

**LAMPIRAN A**  
**FOTO ALAT YANG DIGUNAKAN**

**Lampiran A. Foto alat yang digunakan**



**Gambar A.1** Alat karektisasi I-V Test



**Gambar A.2** Spin coater



**Gambar A.3** UV-Vis spectometri



**Gambar A.4** *Hot plate*



**Gambar A.5** Ruang RH

**LAMPIRAN B**  
**DATA KARAKTERISASI I-V TEST**

**Lampiran B. Data karakterisasi I-V test**

**Tabel B.1** Device properties 80°C-5 menit

Pixel	PCE (%)	FF (%)	Jsc (mA.cm <sup>-2</sup> )	Voc (V)	MP (W)	Rshunt (Ohm.cm <sup>2</sup> )	Rseries (Ohm.cm <sup>2</sup> )
Device 1 - 1	0.01007	22.1967	-3.1137	0.01458	-0.0101	4.67972	4.68141
Device 1 - 2	0.00048	1.60743	-3.1495	0.00954	0.00048	3.03372	3.02284
Device 1 - 3	0.004	11.4037	-3.1408	0.01118	-0.004	3.56417	3.55546
Device 1 - 4	0.0068	17.1153	-3.1683	0.01253	-0.0068	3.96172	3.95392
Device 1 - 5	0.0179	24.4343	-3.1372	0.02335	-0.0179	7.41917	7.41075
Device 1 - 6	0.00569	15.0049	-3.1584	0.01201	-0.0057	3.83898	3.78954
Device 1 - 7	0.00887	20.2375	-3.1956	0.01372	-0.0089	4.31664	4.29302
Device 1 - 8	0.03742	24.4752	-3.1198	0.04901	-0.0374	15.8242	15.3474

**Tabel B.2** Device properties 80°C-15 menit

Pixel	PCE (%)	FF (%)	Jsc (mA.cm <sup>-2</sup> )	Voc (V)	MP (W)	Rshunt (Ohm.cm <sup>2</sup> )	Rseries (Ohm.cm <sup>2</sup> )
Device 1 - 1	0.01937	22.3825	-4.1403	0.0209	-0.0194	5.05821	5.04204
Device 1 - 2	0.01188	16.4162	-4.2854	0.01688	-0.0119	3.94472	3.93798
Device 1 - 3	0.0115	16.2078	-4.2806	0.01658	-0.0115	3.87539	3.87246
Device 1 - 4	0.03259	23.8169	-3.9452	0.03468	-0.0326	8.78055	8.73515
Device 1 - 5	0.01313	17.7971	-4.2688	0.01729	-0.0131	4.04766	4.04976
Device 1 - 6	0.0215	23.7533	-4.123	0.02195	-0.0215	5.3295	5.3219
Device 1 - 7	0	0	0	0	0	0	0
Device 1 - 8	0	0	0	0	0	0	0

**Tabel B.3** Device properties 80°C-25 menit

Pixel	PCE (%)	FF (%)	Jsc (mA.cm <sup>-2</sup> )	Voc (V)	MP (W)	Rshunt (Ohm.cm <sup>2</sup> )	Rseries (Ohm.cm <sup>2</sup> )
Device 1 - 1	0.01036	19.2552	-4.4379	0.01212	-0.0104	2.73307	2.72715
Device 1 - 2	0.01063	15.8511	-4.2074	0.01594	-0.0106	3.79769	3.78317
Device 1 - 3	0.01011	18.727	-4.3991	0.01227	-0.0101	2.79095	2.78615
Device 1 - 4	0.01058	16.0442	-4.2284	0.0156	-0.0106	3.69281	3.68705
Device 1 - 5	0.01037	18.5588	-4.3705	0.01279	-0.0104	2.92741	2.92283
Device 1 - 6	0.01072	17.6623	-4.3226	0.01404	-0.0107	3.2512	3.24377
Device 1 - 7	0.01078	18.1901	-4.3647	0.01358	-0.0108	3.11465	3.10729
Device 1 - 8	0.01063	18.4054	-4.3935	0.01314	-0.0106	3.00301	3.00379

**Tabel B.4** Device properties 100°C-5 menit

Pixel	PCE (%)	FF (%)	Jsc (mA.cm <sup>-2</sup> )	Voc (V)	MP (W)	Rshunt (Ohm.cm <sup>2</sup> )	Rseries (Ohm.cm <sup>2</sup> )
Device 1 - 1	0.15459	43.5688	-2.7505	0.129	-0.1546	94.5901	5.32295
Device 1 - 2	0.02813	25.0627	-2.7495	0.04082	-0.0281	14.956	14.1626
Device 1 - 3	0.051	26.1499	-2.7686	0.07044	-0.051	26.6534	13.3877
Device 1 - 4	0.02787	24.6383	-2.7745	0.04078	-0.0279	14.7883	14.2491
Device 1 - 5	0.01133	24.7732	-2.763	0.01656	-0.0113	5.9661	5.97407
Device 1 - 6	0.00832	23.5895	-2.7188	0.01297	-0.0083	4.79604	4.77444
Device 1 - 7	0.0423	25.4519	-2.8187	0.05896	-0.0423	21.2573	17.9042
Device 1 - 8	0.02337	24.9829	-2.832	0.03303	-0.0234	11.6722	11.4931

**Tabel B.5** Device properties 100°C-15 menit

Pixel	PCE (%)	FF (%)	Jsc (mA.cm <sup>-2</sup> )	Voc (V)	MP (W)	Rshunt (Ohm.cm <sup>2</sup> )	Rseries (Ohm.cm <sup>2</sup> )
Device 1 - 1	0.00984	14.5649	-4.7334	0.01427	-0.0098	3.01117	3.0176
Device 1 - 2	0.02125	23.611	-4.6542	0.01933	-0.0212	4.1502	4.14974
Device 1 - 3	0.02568	24.7898	-4.6448	0.0223	-0.0257	4.79177	4.79608
Device 1 - 4	0.00798	12.1389	-4.8628	0.01352	-0.008	2.78047	2.77946
Device 1 - 5	0.03233	24.4881	-4.6337	0.02849	-0.0323	6.14569	6.13521
Device 1 - 6	0.01741	20.8694	-4.8369	0.01725	-0.0174	3.56299	3.56819
Device 1 - 7	0.0171	20.4288	-4.8788	0.01716	-0.0171	3.50896	3.51677
Device 1 - 8	0.02201	23.1279	-4.8733	0.01953	-0.022	4.00503	4.00579

**Tabel B.6** Device properties 100°C-25 menit

Pixel	PCE (%)	FF (%)	Jsc (mA.cm <sup>-2</sup> )	Voc (V)	MP (W)	Rshunt (Ohm.cm <sup>2</sup> )	Rseries (Ohm.cm <sup>2</sup> )
Device 1 - 1	0.01947	20.4343	-4.4706	0.02131	-0.0195	4.91957	4.81628
Device 1 - 2	0.03425	25.1662	-4.4275	0.03074	-0.0342	6.94369	6.94535
Device 1 - 3	0.0241	22.617	-4.5957	0.02319	-0.0241	5.0458	5.04318
Device 1 - 4	0.01692	22.5975	-5.0468	0.01483	-0.0169	2.94001	2.93788
Device 1 - 5	4.10932	88.3527	-4.0431	1.15035	-4.1093	9634.64	1.89577
Device 1 - 6	0.02134	20.9598	-4.6909	0.02171	-0.0213	4.6195	4.62467
Device 1 - 7	0.04112	23.8558	-4.3869	0.03929	-0.0411	8.95803	8.95716
Device 1 - 8	0.01808	21.106	-4.9075	0.01746	-0.0181	3.55743	3.55796

**Tabel B.7** Device properties 100°C-5 menit

Pixel	PCE (%)	FF (%)	Jsc (mA.cm <sup>-2</sup> )	Voc (V)	MP (W)	Rshunt (Ohm.cm <sup>2</sup> )	Rseries (Ohm.cm <sup>2</sup> )
Device 1 - 1	0.04797	24.671	-3.8165	0.05094	-0.048	13.3612	13.2593
Device 1 - 2	0.007	14.088	-4.2587	0.01167	-0.007	2.73905	2.74423
Device 1 - 3	0.00724	12.41	-4.1518	0.01404	-0.0072	3.38267	3.382
Device 1 - 4	0.00739	14.3734	-4.2374	0.01214	-0.0074	2.86498	2.86475
Device 1 - 5	0.00746	12.7187	-4.1882	0.01401	-0.0075	3.3383	3.34963
Device 1 - 6	0.00777	14.6977	-4.2838	0.01235	-0.0078	2.88077	2.88336
Device 1 - 7	0.0079	14.5355	-4.3055	0.01263	-0.0079	2.92712	2.93945
Device 1 - 8	0.00821	14.5576	-4.3519	0.01296	-0.0082	2.97373	2.98398

**Tabel B.8** Device properties 100°C-15 menit

Pixel	PCE (%)	FF (%)	Jsc (mA.cm <sup>-2</sup> )	Voc (V)	MP (W)	Rshunt (Ohm.cm <sup>2</sup> )	Rseries (Ohm.cm <sup>2</sup> )
Device 1 - 1	0.00652	13.7734	-3.5207	0.01345	-0.0065	3.81591	3.82128
Device 1 - 2	0.00388	9.42298	-3.5859	0.01149	-0.0039	3.20746	3.19962
Device 1 - 3	0.00749	15.1072	-3.5704	0.01389	-0.0075	3.8883	3.89206
Device 1 - 4	0	0	0	0	0	0	0
Device 1 - 5	0.02143	24.7886	-3.4795	0.02485	-0.0214	7.13401	7.12194
Device 1 - 6	0.01064	18.9887	-3.6118	0.01552	-0.0106	4.2971	4.29708
Device 1 - 7	0	0	0	0	0	0	0
Device 1 - 8	0	0	0	0	0	0	0



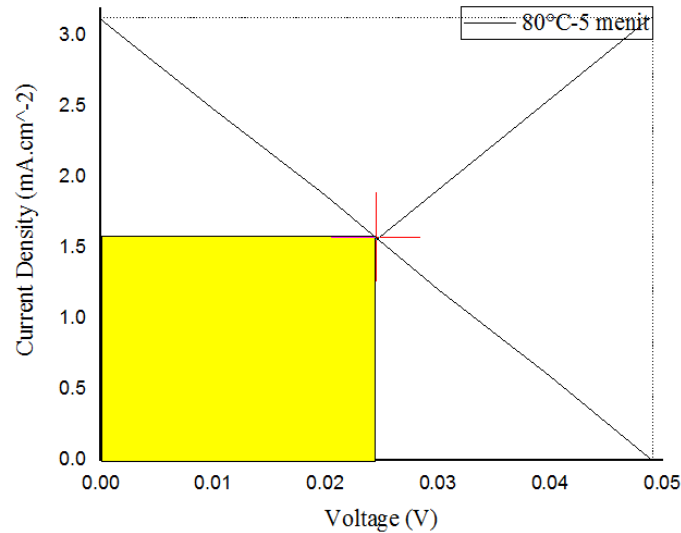
**Tabel B.9** Device properties 100°C-25 menit

Pixel	PCE (%)	FF (%)	Jsc (mA.cm <sup>-2</sup> )	Voc (V)	MP (W)	Rshunt (Ohm.cm <sup>2</sup> )	Rseries (Ohm.cm <sup>2</sup> )
Device 1 - 1	0.28023	26.4091	-3.7272	0.2847	-0.2802	85.6709	55.0045
Device 1 - 2	0.03016	24.5852	-3.9577	0.031	-0.0302	7.81926	7.78417
Device 1 - 3	0.02127	23.5719	-4.1258	0.02187	-0.0213	5.29882	5.30158
Device 1 - 4	0.03	24.8741	-4.0216	0.02999	-0.03	7.46625	7.48614
Device 1 - 5	0.04564	25.1694	-3.9157	0.04631	-0.0456	11.8747	9.40726
Device 1 - 6	0.02156	23.5115	-4.1948	0.02186	-0.0216	5.20079	5.20462
Device 1 - 7	0.01274	17.7425	-4.3314	0.01657	-0.0127	3.84179	3.81699
Device 1 - 8	0.0337	24.0134	-4.0468	0.03468	-0.0337	8.56051	8.51942

**LAMPIRAN C**  
**CONTOH PERHITUNGAN**

### Lampiran C. Contoh Perhitungan

- Perhitungan nilai *fill factor* (FF) dan *power conversion efficiency* (PCE) variasi 80°C – 5 menit



**Gambar C.1** Grafik I-V variasi 80°C – 5 menit

**Diketahui :**

$$J_{sc} = -3,119772189 \text{ mA/cm}^2$$

$$V_{oc} = 0,049005638 \text{ V}$$

$$J_{mp} = 1,58546 \text{ mA/cm}^2$$

$$V_{mp} = 0,02438 \text{ V}$$

$$P_{in} = 100 \text{ mW/cm}^2$$

**Perhitungan :**

$$FF = \frac{J_{mp} \times V_{mp}}{J_{sc} \times V_{oc}}$$

$$FF = \frac{0,02438 \text{ V} \times 1,58546 \text{ mA/cm}^2}{0,049005638 \text{ V} \times -3,119772189 \text{ mA/cm}^2} \times 100\%$$

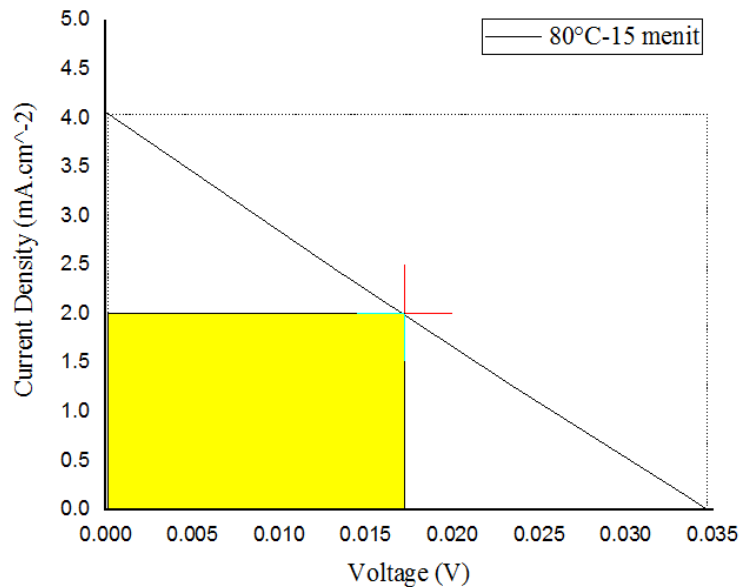
$$FF = 25,28 \%$$

$$PCE = 100\% \times \frac{J_{sc} \times V_{oc}}{P_{in}}$$

$$PCE = 25,28 \times \frac{0,049005638 \text{ V} \times -3,119772189 \text{ mA/cm}^2}{100 \text{ mW/cm}^2}$$

$$PCE = 0,0385 \%$$

2. Perhitungan nilai *fill factor* (FF) dan *power conversion efficiency* (PCE) variasi 80°C – 15 menit



**Gambar C.2** Grafik I-V variasi 80°C – 15 menit

**Diketahui :**

$$J_{sc} = -3.945192796 \text{ mA/cm}^2$$

$$V_{oc} = 0.03467889 \text{ V}$$

$$J_{mp} = 1,99632145 \text{ mA/cm}^2$$

$$V_{mp} = 0,0172047424 \text{ V}$$

$$P_{in} = 100 \text{ mW/cm}^2$$

**Perhitungan :**

$$FF = \frac{J_{mp} \times V_{mp}}{J_{sc} \times V_{oc}}$$

$$FF = \frac{1,99632145 \text{ mA/cm}^2 \times 0,0172047424 \text{ V}}{-3.945192796 \text{ mA/cm}^2 \times 0.03467889 \text{ V}} \%$$

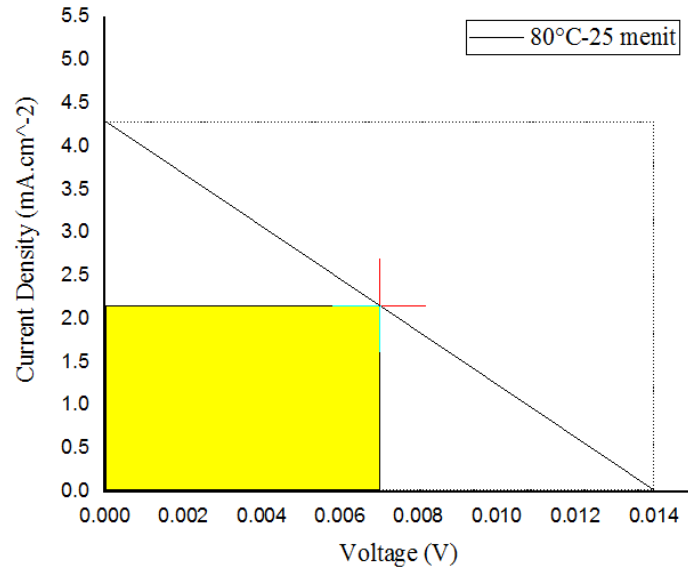
$$FF = 25,1 \%$$

$$PCE = FF \times \frac{J_{sc} \times V_{oc}}{P_{in}}$$

$$PCE = 100\% \times \frac{-3.945192796 \text{ mA/cm}^2 \times 0.03467889 \text{ V}}{100 \text{ mW/cm}^2}$$

$$PCE = 0,034 \%$$

3. Perhitungan nilai *fill factor* (FF) dan *power conversion efficiency* (PCE) variasi 80°C – 25 menit



**Gambar C.3** Grafik I-V variasi 80°C – 25 menit

**Diketahui :**

$$J_{sc} = -4.364726551 \text{ mA/cm}^2$$

$$V_{oc} = 0.013581471 \text{ V}$$

$$J_{mp} = 0,007 \text{ mA/cm}^2$$

$$V_{mp} = 2,1539 \text{ V}$$

$$P_{in} = 100 \text{ mW/cm}^2$$

**Perhitungan :**

$$FF = \frac{J_{mp} \times V_{mp}}{J_{sc} \times V_{oc}}$$

$$FF = \frac{0,007 \text{ mA/cm}^2 \times 2,1539 \text{ V}}{0.013581471 \text{ V} \times -4.364726551 \text{ mA/cm}^2} \times 100 \%$$

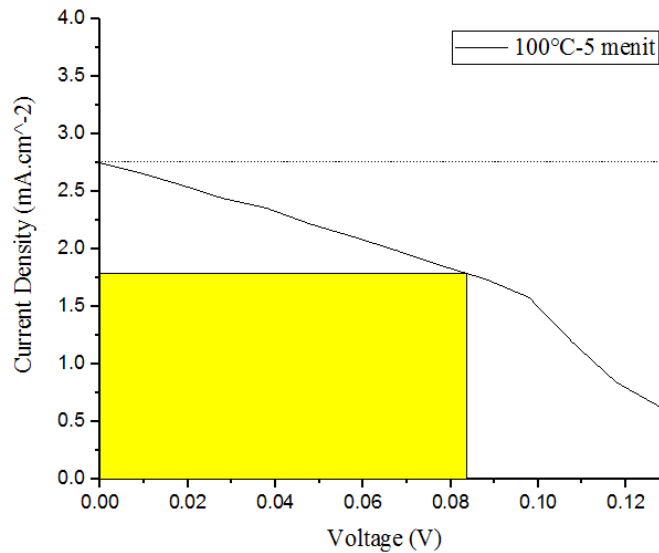
$$FF = 25,44\%$$

$$PCE = FF \times \frac{J_{sc} \times V_{oc}}{P_{in}}$$

$$PCE = 25,44\% \times \frac{0.013581471 \text{ V} \times -4.364726551 \text{ mA/cm}^2}{100 \text{ mW/cm}^2}$$

$$PCE = 0,015\%$$

4. Perhitungan nilai *fill factor* (FF) dan *power conversion efficiency* (PCE) variasi 100°C – 5 menit



**Gambar C.4** Grafik I-V variasi 100°C – 5 menit

**Diketahui :**

$$J_{sc} = -2.750471858 \text{ mA/cm}^2$$

$$V_{oc} = 0.129003 \text{ V}$$

$$J_{mp} = 0,083643 \text{ mA/cm}^2$$

$$V_{mp} = 1,788 \text{ V}$$

$$P_{in} = 100 \text{ mW/cm}^2$$

**Perhitungan :**

$$FF = \frac{J_{mp} \times V_{mp}}{J_{sc} \times V_{oc}}$$

$$FF = \frac{0,083643 \text{ mA/cm}^2 \times 1,788 \text{ V}}{-2.750471858 \text{ mA/cm}^2 \times 0.129003 \text{ V}} 100\%$$

$$FF = 0,4215 \%$$

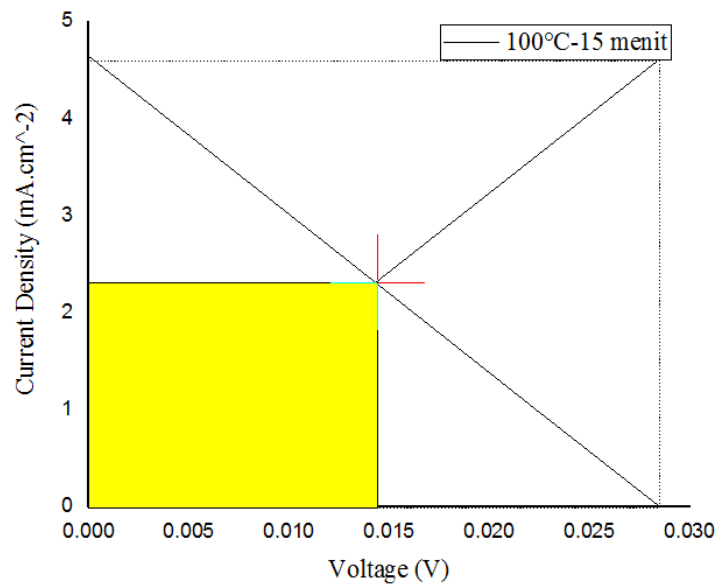
$$PCE = FF \times \frac{J_{sc} \times V_{oc}}{P_{in}}$$

$$PCE = 0,4215 \% \times \frac{-2.750471858 \text{ mA/cm}^2 \times 0.129003 \text{ V}}{100 \text{ mW/cm}^2}$$

$$PCE = 0,14955 \%$$

5. Perhitungan nilai *fill factor* (FF) dan *power conversion efficiency* (PCE) variasi

100°C – 15 menit



**Gambar C.5** Grafik I-V variasi 100°C – 15 menit

**Diketahui :**

$$J_{sc} = -4.633720495 \text{ mA/cm}^2$$

$$V_{oc} = 0.028491609 \text{ V}$$

$$J_{mp} = 2,3076 \text{ mA/cm}^2$$

$$V_{mp} = 0,02443 \text{ V}$$

$$P_{in} = 100 \text{ mW/cm}^2$$

**Perhitungan :**

$$FF = \frac{J_{mp} \times V_{mp}}{J_{sc} \times V_{oc}}$$

$$FF = \frac{2,3076 \text{ mA/cm}^2 \times 0,01443 \text{ V}}{4.633720495 \text{ mA/cm}^2 \times 0.028491609 \text{ V}} 100\%$$

$$FF = 25,206 \%$$

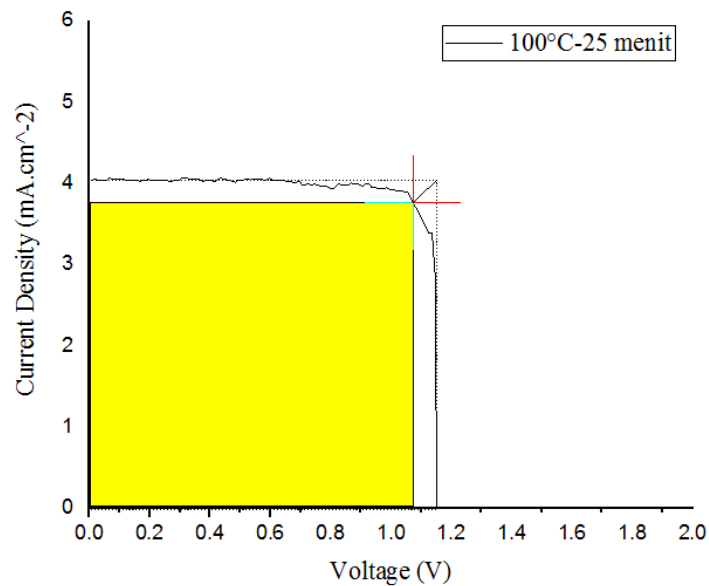
$$PCE = FF \times \frac{J_{sc} \times V_{oc}}{P_{in}}$$

$$PCE = 15,206 \% \times \frac{-4.633720495 \text{ mA/cm}^2 \times 0.028491609 \text{ V}}{100 \text{ mW/cm}^2}$$

$$PCE = 0,03327 \%$$

6. Perhitungan nilai *fill factor* (FF) dan *power conversion efficiency* (PCE) variasi

100°C – 25 menit



**Gambar C.6** Grafik I-V variasi 100°C – 25 menit

**Diketahui :**

$$J_{sc} = -4.043149675 \text{ mA/cm}^2$$

$$V_{oc} = 1.150350172 \text{ V}$$

$$J_{mp} = 3,764 \text{ mA/cm}^2$$

$$V_{mp} = 1,0734 \text{ V}$$

$$P_{in} = 100 \text{ mW/cm}^2$$

**Perhitungan :**

$$FF = \frac{J_{mp} \times V_{mp}}{J_{sc} \times V_{oc}}$$

$$FF = \frac{3,764 \text{ mA/cm}^2 \times 1,0734 \text{ V}}{-4.043149675 \text{ mA/cm}^2 \times 1.150350172 \text{ V}} 100 \%$$

$$FF = 86,898\%$$

$$PCE = FF \times \frac{J_{sc} \times V_{oc}}{P_{in}}$$

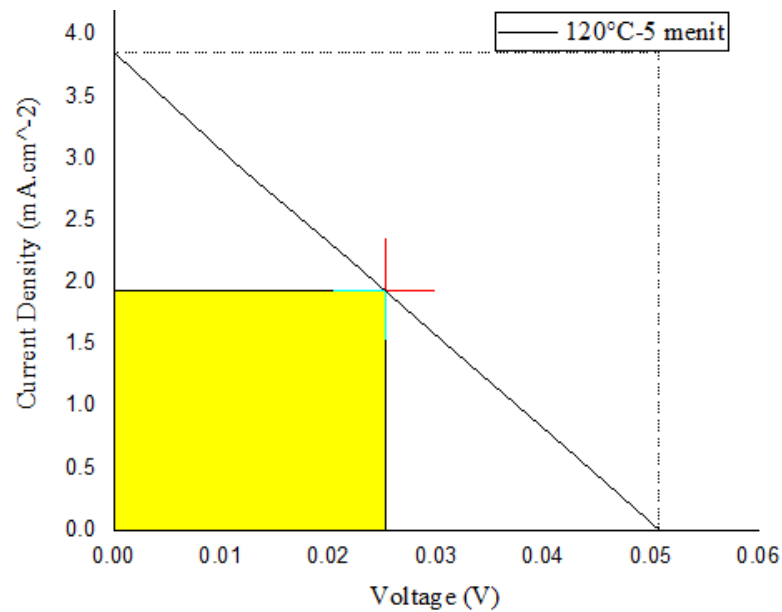
$$PCE = 86,898\% \times \frac{-4.043149675 \text{ mA/cm}^2 \times 1.150350172 \text{ V}}{100 \text{ mW/cm}^2}$$

$$PCE = 4,04 \%$$

7. Perhitungan nilai *fill factor* (FF) dan *power conversion efficiency* (PCE) variasi



120°C – 5 menit



**Gambar C.7** Grafik I-V variasi 120°C – 5 menit

**Diketahui :**

$$J_{sc} = -3.816496728 \text{ mA/cm}^2$$

$$V_{oc} = 0.050944329 \text{ V}$$

$$J_{mp} = 1,938 \text{ mA/cm}^2$$

$$V_{mp} = 0,0252 \text{ V}$$

$$P_{in} = 100 \text{ mW/cm}^2$$

**Perhitungan :**

$$FF = \frac{J_{mp} \times V_{mp}}{J_{sc} \times V_{oc}}$$

$$FF = \frac{1,938 \text{ mA/cm}^2 \times 0,0252 \text{ V}}{-3.816496728 \text{ mA/cm}^2 \times 0.050944329 \text{ V}} \times 100 \%$$

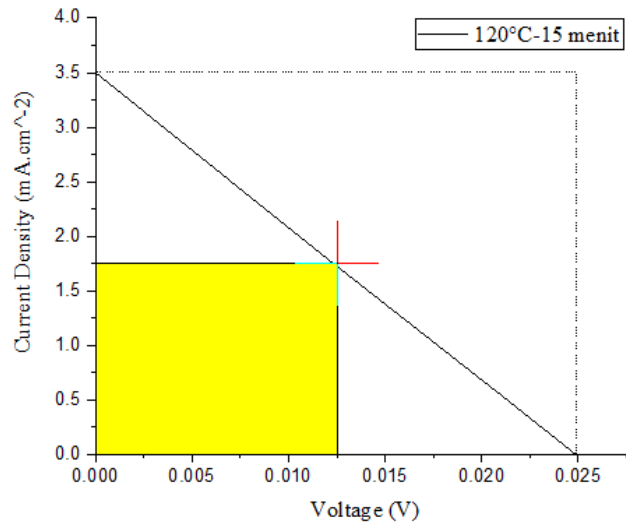
$$FF = 25,12\%$$

$$PCE = FF \times \frac{J_{sc} \times V_{oc}}{P_{in}}$$

$$PCE = 25,12\% \times \frac{100 \text{ mW/cm}^2}{100 \text{ mW/cm}^2}$$

$$PCE = 12,268 \%$$

8. Perhitungan nilai *fill factor* (FF) dan *power conversion efficiency* (PCE) variasi 120°C – 15 menit



**Gambar C.8** Grafik I-V variasi 120°C – 15 menit

**Diketahui :**

$$J_{sc} = -3.479500991 \text{ mA/cm}^2$$

$$V_{oc} = 0.024846159 \text{ V}$$

$$J_{mp} = 1,75 \text{ mA/cm}^2$$

$$V_{mp} = 0,0125 \text{ V}$$

$$P_{in} = 100 \text{ mW/cm}^2$$

**Perhitungan :**

$$FF = \frac{J_{mp} \times V_{mp}}{J_{sc} \times V_{oc}}$$

$$FF = \frac{1,8845 \text{ mA/cm}^2 \times 0,147 \text{ V}}{-3.479500991 \text{ mA/cm}^2 \times 0.024846159 \text{ V}} \times 100 \%$$

$$FF = 25,3 \%$$

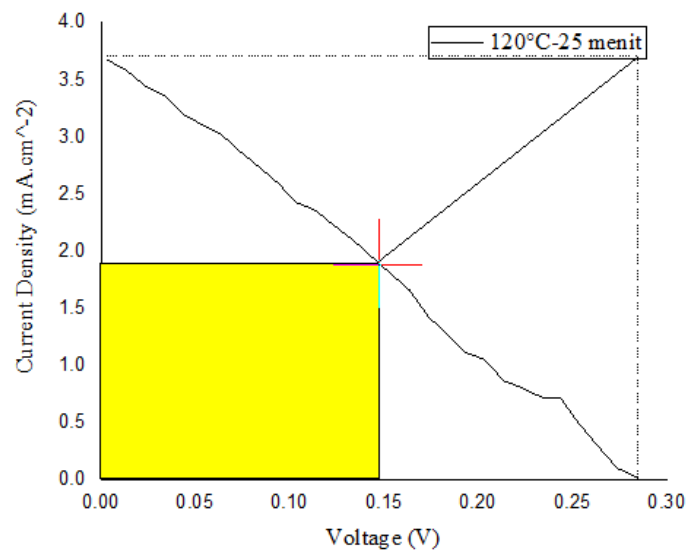
$$PCE = FF \times \frac{J_{sc} \times V_{oc}}{P_{in}}$$

$$PCE = FF \times \frac{-3.479500991 \text{ mA/cm}^2 \times 0.024846159 \text{ V}}{100 \text{ mW/cm}^2}$$

$$PCE = 0,0218 \%$$

9. Perhitungan nilai *fill factor* (FF) dan *power conversion efficiency* (PCE) variasi

120°C – 25 menit



**Gambar C.9** Grafik I-V variasi 120°C – 5 menit

**Diketahui :**

$$J_{sc} = -3.727171571 \text{ mA/cm}^2$$

$$V_{oc} = 0.284695416 \text{ V}$$

$$J_{mp} = 1,8845 \text{ mA/cm}^2$$

$$V_{mp} = 0,147 \text{ V}$$

$$P_{in} = 100 \text{ mW/cm}^2$$

**Perhitungan :**

$$FF = \frac{J_{mp} \times V_{mp}}{J_{sc} \times V_{oc}}$$

$$FF = \frac{1,8845 \text{ mA/cm}^2 \times 0,147 \text{ V}}{-3.727171571 \text{ mA/cm}^2 \times 0.284695416 \text{ V}} \times 100 \%$$

$$FF = 24,86 \%$$

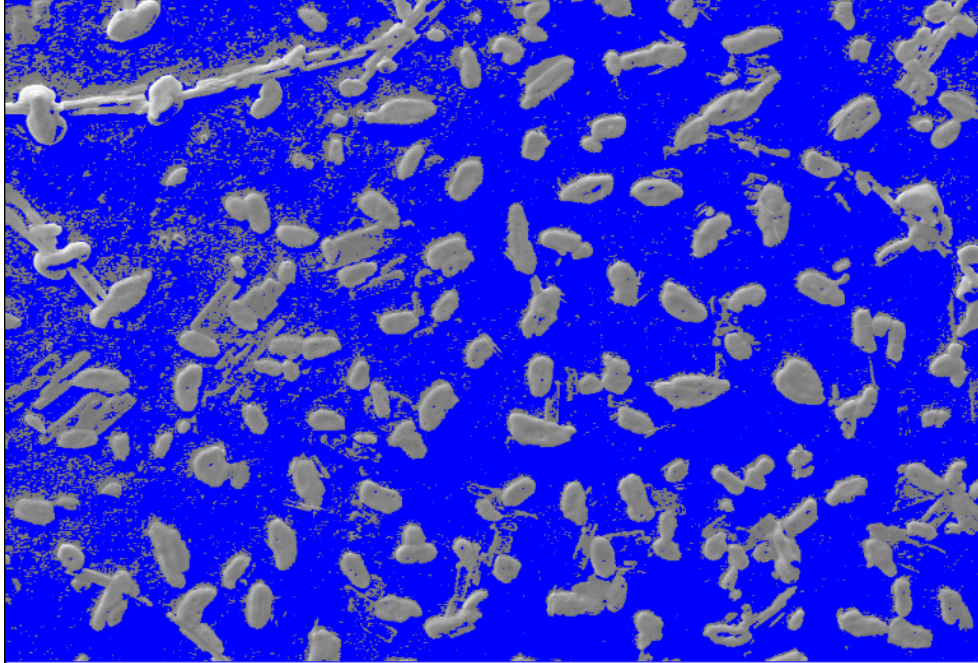
$$PCE = FF \times \frac{J_{sc} \times V_{oc}}{P_{in}}$$

$$PCE = 24,86 \% \times \frac{-3.727171571 \text{ mA/cm}^2 \times 0.284695416 \text{ V}}{100 \text{ mW/cm}^2}$$

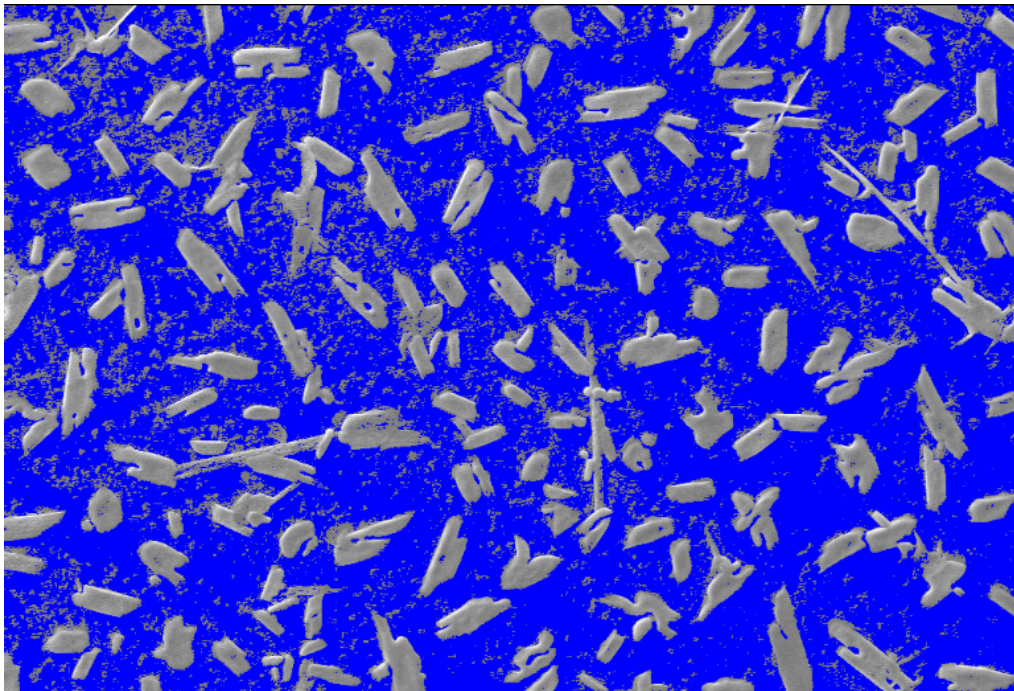
$$PCE = 26 \%$$

**LAMPIRAN D**  
**GAMBAR HASIL SEM**

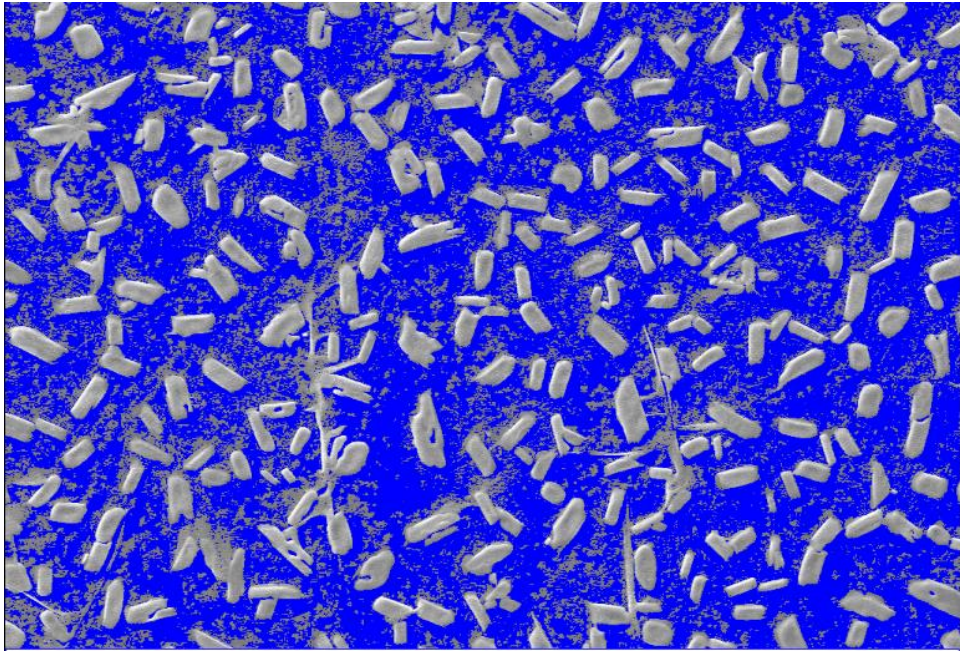
**Lampiran D. Gambar Hasil Image J**



**Gambar D.1** Gambar hasil Image J dengan variasi 100°C dan waktu 5 menit yang menggunakan perbesaran 1000 X



**Gambar D.2** Gambar hasil Image J dengan variasi 100°C dan waktu 15 menit yang menggunakan perbesaran 1000 X



**Gambar D.3** Gambar hasil Imag J dengan variasi 100°C dan waktu 25 menit yang menggunakan perbesaran 1000 X