6. Discussion

The theoretical efficiency of 1.4 % could be achieved using BiTe modular design. There are many designs work in the range of 5 % - 10 % efficiency like, exhaust duct, Inclinators etc. Here with transformers it is very low because of low temperature difference and the less heat flux. The transformers are not moving machines and work with more than 98% efficiency in comparison with 40 % efficiency of IC engine.

Based on some valuable data on waste heat thermoelectric generators reported so far, we should discuss key issues to be solved from technical and economic points of view:

(1) The performance of the thermoelectric materials used to build the thermoelectric generator.

(2) The fabrication of a good electrical contact of a metal electrode to the materials, where mechanically durable properties are required against a harsh heat cycle.

(3) The achievement of a minimum contact heat loss at the heat exchanger.

Vast quantities of untapped natural heat is available together with huge amount of waste heat, most of which is below 100C and is discharged into the environment. Thermoelectric generation is an environmentally friendly technology which can convert this unused heat, and in particular lower temperature heat, into electricity. This technology has been successfully demonstrated on a laboratory scale and in prototype commercial systems. Collaboration between University and Industry has resulted in research and development in this area of thermoelectric technology progressing rapidly.

In the near future thermoelectric waste heat recovery will make a significant contribution, over a wide range of applications, in reducing fossil fuel consumption and global warming. The price for such TE module of 1 W will be 1\$. So the payback period may be 416 days when it is continuously operating. But if we proceed with nano film / quantum well designs we can further decrease the payback period to 83 days.

7. Conclusion

Energy collection using thermoelectric effect of materials is much more cost effective, continuous method compared to conventional solar power. While the transformers in operation it continuously dissipate heat, not subjected to natural changes in the environment. No need to have exposure or large room to install a thermopile which efficiently extracts energy.

So it is the biggest challenge to design a well suited thermo element using cost effective materials even it gives a little electro motive force. When it is connected with all the fins of a transformer collectively it gives a substantial energy, which can there be stored or can use for another application at the site.

The theoretical efficiency of 1.4 % could be achieved using BiTe modular design. But many challenges still exist in the event of fixing to the transformer fin. The contact resistance would be the biggest problem. Today the thin film nano technology developed towards to the TE applications. So without pasting them on transformer fins, it is easier to fabricate the radiators with TE nano films embedded. That will drastically cut down the contact resistances and additional works involved in fixing these modules to the radiator. These panel type radiators are standard design, so one manufactured the radiator with TE coating, with some additional cost would definitely have a different market. Actually this TE conversions seems to be costly because of lees usage, but with the increase of use will definitely cut down the prices in future.

8. References

F.J. DiSalvo, "Thermoelectric cooling and power generation." Science, vol. 285, pp. 703-706, 1999.

International Union of Pure and Applied Chemistry. "semiconductor". Compendium of Chemical Terminology Internet edition.

J. F. Schooley, Thermometry, New York:CRC Press,1986,pp.172-186.

J. Lopez, M. Gonzalez, J.C. Viera, and C. Blanco, "Fast-charge in lithium-ion batteries for portable applications," 26th Annual International Telecommunications Energy Conference, pp. 19-24, 2004.

D.M. Rowe (Ed) Handbook of Thermoelectrics, CRC Press, Boca Raton., USA, 1994.

G.H. Nolas, G.J. Sharp and H.J. Goldsmid, 'Thermoelectrics' Springer

D.M.Rowe (Ed) 'Thermoelectrics Handbook, Macro to Nano' CRC Press, Boca Raton, USA, 2005.

Proceedings of International Thermoelectric Conference 1976- present. Available from IEEE e-mail address, hffp//www.its.org/proceedings/

Proceedings of European Conferences/ Workshops on Thermoelectrics 1987-present. Information available from website, thermoelectrics.com

Proceedings of the International Forum on Thermoelectrics, published in The Journal of Thermoelectricity 1994-present. Available from Prof. L.Anatychuk at anatychuk@ite.cv.ua

Thermal Conduction in Semiconductors, C.M. Bhandari, and D.M. Rowe, Wiley Eastern Ltd, 1988.

G.A. Slack, 'Design Concepts for improved thermoelectric materials' Mat. Res. Symp. Proc. Vol 478 pp. 47-54, 1997.

J.P. Fleurial, T. Caillat.and A. Borshchevsky 'Skutterudites; An Update. Proc. ICT 97. pl 1970.

G.S. Nolas, Semiconductor Clathrates; A PGEC System with potential for thermoelectric applications 'Thermoelectric Materials' Mat. Res. Symp. Proc. Vol 545, pp. 435-442, 1999.

G. Chen, Phys. Rev. B 57(23), p. 14958, 1998.

M. Federov and V. Zsitsev, 'Thermolectrics of Transition Metal Silicides' Thermoelectrics Handbook, Macro to Nano, D.M.Rowe (Ed)CRC Press, Boca Raton, USA,2005 .

D.M. Rowe and G. Min, 'Evaluation of Thermoelectric Modules for Power Generation', Journal of Power Sources, pp. 193-198, ISBN 0950- 0839, 1998

D.M. Rowe, V.L. Kuznetsov, L.A. Kuznetsova and G. Min, 'Electrical and thermal transport properties of intermediate-valence YbA13' J. Phys. D: Appl. Phys. 35 (2002), ISBN 2183-2186.

D.M. Rowe and G. Min, 'Multiple Potential Barriers as a possible mechanism to increase the Seebeck Coefficient and Electrical Power Factor' Proc. of 13th IT Conf. Kansas, USA, pp. 339, 1994

X.Y. Yu, G. Chen, A. Verma and J.S. Smith, J. Appl.Phys. 67, pp. 3553, 68, pp. 1303, 1995.

A.E. Kaliazin, V.L. Kuznetsov and D.M. Rowe, 'Rigorous calculations related to functionally graded and segmented thermo elements' Proceedings of the 20th Int. Conf on Thermoelectrics, June 8-11th 2001, Beijing, China, pp., 286-292, ISBN: 0-7803-7205-0

Park, T.J., Choi, Y.C., Choi, B.J., Hong, J.C., and Park, J.S., Research on the waste heat recovery technology using thermoelectric generation, pp. 313 – 316. Proceedings of the 19th International Conference on Thermoelectrics, Baltimore, MD, 2000.

Kajikawa, T., Status and future prospects on the development of thermoelectric power generation systems utilizing combustion heat from municipal solid waste, pp. 28 – 36. Proceedings of the 16th International Conference on Thermoelectrics, Dresden, Germany, 1997.

Haider, J.G. and Ghojel, J.I., Waste heat recovery from the exhaust of low-power diesel engine using thermoelectric generators, pp. 413 – 417. Proceedings of the 20th International Conference on Thermoelectrics, Beijing, China. 2001.

Nagayoshi, H., Kajikawa, T., and Sugiyama, T., Comparison of maximum power point control method for thermoelectric power generator, pp. 450 – 453. Proceedings of the 21st International Conference on Thermoelectrics. Long Beach, CA, 2002.

Appendix I:

Thermoelectric Technical Reference —
Averaged Module Material Parameters at Various Temperatures

For all tables:

SM = Module Seebeck coefficient in volts/K (or volts/degreeC)

RM = Module resistance in ohms

KM = Module thermal conductable in watts/K (or watts/degreeC)

NOTE: The data on the following tables reflects effective module parameters of Ferrotec manufactured TEs, in normal ambient air using thermal grease at both the hot and cold module interfaces. Raw Bismuth Telluride semiconductor material not in module form has substantially different values for these parameters. We *do not* recommend using this data for the analysis of other manufacturer's modules.

31-Couple Modules

Temperature			**9-Ampere Module**		**15-Ampere Module**	
		S_M	**R_M**	**K_M**	**R_M**	**K_M**
°C	**°K**	**V/K**	**ohms**	**w/K**	**ohms**	**w/K**
-100	173.2	0.00859	0.2130	0.2103	0.1278	0.3504
-90	183.2	0.00898	0.2186	0.2086	0.1312	0.3477
-80	193.2	0.00938	0.2263	0.2056	0.1358	0.3427
-70	203.2	0.00978	0.2360	0.2018	0.1416	0.3364
-60	213.2	0.01017	0.2474	0.1976	0.1484	0.3293
-50	223.2	0.01056	0.2604	0.1933	0.1562	0.3221
-40	233.2	0.01094	0.2748	0.1892	0.1649	0.3153

-30	243.2	0.01130	0.2906	0.1857	0.1743	0.3096
-20	253.2	0.01165	0.3075	0.1831	0.1845	0.3052
-10	263.2	0.01198	0.3253	0.1816	0.1952	0.3027
0	273.2	0.01229	0.3440	0.1815	0.2064	0.3024
10	283.2	0.01257	0.3634	0.1828	0.2180	0.3047
20	293.2	0.01282	0.3833	0.1858	0.2300	0.3096
30	303.2	0.01304	0.4035	0.1905	0.2421	0.3176
40	313.2	0.01323	0.4239	0.1971	0.2544	0.3286
50	323.2	0.01337	0.4444	0.2057	0.2666	0.3428
60	333.2	0.01347	0.4647	0.2162	0.2788	0.3602
70	343.2	0.01353	0.4848	0.2286	0.2909	0.3809
80	353.2	0.01353	0.5044	0.2428	0.3026	0.4047
90	363.2	0.01349	0.5234	0.2589	0.3140	0.4316
100	373.2	0.01338	0.5417	0.2768	0.3250	0.4613
110	383.2	0.01322	0.5590	0.2961	0.3354	0.4936
120	393.2	0.01300	0.5753	0.3169	0.3452	0.5282
130	403.2	0.01271	0.5904	0.3389	0.3542	0.5649
140	413.2	0.01235	0.6041	0.3619	0.3624	0.6032
150	423.2	0.01192	0.6162	0.3856	0.3697	0.6426

71-Couple Modules

Temperature			4-Ampere Module		6-Ampere Module	
		S_M	R_M	K_M	R_M	K_M
°C	°K	V/K	ohms	w/K	ohms	w/K
-100	173.2	0.01968	1.0980	0.2140	0.7318	0.3210
-90	183.2	0.02058	1.1270	0.2123	0.7511	0.3185
-80	193.2	0.02148	1.1663	0.2093	0.7775	0.3140
-70	203.2	0.02239	1.2159	0.2054	0.8106	0.3082
-60	213.2	0.02329	1.2746	0.2011	0.8498	0.3017
-50	223.2	0.02418	1.3417	0.1967	0.8945	0.2951
-40	233.2	0.02505	1.4162	0.1926	0.9441	0.2889
-30	243.2	0.02588	1.4974	0.1891	0.9983	0.2836
-20	253.2	0.02668	1.5844	0.1864	1.0563	0.2796
-10	263.2	0.02744	1.6766	0.1849	1.1177	0.2773
0	273.2	0.02814	1.7729	0.1847	1.1819	0.2771
10	283.2	0.02879	1.8727	0.1861	1.2485	0.2791
20	293.2	0.02937	1.9751	0.1891	1.3167	0.2837
30	303.2	0.02987	2.0793	0.1939	1.3862	0.2909
40	313.2	0.03029	2.1845	0.2007	1.4564	0.3010
50	323.2	0.03062	2.2899	0.2094	1.5266	0.3140
60	333.2	0.03085	2.3947	0.2200	1.5965	0.3300

70	343.2	0.03098	2.4980	0.2326	1.6654	0.3490
80	353.2	0.03100	2.5991	0.2472	1.7327	0.3708
90	363.2	0.03089	2.6971	0.2636	1.7981	0.3954
100	373.2	0.03066	2.7913	0.2817	1.8608	0.4226
110	383.2	0.03029	2.8807	0.3015	1.9205	0.4522
120	393.2	0.02977	2.9647	0.3226	1.9765	0.4839
130	403.2	0.02911	3.0423	0.3450	2.0282	0.5175
140	413.2	0.02828	3.1129	0.3684	2.0753	0.5526
150	423.2	0.02729	3.1755	0.3925	2.1170	0.5887

127-Couple Modules

Temperature			**4-Ampere Module**		**6-Ampere Module**	
		S_M	**R_M**	**K_M**	**R_M**	**K_M**
°C	**°K**	**V/K**	**ohms**	**w/K**	**ohms**	**w/K**
-100	173.2	0.03520	1.9634	0.3828	1.3089	0.5742
-90	183.2	0.03680	2.0152	0.3798	1.3435	0.5697
-80	193.2	0.03843	2.0862	0.3744	1.3908	0.5616
-70	203.2	0.04005	2.1749	0.3675	1.4500	0.5512
-60	213.2	0.04166	2.2800	0.3597	1.5200	0.5396
-50	223.2	0.04325	0.3999	0.3519	1.6000	0.5278

-40	233.2	0.04480	2.5332	0.3445	1.6888	0.5168
-30	243.2	0.04630	2.6784	0.3382	1.7856	0.5073
-20	253.2	0.04773	2.8341	0.3335	1.8894	0.5002
-10	263.2	0.04908	2.9989	0.3307	1.9993	0.4961
0	273.2	0.05034	3.1713	0.3304	2.1142	0.4956
10	283.2	0.05150	3.3498	0.3328	2.2332	0.4992
20	293.2	0.05253	3.5329	0.3383	2.3553	0.5074
30	303.2	0.05343	3.7193	0.3469	2.4796	0.5204
40	313.2	0.05418	3.9075	0.3590	2.6050	0.5384
50	323.2	0.05477	4.0961	0.3745	2.7307	0.5617
60	333.2	0.05519	4.2835	0.3936	2.8556	0.5903
70	343.2	0.05542	4.4683	0.4161	2.9789	0.6242
80	353.2	0.05544	4.6491	0.4422	3.0994	0.6632
90	363.2	0.05525	4.8244	0.4715	3.2163	0.7072
100	373.2	0.05483	4.9928	0.5039	3.3285	0.7559
110	383.2	0.05417	5.1528	0.5392	3.4352	0.8088
120	393.2	0.05325	5.3030	0.5771	3.5354	0.8656
130	403.2	0.05206	5.4419	0.6171	3.6280	0.9257
140	413.2	0.05059	5.5681	0.6589	3.7121	0.9884
150	423.2	0.04882	5.6801	0.7021	3.7867	1.0531

Appendix II :

Specification of step up transformer

You can count on our quality

Products

- Power transformers from 5 to 100 MVA up to Um 170 KV ONAN / ONAF / OFWF 16 2/3 Hz / 50 Hz / 60 Hz
- Oil chokes
- Neutral electromagnetic coupler
- Earthing transformers and Peterson coils
- Single phase transformers
- Resonant circuit reactances
- Coupling transformers and reactors for ripple control
- Shunt reactors and current limiting reactors
- Transformers with line drop and parallel regulation
- Rectifier and furnace transformers

Repair

- All types of transformers > 5 MVA
- Manufacture of complete spare parts

Maintenance

Provider of services for everything to do with transformers

Quality management

The complete operational process is controlled by a tried and tested quality management system

The SGB Group is certified in accordance with
- ISO 9001
- Federal railways welding authorisation
- KTA 1401

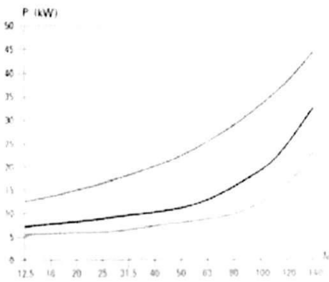
Markets

The SGB group manufactures and tests transformers for the world market.

We comply with the standards of
- DIN / VDE
- IEC 76
- British standard
- ANSI / IEEE
- CAN / CSA
- NEMA
- and others
- UL
- ENEL
- ÖVE
- SVV
- UNE
- NF

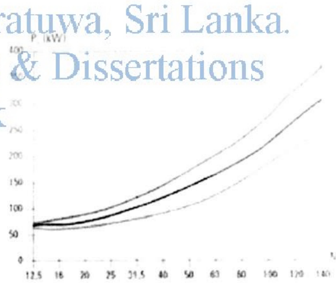
No-load losses / Noise

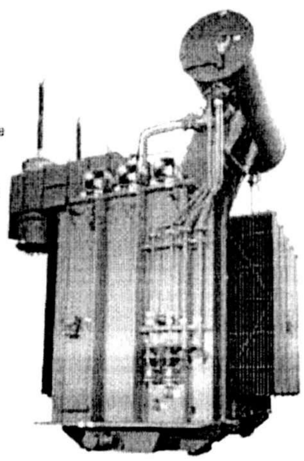
Up to the minute core-laying technology (step lap) and the application of high quality, extremely low loss sheet steel with low magnetism, guarantees the customer low no-load losses and noise emissions.

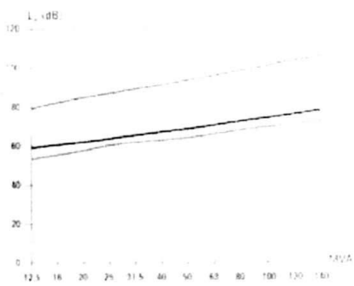


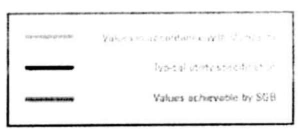
Short-circuit losses

Thanks to the optimisation of the conductor cross sections, low-load losses can be achieved in relation to the additional losses. As a result, SGB transformers completely meet the technical as well as the economical requirements with regard to short circuit proofing.









3

Appendix III :

Spreadsheet Calculation of p-Type Element Performance

T (C)	Material	T (K)	α (μV/K)	ρ (10^{-3} Ω cm)	κ (mW/cm K)	zT	Max Red Eff (%)	s (1/V)	u (1/V)	Red Eff (%)	$u\kappa$ dT (A/cm)	$JI(x)$ (A/cm)	Φ (V)	Efficiency (%)
700	$CeFe_4Sb_{12}$	973	156	0.849	26.89	1.04	17.62	2.82	3.6179	16.70		0.00	0.42833	
675	$CeFe_4Sb_{12}$	948	160	0.842	26.98	1.07	18.04	2.89	3.6457	17.26	2.4457	2.45	0.42643	0.44
650	$CeFe_4Sb_{12}$	923	164	0.834	27.06	1.09	18.27	2.96	3.6573	17.62	2.4668	4.91	0.42443	0.91
625	$CeFe_4Sb_{12}$	898	166	0.826	27.12	1.10	18.34	3.02	3.6551	17.81	2.4763	7.39	0.42237	1.39
600	$CeFe_4Sb_{12}$	873	167	0.818	27.17	1.09	18.26	3.07	3.6413	17.84	2.4757	9.86	0.42024	1.89
575	$CeFe_4Sb_{12}$	848	167	0.809	27.20	1.08	18.06	3.11	3.6184	17.74	2.4668	12.33	0.41807	2.39
550	$CeFe_4Sb_{12}$	823	167	0.800	27.22	1.05	17.75	3.15	3.5884	17.52	2.4512	14.78	0.41588	2.91
525	$CeFe_4Sb_{12}$	798	166	0.791	27.23	1.02	17.36	3.18	3.5533	17.19	2.4303	17.21	0.41366	3.43
500	$CeFe_4Sb_{12}$	773	164	0.782	27.23	0.98	16.89	3.20	3.5146	16.78	2.4056	19.62	0.41143	3.95
475	$CeFe_4Sb_{12}$	748	162	0.772	27.22	0.94	16.37	3.23	3.4737	16.30	2.3781	22.00	0.40921	4.46
450	$CeFe_4Sb_{12}$	723	160	0.762	27.21	0.89	15.79	3.25	3.4317	15.76	2.3490	24.35	0.40699	4.98
425	$CeFe_4Sb_{12}$	698	157	0.752	27.19	0.84	15.18	3.26	3.3893	15.16	2.3189	26.66	0.40479	5.50
400	$CeFe_4Sb_{12}$	673	154	0.741	27.16	0.80	14.54	3.28	3.3474	14.53	2.2885	28.95	0.40261	6.01
400	Zn_4Sb_3	673	200	3.118	6.37	1.35	21.04	3.97	3.7279	20.99	0	28.95	0.40261	6.01
375	Zn_4Sb_3	648	195	3.064	6.37	1.27	20.18	3.99	3.6651	20.09	0.5889	29.54	0.39950	6.73
350	Zn_4Sb_3	623	191	3.008	6.32	1.20	19.45	4.05	3.6063	19.28	0.5768	30.12	0.39643	7.45
325	Zn_4Sb_3	598	187	2.949	6.22	1.14	18.78	4.14	3.5512	18.51	0.5607	30.68	0.39338	8.15
300	Zn_4Sb_3	573	182	2.889	6.10	1.08	18.13	4.24	3.4991	17.73	0.5430	31.22	0.39035	8.87
275	Zn_4Sb_3	548	178	2.825	6.00	1.02	17.43	4.33	3.4498	16.89	0.5257	31.75	0.38736	9.57
250	Zn_4Sb_3	523	173	2.760	5.93	0.96	16.64	4.41	3.4028	15.98	0.5107	32.26	0.38441	10.25
225	Zn_4Sb_3	498	168	2.691	5.91	0.88	15.71	4.45	3.3576	14.96	0.4999	32.76	0.38151	10.93
209	Zn_4Sb_3	482	165	2.645	5.93	0.83	15.02	4.45	3.3295	14.26	0.3167	33.08	0.37970	11.35
209	p-Bi_2Te_3	482	196	2.225	10.71	0.78	14.31	3.53	3.5079	14.31	0	33.08	0.37970	11.35
200	p-Bi_2Te_3	473	198	2.174	10.43	0.82	14.86	3.72	3.5107	14.83	0.3339	33.41	0.37866	11.62
175	p-Bi_2Te_3	448	202	2.016	9.92	0.92	16.14	4.24	3.5109	15.77	0.8932	34.30	0.37551	12.33
150	p-Bi_2Te_3	423	204	1.834	9.71	0.99	17.03	4.75	3.4999	16.12	0.8603	35.16	0.37209	13.13
125	p-Bi_2Te_3	398	203	1.632	9.70	1.04	17.64	5.29	3.4783	16.02	0.8466	36.01	0.36846	13.89
100	p-Bi_2Te_3	373	200	1.415	9.79	1.08	18.09	5.92	3.4474	15.58	0.8435	36.85	0.36471	14.95
75	p-Bi_2Te_3	348	194	1.198	9.87	1.11	18.41	6.69	3.4085	14.81	0.8424	37.70	0.36089	15.73
50	p-Bi_2Te_3	323	185	1.015	9.85	1.11	18.40	7.55	3.3633	13.69	0.8350	38.53	0.35708	16.63
25	p-Bi_2Te_3	298	173	0.927	9.63	1.00	17.14	8.02	3.3128	12.09	0.8132	39.34	0.35341	17.49

α, ρ, κ are the measured material properties. zT, the maximum reduced efficiency, and s are calculated from Equation 9.16, Equation 9.20, and Equation 9.18. The calculation uses $u_0 = 3.6179\ V^{-1}$ as a starting value for u. The subsequent values of u use $\frac{1}{u_n} = \frac{1}{u_{n-1}}\sqrt{1 - 2u_{n-1}^2\left(\frac{\rho_n\kappa_n + \rho_{n-1}\kappa_{n-1}}{2}\right)(T_n - T_{n-1})} - \left(\frac{T_n + T_{n-1}}{2}\right)(\alpha_n - \alpha_{n-1})$ following Equation 9.55. The reduced efficiency is given by Equation 9.15, the maximum reduced efficiency ($u = s$, infinitely staged), by Equation 9.20. The column "$u\kappa$ dT" is used to find the physical length of each interval. Specifically, $(u\kappa\, dT)_n = \frac{u_n\kappa_n + u_{n-1}\kappa_{n-1}}{2}(T_{n-1} - T_n)$ following Equation 9.40. JI is the running sum of $(u\kappa\, dT)_n$ and is proportional to the distance to the hot end. The thermoelectric potential (voltage), Φ is given by Equation 9.21 "efficiency" is the single element efficiency, including Carnot, (Equation 9.35) from the hot end (700 C) to the point in question.

Appendix IV :

Spreadsheet Calculation of n-Type Element Performance

Material	T(K)	α (μV/K)	ρ (10^{-3} Ω cm)	κ (mW/cm K)	zT	Max Red Eff (%)	s (1/V)	u (1/V)	Red Eff (%)	uκdT (A/cm)	JI(x) (A/cm)	Φ (V)	Efficiency (%)
Metal	975	0	0.0200	1190	0.00	0.00	0.00	−1.8558	−7.99		0.00	−0.53886	
Metal	974	0	0.0200	1188	0.00	0.00	0.00	−1.8556	−7.97	−2.2062	−2.21	−0.53891	−0.01
Contact	974	0	10.000	0.00238	0.00	0.00	0.00	−1.8556	−7.97	0	−2.21	−0.53891	−0.01
Contact	973	0	10.000	0.00237	0.00	0.00	0.00	−1.8555	−7.95	-4.41×10^{-6}	−2.21	−0.53895	−0.02
n-$CoSb_3$	973	−186	0.981	42.74	0.80	14.62	−1.89	−1.7929	12.43	0	−2.21	−0.53895	−0.02
n-$CoSb_3$	948	−188	0.985	41.86	0.82	14.80	−1.95	−1.7886	12.95	−2.5512	−5.16	−0.53716	0.32
n-$CoSb_3$	923	−191	0.983	41.02	0.83	14.95	−2.00	−1.7828	13.41	−2.8861	−8.04	−0.53526	0.67
n-$CoSb_3$	898	−193	0.991	40.24	0.84	15.07	−2.05	−1.7754	13.80	−2.8229	−10.87	−0.53326	1.04
n-$CoSb_3$	873	−194	0.992	39.50	0.84	15.14	−2.10	−1.7666	14.12	−2.7621	−13.63	−0.53115	1.43
n-$CoSb_3$	848	−196	0.993	38.83	0.84	15.17	−2.15	−1.7560	14.36	−2.7040	−16.33	−0.52895	1.84
n-$CoSb_3$	823	−197	0.993	38.23	0.84	15.15	−2.20	−1.7437	14.52	−2.6451	−18.98	−0.52667	2.26
n-$CoSb_3$	798	−198	0.992	37.71	0.84	15.08	−2.25	−1.7296	14.59	−2.5979	−21.58	−0.52431	2.70
n-$CoSb_3$	773	−198	0.989	37.27	0.83	14.94	−2.29	−1.7137	14.57	−2.5509	−24.13	−0.52183	3.15
n-$CoSb_3$	748	−198	0.985	36.93	0.81	14.73	−2.33	−1.6959	14.46	−2.5086	−26.64	−0.51940	3.61
n-$CoSb_3$	723	−198	0.979	36.68	0.79	14.45	−2.36	−1.6762	14.26	−2.4715	−29.11	−0.51687	4.03
n-$CoSb_3$	698	−197	0.972	36.55	0.76	14.09	−2.38	−1.6546	13.95	−2.4401	−31.55	−0.51431	4.56
n-$CoSb_3$	673	−196	0.963	36.54	0.73	13.65	−2.40	−1.6312	13.56	−2.4147	−33.97	−0.51174	5.03
n-$CoSb_3$	648	−194	0.952	36.65	0.70	13.13	−2.41	−1.6061	13.07	−2.3956	−36.36	−0.50913	5.51
n-$CoSb_3$	623	−191	0.939	36.89	0.66	12.54	−2.41	−1.5794	12.49	−2.3832	−38.74	−0.50663	5.93
n-$CoSb_3$	598	−188	0.924	37.25	0.61	11.87	−2.40	−1.5514	11.83	−2.3774	−41.12	−0.50412	6.45
n-$CoSb_3$	573	−184	0.907	37.75	0.56	11.13	−2.38	−1.5222	11.10	−2.3783	−43.50	−0.50165	6.90
n-$CoSb_3$	548	−179	0.883	38.37	0.51	10.34	−2.35	−1.4921	10.31	−2.3855	−45.89	−0.49923	7.34
n-$CoSb_3$	523	−174	0.867	39.10	0.46	9.51	−2.32	−1.4617	9.48	−2.3984	−48.28	−0.49699	7.77
n-$CoSb_3$	498	−168	0.845	39.92	0.41	8.65	−2.27	−1.4313	8.62	−2.4164	−50.70	−0.49480	8.13
n-$CoSb_3$	473	−161	0.822	40.82	0.37	7.80	−2.22	−1.4014	7.75	−2.4387	−53.14	−0.49273	8.56
n-$CoSb_3$	448	−155	0.799	41.79	0.32	6.95	−2.16	−1.3725	6.89	−2.4649	−55.60	−0.49077	8.92
n-$CoSb_3$	440	−153	0.791	42.12	0.31	6.69	−2.13	−1.3637	6.62	−0.7948	−56.40	−0.49019	9.03
Metal	440	0	0.0200	537	0.00	0.00	0.00	−1.0400	−1.97	0	−56.40	−0.49019	9.03
Metal	439	0	0.0200	536	0.00	0.00	0.00	−1.0399	−1.96	−1.0938	−57.49	−0.49021	9.03
Contact	439	0	10.000	0.00107	0.00	0.00	0.00	−1.0399	−1.96	0	−57.49	−0.49021	9.03
Contact	438	0	10.000	0.00107	0.00	0.00	0.00	−1.0398	−1.95	-2.18×10^{-6}	−57.49	−0.49024	9.02
n-Bi_2Te_3	438	−161	2.88	12.78	0.71	6.68	−2.03	−1.3816	6.51	0	−57.49	−0.49024	9.02
n-Bi_2Te_3	423	−171	2.92	12.07	0.75	7.52	−2.25	−1.3999	7.49	−0.4454	−57.94	−0.48803	9.25
n-Bi_2Te_3	398	−187	2.94	10.92	0.84	9.02	−2.66	−1.4272	8.96	−0.6933	−58.63	−0.48657	9.70

(continued on next page)