LOW TEMPERATURE PHONON RESISTIVITY OF METALS; A COMPARISON AMONG DIFFERENT SYSTEMS

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From reviewed experimental results[1,2] it can be easily seen, that temperature dependent part of the low temperature resistivity of metals and dilute nonmagnetic alloys has temperature dependence $\rho_T-\rho_0 \propto T^n$, where n varies between 3 and 4 for the most systems. That particularly holds for Al[3] and Ga. From the newest results[4] one can believe that the same is true for noble metals, providing they are free of magnetic impurities. Only for Zn and In holds $n \cong 5$.

The aim of this paper is to look whether it is possible to extrapolate, from the existing experimental data, the Bloch-Grüneissen term T^5 in temperature dependent part of low temperature resistivity. Assuming relation $\rho_T-\rho_0=BT^5+\Delta$ (Δ is the deviation from Matthiessen's rule) we tabulated the values of B extrapolated by three different ways:

- B_N, calculated from relation $B_N=497.6\frac{\rho_\theta}{\Theta^5}$ which folows[5] from Bloch-Grüneissen equation assuming that only N processes in electron-phonon scattering are relevant;
- $B_{p.l.}$, which is extrapolated by the use of "pure limit" values[2] of $\{\rho_T-\rho_0\}$ assuming that in pure limit n=5 and $\Delta=0$;
- B_{imp}, extrapolated in impure region of dilute alloys using[3] the plot $(\rho_T-\rho_0)_{imp}=AT^3+B_{imp}T^5$.

Such approach is somewhat conditional. First of all it follows from equation for B_N, that there is no true T^5 dependence of $\rho_T-\rho_0$ even for N processes because θ is temperature dependent in low temperature region, and its temperature dependence is not exactly known. Nevertheless by the proposed method we can obtain some usefull information on $\rho(T)$ and $\theta(T)$ behaviour.

Unfortunately pure limit values of $\rho_T-\rho_0$ were not obtained for the most of metals at the lowest T, and for some of them (alkali metals for instance) they were not obtained at all in relevant temperature region ($T<\frac{\theta}{15}$). Even worse is situation with

	$\theta_R(K)$ $\theta_0(K)$	ρ_θ $(10^{-16}\Omega cm)$	B_N $(10^{-16}\frac{\Omega cm}{K^5})$	T(K)	$(\rho_T-\rho_0)_{p.1.}$ $10^{-9}\Omega cm$	$B_{p.1.}$ $(10^{-16}\frac{\Omega cm}{K^5})$	B_{imp} $(10^{-16}\frac{\Omega cm}{K^5})$
Li	440	14,82	4.5	20	20	62	-
	370	12.17	8.7	40	150	14	
K	110	2.12	650	4	0.20	1900	-
	89	1.59	1400	10	12	1200	
Cu	320	1.87	2.8	15.7	0.25	2.6	1,2 ± 0,4
	340	2.00	2.2	23.4	1.65	2.4	
Ag	200	1.04	16.2	10	0,11	11	9 ± 3
	226	1.14	9.6				
Au	200	1.44	22	7.2	0.13	77	-
				10.7	0.75	53	
	162	1.14	51	20	12.5	39	
Mg	340	5.03	5.5	14.9	2.5	34	-
	395	5.94	3.1	23.8	11	14	
Zn	175	3.28	100	7	0.26	150	-
				10	1.3	130	
	310	6.24	11	20	31	100	
Al	395	3.866	2.0	4.2	0.008	60	2.2±0.3
			1.5	14	0.1	1.9	
	428	4.236		20	0.7	2.2	
Ga	215	10.37	110	4.2	0.05	380	-
	325	16.5	23				
In	-	-	-	4.2	0.30	2300	2300 to 5500
	111	2.71	800				
Sn	183	6.30	150	4.2	0.075	570	-
	195	6.79	120	9.3	4.4	630	
Pt	240	8.31	52	10.5	2.8	220	-
	240	8.31	52	20.3	40	120	

B_{imp}, due to the lack of experimental results.

From the Table 1. we see reasonable agreement among B_N, B_{pl} and B_{imp}. The agreement is very good for the metals with simpler Fermi surfaces (Ag,Cu,Au and Al).From decreasing of B_{pl} with T we can conclude that even for the purest sample there exists an additional term in resistivity (beside T^5 term) which depends on temperature slower than T^5.

References:

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