ARDB-42 David Pritzkau 3/25/97

Pulsed Temperature Rise - Update of ARDB-5

In ARDB-5[1] it was shown that the amount of temperature rise due to pulsed heating can be reduced by lowering the operating temperature. There has been some light debate over how much this reduction will be. It is the purpose of this note to update these calculations with recent data on the properties of pure copper.

Given in Table 1 is the data for the thermal conductivity of copper[2]. Table 2 contains the data for the electrical resistivity of copper[3]. Given below is the formula used to obtain the heat capacity of copper at constant volume[4]

$$C_V = R\left[\frac{36}{x^3}\int_0^x \frac{y^3 dy}{e^y - 1} - \frac{9x}{e^x - 1}\right]$$

$$x = \frac{\theta_D}{T} \qquad \theta_D = 343K$$

where R=8.3143 J/mole-K, θ_d is the Debye temperature for copper and T is the temperature in °K. Table 3 contains all of the data that share the same temperature.

From ARDB-5 we know that the temperature rise scales as

$$\Delta T \propto \sqrt{\frac{\rho}{CK}}$$

where ρ is the resistivity, C is the heat capacity and K is the thermal conductivity. A plot of ΔT as a function of temperature is given in Fig.1. ΔT is scaled with respect to T=300K. The data was fit to a polynomial of order 6 and is also shown in Fig.1. The plot gives

$$\frac{\Delta T(77K)}{\Delta T(300K)} = 0.39$$

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[1] R. Siemann, "Pulsed Temperature Rise", ARDB-5

[2] D.R. Lide, editor, Handbook of Chemistry and Physics, 77th ed. 1996-1997, p.12-174

[3] D.R. Lide, editor, Handbook of Chemistry and Physics, 77th ed. 1996-1997, p.12-40

[4] Furukawa, G.T. and Douglas, T.B., American Institute of Physics Handbook, 3rd ed. "Heat Capacities" p.4-113

TABLE 1

T(K)	Thermal Conductivity (W/m-K)
1	4220
2	8400
3	12500
4	16200
5	19500
6	22200
7	23900
8	24800
9	24900
10	24300
15	17100
20	10800
30	4450
40	2170
50	1250
60	829
70	647
80	557
90	508
100	482
150	429
200	413
250	406
300	401
350	396
400	393
500	386
600	379
800	366
1000	352
1200	339

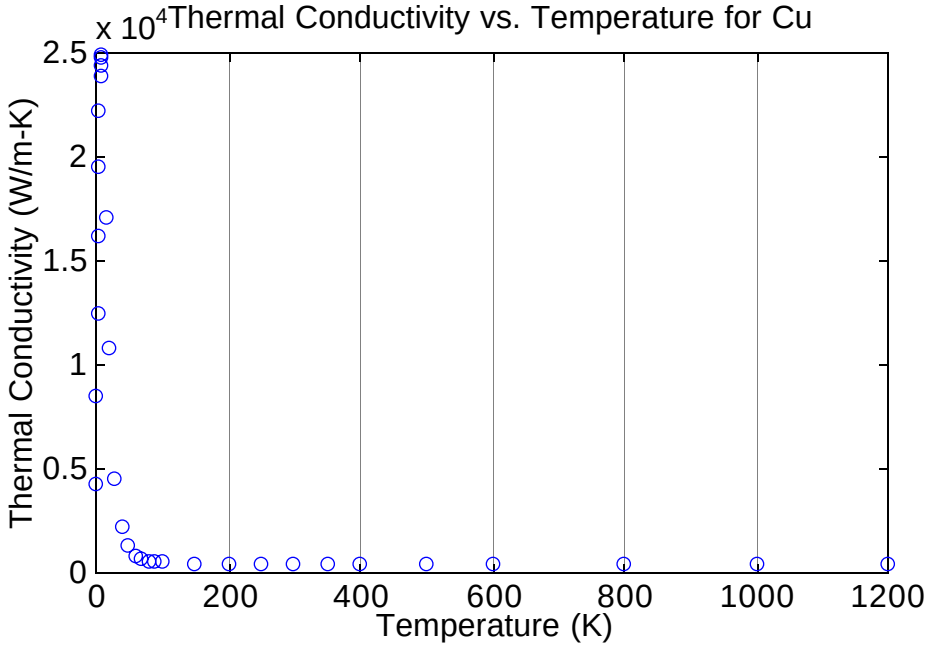

TABLE 2

T(K)	Resistivity (10^(-8) Ohm-m)
1	0.002
10	0.00202
20	0.0028
40	0.0239
60	0.0971
80	0.215
100	0.348
150	0.699
200	1.046
273	1.543
293	1.678
298	1.712
300	1.725
400	2.402
500	3.09
600	3.792
700	4.514
800	5.262
900	6.041

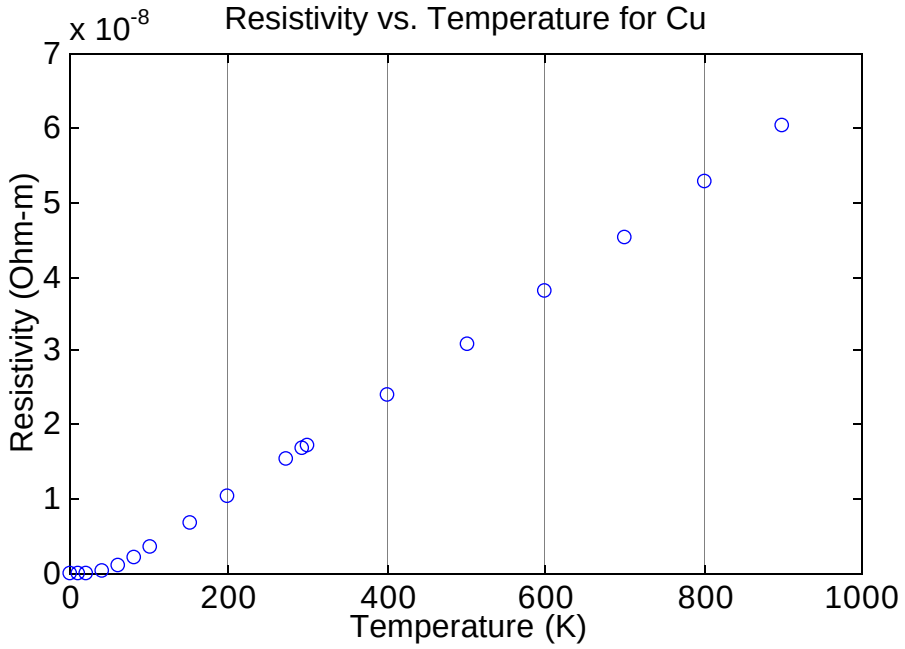

TABLE 3

T(K)	K(W/m-K)	Rho(100 Ohm-nm)	C(J/mol-K)	DeltaT(K)
10	24300	0.00202	0.0482	0.097
20	10800	0.0028	0.386	0.060
40	2170	0.0239	2.88	0.144
60	829	0.0971	7.28	0.296
80	557	0.215	11.52	0.427
100	482	0.348	14.78	0.515
150	429	0.699	19.48	0.675
200	413	1.046	21.65	0.798
300	401	1.725	23.4	1.000
400	393	2.402	24.07	1.175
500	386	3.09	24.39	1.336
600	379	3.792	24.56	1.489
800	366	5.262	24.74	1.778

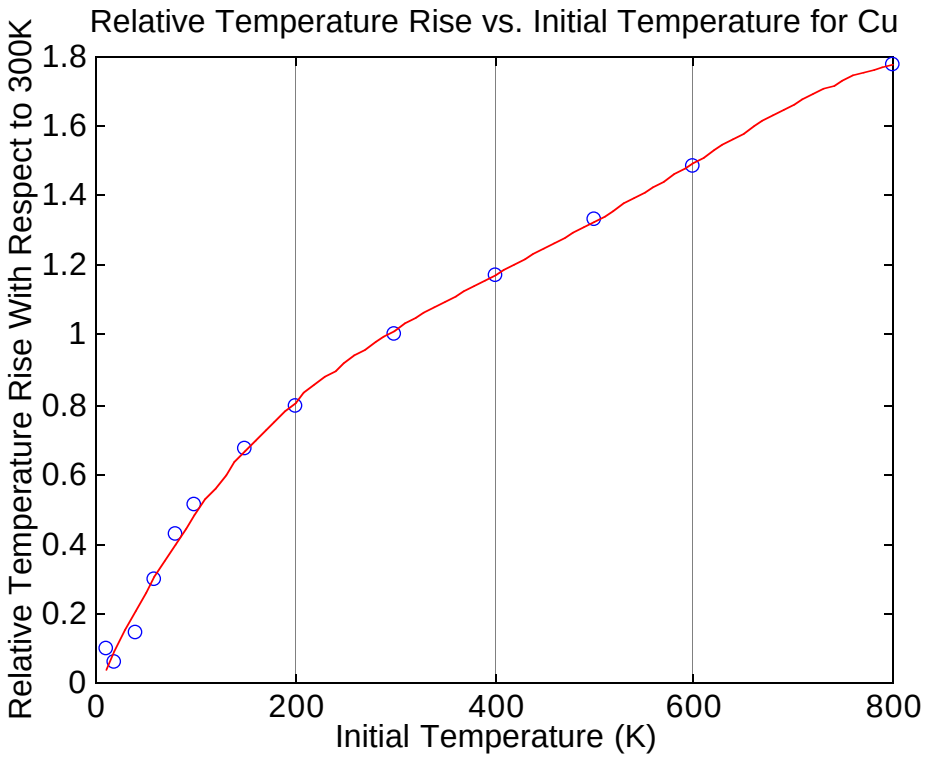

FIG 1