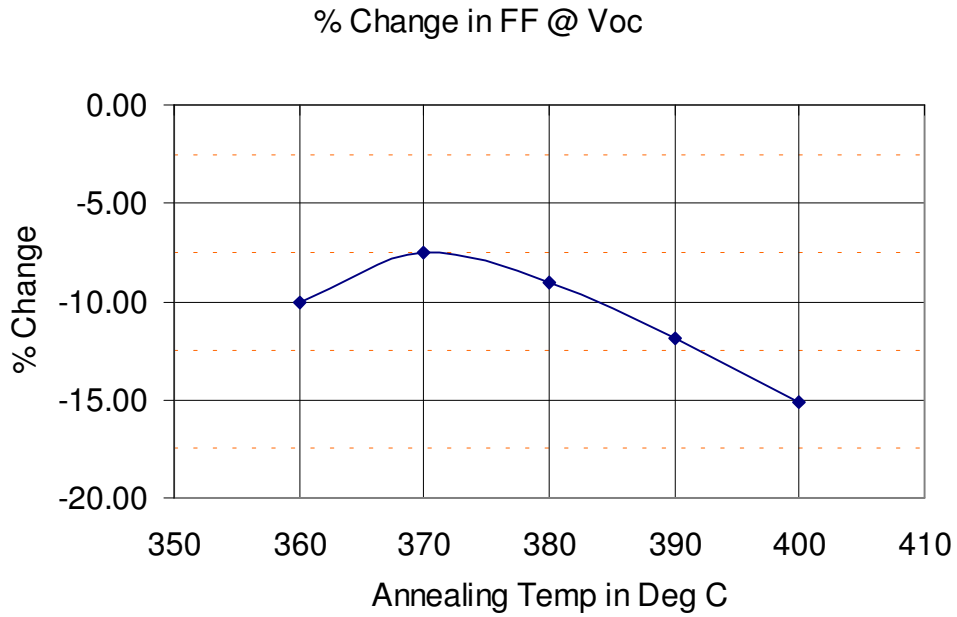
Stability Analysis of CdS/CdTe Solar cells
Ashok Rangaswamy



Stability Analysis of CdS/CdTe Solar cells
Ashok Rangaswamy

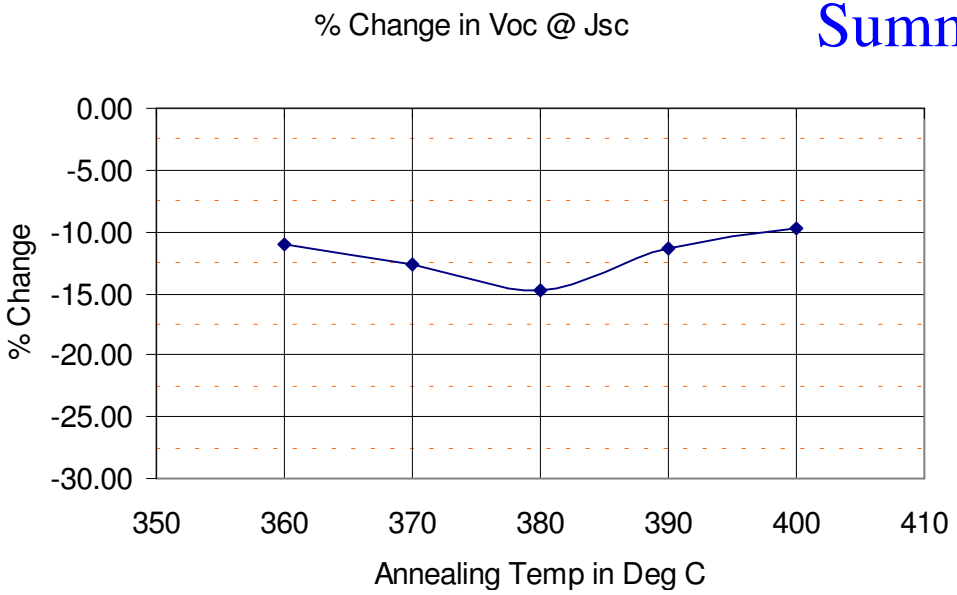
Post Annealing Effect on device stability
Summary

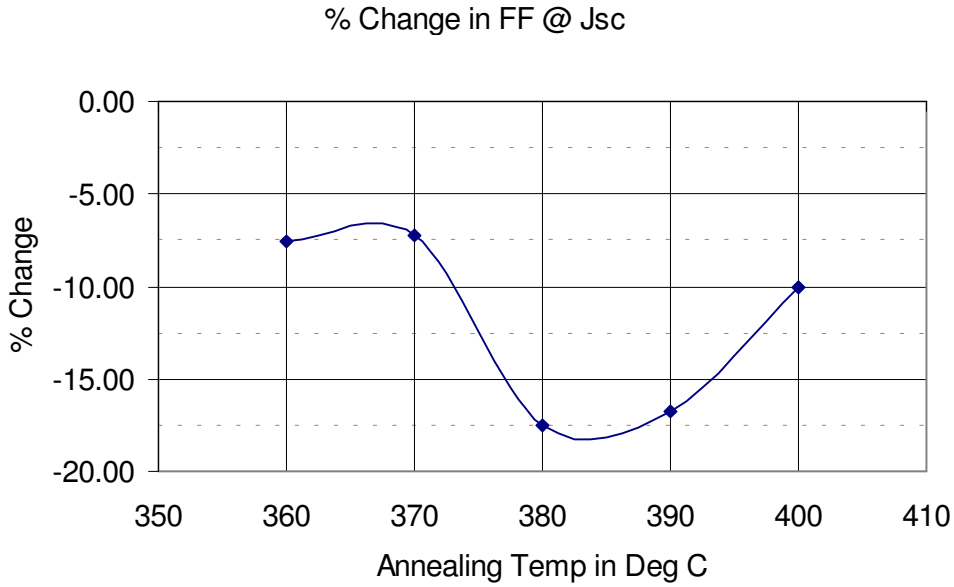




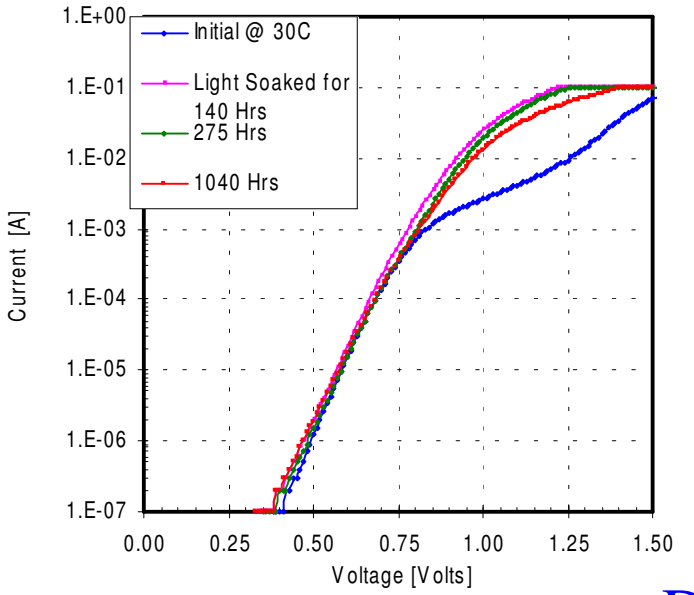
Post Annealing Effect on device stability

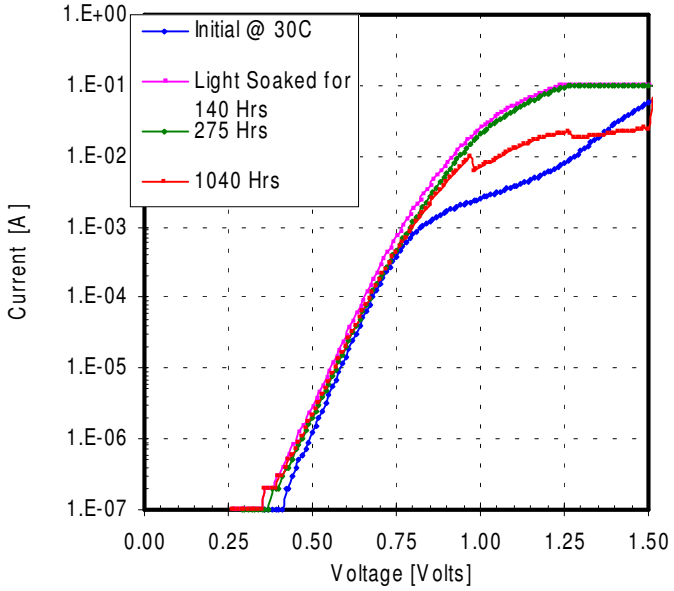
Summary



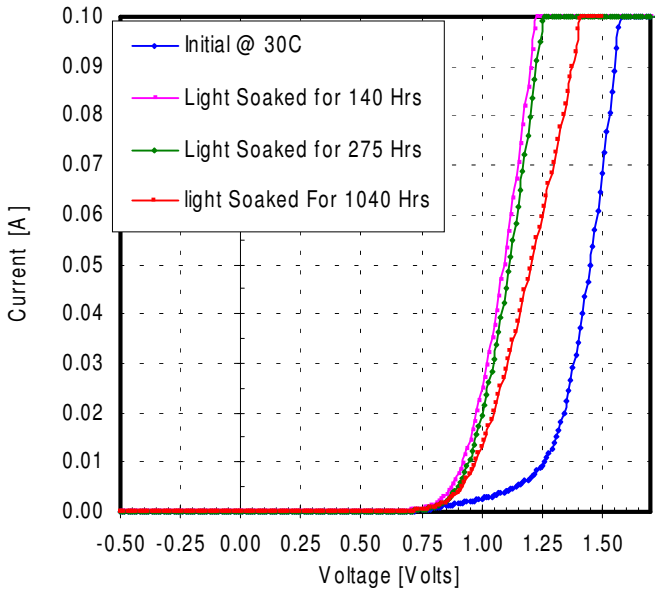


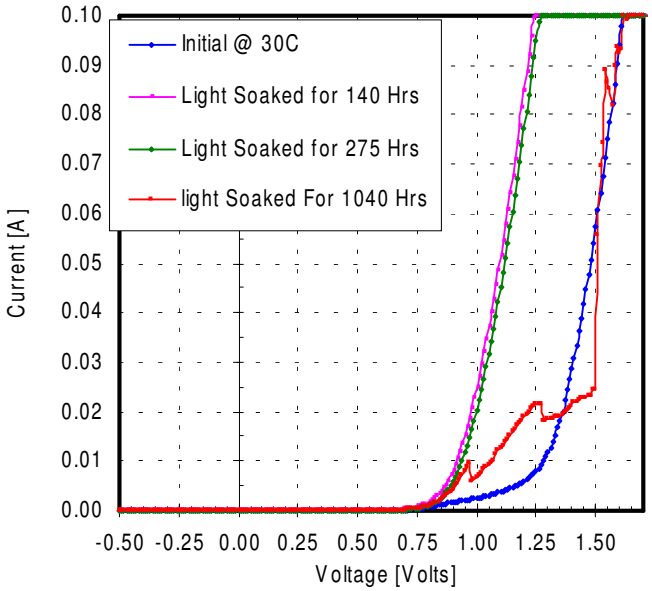
CuCl on CdS



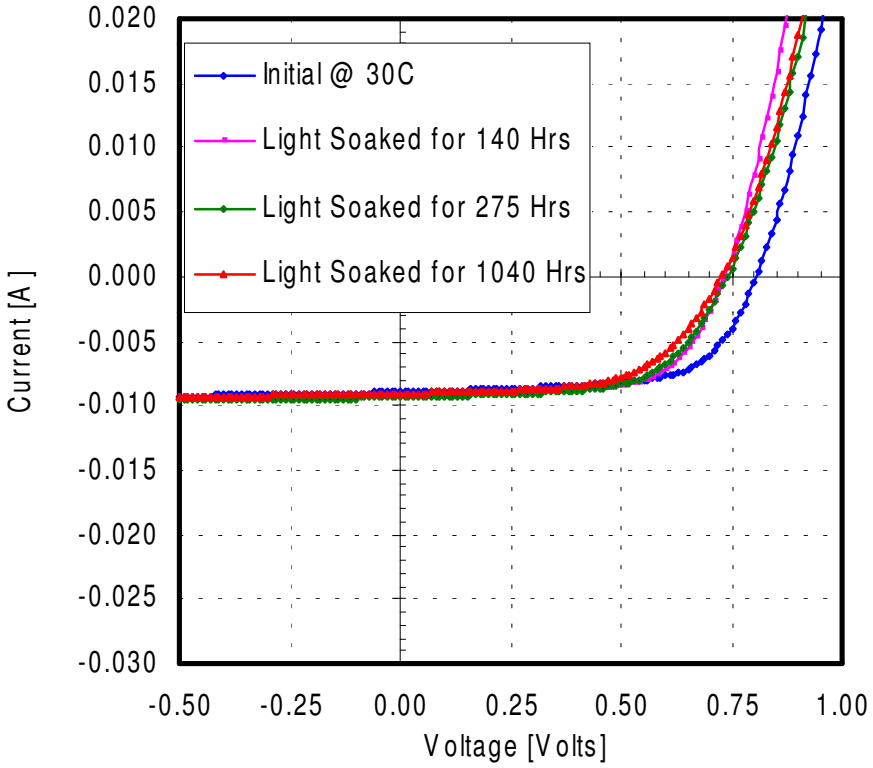


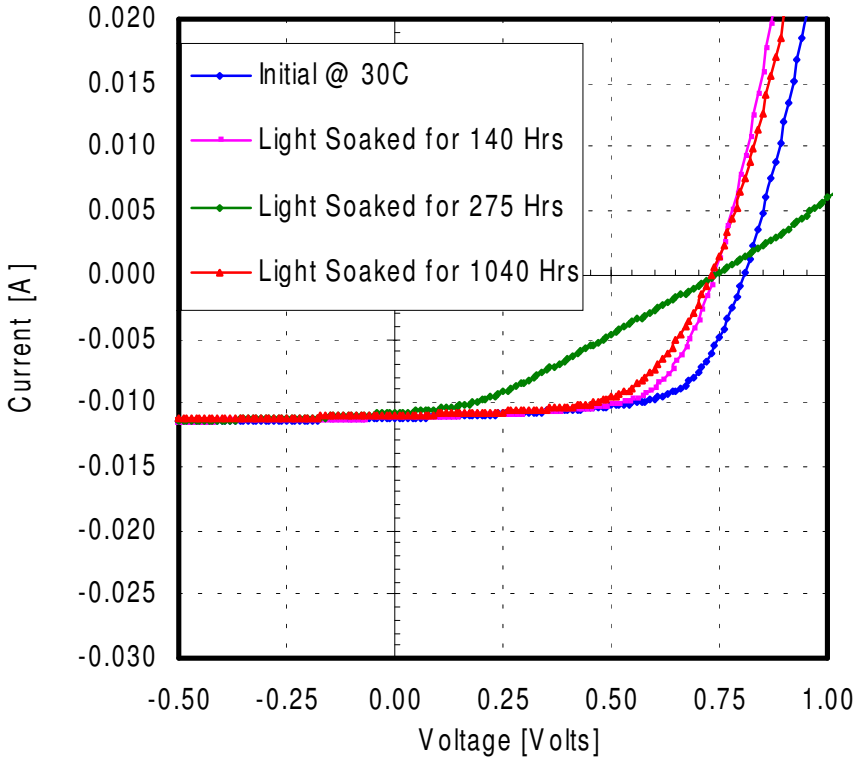
Dark I-V





CuCl on CdS


Initial @ 30C
Light Soaked for 140 Hrs
Light Soaked for 275 Hrs
Light Soaked for 1040 Hrs
Current [A]
Voltage [Volts]
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00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Current [A]
Voltage [Volts]
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00

Future Work

- Integrate and Calibrate measurement system for automation
- Stability analysis of CdTe samples with Cu treatment in different layers
- Analyze the possible degradation mechanisms using present results