Measuring Boltzmann Constant

Chirag Verma
Course : B.Sc. (H) Physics - III year
College Roll Number: 31830172
University Roll Number : 18036567028

September 17, 2020

Date Performed: September 17, 2020
Instructor: Dr. Sangeeta Gadre

Aim

To draw the graph using Least Square Fitting to find k (or n) and find the log error.

Formula Used

$$I_d = I_s \exp(\frac{qV_0}{nK_BT} - 1) \tag{1}$$

where the symbols have their usual meanings.

$$\log I_d = \frac{qV_d}{nK_BT} + (\log I_s - 1) \tag{2}$$

Equation (2.2) can be written as

$$y = mx + c$$

with

$$y = \log I_d, m = \frac{q}{nK_BT}, x = V_d, c = \log I_s - 1$$

Observations

The experiment was performed with the help of MHRD virtual lab :
http://vlabs.iitkgp.ernet.in/be/exp5/index.html

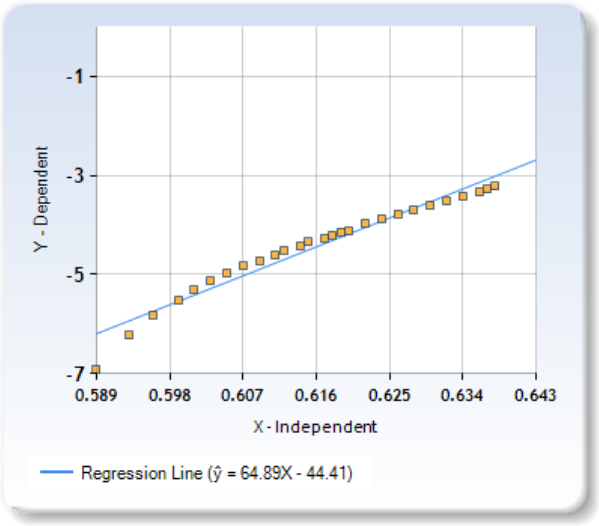
Semiconductor wafer material : Silicon
Least Count of Ammeter = 0.001 mA
Least Count of Voltmeter = 0.001 V
Empirical constant of the given semiconductor, n = 1.5
Temperature, T = 300K

S.No.	P.D across the Diode(V)	Current Across the Diode (mA)	Log(Current)
1	0	0	Err:502
2	0.589	0.997	-6.911
3	0.593	1.99	-6.220
4	0.596	2.99	-5.812
5	0.599	3.99	-5.524
6	0.601	4.99	-5.300
7	0.603	5.98	-5.119
8	0.605	6.98	-4.965
9	0.607	7.98	-4.831
10	0.609	8.97	-4.714
11	0.611	9.97	-4.608
12	0.612	11	-4.510
13	0.614	12	-4.423
14	0.615	13	-4.343
15	0.617	14	-4.269
16	0.618	15	-4.200
17	0.619	16	-4.135
18	0.62	16.4	-4.110
19	0.622	18.9	-3.969
20	0.624	20.9	-3.868
21	0.626	22.9	-3.777
22	0.628	24.9	-3.693
23	0.63	26.9	-3.616
24	0.632	29.9	-3.510
25	0.634	32.9	-3.414
26	0.636	35.9	-3.327
27	0.637	37.9	-3.273
28	0.638	39.9	-3.221

Calculations

REGRESSION ANALYSIS:

S.No.	X	Y	X - mean(X)	Y - mean (Y)
1	0.589	-6.911	-0.0271	-2.4791
2	0.593	-6.220	-0.0231	-1.7881
3	0.596	-5.812	-0.0201	-1.3801
4	0.599	-5.524	-0.0171	-1.0921
5	0.601	-5.300	-0.0151	-0.8681
6	0.603	-5.119	-0.0131	-0.6871
7	0.605	-4.965	-0.0111	-0.5331
8	0.607	-4.831	-0.0091	-0.3991
9	0.609	-4.714	-0.0071	-0.2821
10	0.611	-4.608	-0.0051	-0.1761
11	0.612	-4.510	-0.0041	-0.0781
12	0.614	-4.423	-0.0021	0.0089
13	0.615	-4.343	-0.0011	0.0889
14	0.617	-4.269	0.0009	0.1629
15	0.618	-4.200	0.0019	0.2319
16	0.619	-4.135	0.0029	0.2969
17	0.62	-4.110	0.0039	0.3219
18	0.622	-3.969	0.0059	0.4629
19	0.624	-3.868	0.0079	0.5639
20	0.626	-3.777	0.0099	0.6549
21	0.628	-3.693	0.0119	0.7389
22	0.63	-3.616	0.0139	0.8159
23	0.632	-3.510	0.0159	0.9219
24	0.634	-3.414	0.0179	1.0179
25	0.636	-3.327	0.0199	1.1049
26	0.637	-3.273	0.0209	1.1049
27	0.638	-3.221	0.0219	1.2109



This gives : m = 64.89368, c = -44.41365
On putting this in equation (2) with n = 1.5: we get, $k = 1.23 \cdot 10^{-23} m^2 kg s^{-2} K^{-1}$

Error Analysis

Relative Voltage Error	Relative Current Error	Relative error in Boltzmann const.
DIV/0!	DIV/0!	DIV/0!
0.00170	0.00100	0.0060
0.00169	0.00050	0.0055
0.00168	0.00033	0.0053
0.00167	0.00025	0.0053
0.00166	0.00020	0.0052
0.00166	0.00017	0.0052
0.00165	0.00014	0.0051
0.00165	0.00013	0.0051
0.00164	0.00011	0.0051
0.00164	0.00010	0.0051
0.00163	0.00009	0.0051
0.00163	0.00008	0.0050
0.00163	0.00008	0.0050
0.00162	0.00007	0.0050
0.00162	0.00007	0.0050
0.00162	0.00006	0.0050
0.00161	0.00006	0.0050
0.00161	0.00005	0.0050
0.00160	0.00005	0.0050
0.00160	0.00004	0.0050
0.00159	0.00004	0.0050
0.00159	0.00004	0.0050
0.00158	0.00003	0.0049
0.00158	0.00003	0.0049
0.00157	0.00003	0.0049
0.00157	0.00003	0.0049
0.00157	0.00003	0.0049

Therefore, Average log error in k = 0.00703