SOLECON LABS TECHNICAL NOTE

How Do We Calculate Carrier Concentration?

The short answer is that we measure the spreading resistance; correct for sampling volume effects[(1)] (if necessary); use the appropriate calibration chart to obtain resistivity vs depth; then use published[(2)] values of carrier mobility to calculate carrier concentration vs depth. Dopant concentration vs depth can be inferred or, in some cases, calculated[(3)] from the carrier concentration.

The carrier mobility is concentration dependent. If you want to know the carrier mobility that we used for a given point, you can calculate if from the numerical listing of the profile. Please see the example below:

The Numerical Data for an N+/P Profile

Point #	Depth Microns	Type	C Conc cm^{-3}	Rho Ohm-cm	R(meas) Ohms	R(corr) Ohms
11	.038	n	6.34E+18	7.99E-03	1.89E+02	5.89E+01
12	.076	n	6.72E+18	7.70E-03	2.06E+02	5.67E+01
13	.114	n	6.74E+18	7.68E-03	2.27E+02	5.65E+01
14	.153	n	5.89E+18	8.37E-03	2.58E+02	6.20E+01
15	.191	n	5.45E+18	8.78E-03	2.88E+02	6.54E+01
16	.229	n	5.12E+18	9.12E-03	3.31E+02	6.86E+01
17	.267	n	4.19E+18	1.03E-02	3.85E+02	7.96E+01
18	.305	n	3.60E+18	1.12E-02	4.46E+02	8.88E+01
19	.343	n	3.49E+18	1.14E-02	5.17E+02	9.08E+01
20	.381	n	2.97E+18	1.25E-02	6.28E+02	1.01E+02
21	.420	n	2.26E+18	1.44E-02	7.67E+02	1.22E+02
22	.458	n	1.95E+18	1.56E-02	9.35E+02	1.35E+02
23	.496	n	1.70E+18	1.68E-02	1.18E+03	1.48E+02
24	.534	n	1.23E+18	1.99E-02	1.58E+03	1.82E+02
25	.572	n	9.30E+17	2.30E-02	2.08E+03	2.19E+02
26	.610	n	6.61E+17	2.75E-02	3.01E+03	2.74E+02
27	.649	n	4.30E+17	3.48E-02	4.45E+03	3.70E+02
28	.687	n	2.75E+17	4.47E-02	7.22E+03	5.11E+02
29	.725	n	1.78E+17	5.81E-02	1.24E+04	7.09E+02
30	.763	n	9.35E+16	8.81E-02	2.73E+04	1.16E+03
31	.801	n	2.92E+16	2.08E-01	9.05E+04	3.23E+03
32	.839	n	2.87E+15	1.63E+00	7.44E+05	3.20E+04
33	.877	P	2.20E+14	5.93E+01	3.65E+05	3.77E+05
34	.916	P	4.26E+14	3.07E+01	1.57E+05	1.63E+05
35	.954	P	6.24E+14	2.10E+01	9.70E+04	1.02E+05
36	.992	P	7.60E+14	1.73E+01	7.99E+04	8.10E+04
37	1.030	P	8.47E+14	1.55E+01	6.89E+04	7.02E+04

The approximation

$$\frac{1}{\rho} = \mu q N$$

Where

ρ is the resistivity in ohm-cm
μ is the carrier mobility in cm^2/volt-sec
N is the dopant concentration in cm^{-3}
q is the charge of an electron (1.6021×10^{-19} coulombs)

can be re-written as

$$\mu = \frac{1}{qN\rho}$$

Note: volt-sec = ohms-coulomb. Can be obtained by substituting amps = columbs/sec into Ohm's Law.

The Carrier Mobility Values for the Previous Profile

Point #	Depth microns	Type	C Conc cm^{-3}	Rho Ohm-cm	Mobility (cm2/volt-sec) (Conc x Rho x 1.6E-19)$^{-1}$
11	.038	N	3.34E+18	7.99E-03	123.2181
12	.076	N	6.72E+18	7.70E-03	120.6286
13	.114	N	6.74E+18	7.68E-03	120.5839
14	.153	N	5.89E+18	8.37E-03	126.6105
15	.191	N	5.45E+18	8.78E-03	130.4426
16	.229	N	5.12E+18	9.12E-03	133.6736
17	.267	N	4.19E+18	1.03E-02	144.6303
18	.305	N	3.60E+18	1.12E-02	154.8068
19	.343	N	3.49E+18	1.14E-02	156.8845
20	.381	N	2.97E+18	1.25E-02	168.1295
21	.420	N	2.26E+18	1.44E-02	191.796
22	.458	N	1.95E+18	1.56E-02	205.1877
23	.496	N	1.70E+18	1.68E-02	218.5507
24	.534	N	1.23E+18	1.99E-02	255.0071
25	.572	N	9.30E+17	2.30E-02	291.8096
26	.610	N	6.61E+17	2.75E-02	343.381
27	.649	N	4.30E+17	3.48E-02	417.1216
28	.687	N	2.75E+17	4.47E-02	507.7737
29	.725	N	1.78E+17	5.81E-02	603.5514
30	.763	N	9.35E+16	8.81E-02	757.7446
31	.801	N	2.92E+16	2.08E-01	1027.695
32	.839	N	2.87E+15	1.63E+00	1334.261
33	.877	P	2.20E+14	5.93E+01	478.4462
34	.916	P	4.26E+14	3.07E+01	477.2682
35	.954	P	6.24E+14	2.10E+01	476.3284
36	.992	P	7.60E+14	1.73E+01	474.7344
37	1.030	P	8.47E+14	1.55E+01	475.7395

Note that the mobility increases as the n concentration decreases. Also, the hole mobility (p-type) is considerably less than the electron mobility (n-type) for a given concentration. The calculated mobility values should have been rounded to three significant figures but we thought it would be interesting to leave them this way.

References

1. D. Dickey and J. Ehrstein, N. B. S. Special Publication 400-48, May 1979.
2. W. Thurber, R. Mattis, Y. Liu, and J. Fillben, N. B. S. Special Publication 400-64, May 1981, Table 10, p. 34 and Table 14, p. 40.
3. W. Vandervorst and T. Clarysse, J. Electrochem. Soc. 137, 679 (1990).