HIGH TEMPERATURE SUPERCONDUCTORS

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The following tables give properties of a number of high temperature superconductors. Table 1 lists the crystal structure (space group and lattice constants) and the critical transition temperature T_c for the more important high temperature superconductors so far studied. Table 2 gives energy gap, critical current density, and penetration depth in the superconducting state. Table 3 gives electrical and thermal properties of some of these materials in the normal state. The tables were prepared in November 1992 and updated in November 1994.

References

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TABLE 1. Structural Parameters and Approximate T_c Values of High-Temperature Superconductors

Material	Structure	T_c/K (maximum value)
$La_2CuO_{4+\delta}$	Bmab; a = 5.355, b = 5.401, c = 13.15 Å	39
$La_{2-x}Sr_x(Ba_x)CuO_4$	I4/mmm; a = 3.779, c = 13.23 Å	35
$La_2Ca_{1-x}Sr_xCu_2O_6$	I4/mmm; a = 3.825, c = 19.42 Å	60
$YBa_2Cu_3O_7$	Pmmm; a = 3.821, b = 3.885, c = 11.676 Å	93
$YBa_2Cu_4O_8$	Ammm; a = 3.84, b = 3.87, c = 27.24 Å	80
$Y_2Ba_4Cu_7O_{15}$	Ammm; a = 3.851, b = 3.869, c = 50.29 Å	93
$Bi_2Sr_2CuO_6$	Amaa; a = 5.362, b = 5.374, c = 24.622 Å	10
$Bi_2CaSr_2Cu_2O_8$	A_2aa; a = 5.409, b = 5.420, c = 30.93 Å	92
$Bi_2Ca_2Sr_2Cu_3O_{10}$	A_2aa; a = 5.39, b = 5.40, c = 37 Å	110
$Bi_2Sr_2(Ln_{1-x}Ce_x)_2Cu_2O_{10}$	P4/mmm; a = 3.888, c = 17.28 Å	25
$Tl_2Ba_2CuO_6$	A_2aa; a = 5.468, b = 5.472, c = 23.238 Å; I4/mmm; a = 3.866, c = 23.239 Å	92
$Tl_2CaBa_2Cu_2O_8$	I4/mmm; a = 3.855, c = 29.318 Å	119
$Tl_2Ca_2Ba_2Cu_3O_{10}$	I4/mmm; a = 3.85, c = 35.9 Å	128
$Tl(BaLa)CuO_5$	P4/mmm; a = 3.83, c = 9.55 Å	40
$Tl(SrLa)CuO_5$	P4/mmm; a = 3.7, c = 9 Å	40
$(Tl_{0.5}Pb_{0.5})Sr_2CuO_5$	P4/mmm; a = 3.738, c = 9.01 Å	40
$TlCaBa_2Cu_2O_7$	P4/mmm; a = 3.856, c = 12.754 Å	103
$(Tl_{0.5}Pb_{0.5})CaSr_2Cu_2O_7$	P4/mmm; a = 3.80, c = 12.05 Å	90
$TlSr_2Y_{0.5}Ca_{0.5}Cu_2O_7$	P4/mmm; a = 3.80, c = 12.10 Å	90
$TlCa_2Ba_2Cu_3O_8$	P4/mmm; a = 3.853, c = 15.913 Å	110
$(Tl_{0.5}Pb_{0.5})Sr_2Ca_2Cu_3O_9$	P4/mmm; a = 3.81, c = 15.23 Å	120
$TlBa_2(La_{1-x}Ce_x)_2Cu_2O_9$	I4/mmm; a = 3.8, c = 29.5 Å	40
$Pb_2Sr_2La_{0.5}Ca_{0.5}Cu_3O_8$	Cmmm; a = 5.435, b = 5.463, c = 15.817 Å	70
$Pb_2(Sr,La)_2Cu_2O_6$	P22$_1$2; a = 5.333, b = 5.421, c = 12.609 Å	32
$(Pb,Cu)Sr_2(La,Ca)Cu_2O_7$	P4/mmm; a = 3.820, c = 11.826 Å	50
$(Pb,Cu)(Sr,Eu)(Eu,Ce)Cu_2O_x$	I4/mmm; a = 3.837, c = 29.01 Å	25
$Nd_{2-x}Ce_xCuO_4$	I4/mmm; a = 3.95, c = 12.07 Å	30
$Ca_{1-x}Sr_xCuO_2$	P4/mmm; a = 3.902, c = 3.35 Å	110
$Sr_{1-x}Nd_xCuO_2$	P4/mmm; a = 3.942, c = 3.393 Å	40
$Ba_{0.6}K_{0.4}BiO_3$	Pm3m; a = 4.287 Å	31
Rb_2CsC_{60}	a = 14.493 Å	31
$NdBa_2Cu_3O_7$	Pmmm; a = 3.878, b = 3.913, c = 11.753	58
$SmBaSrCu_3O_7$	I4/mmm; a = 3.854, c = 11.62	84
$EuBaSrCu_3O_7$	I4/mmm; a = 3.845, c = 11.59	88
$GdBaSrCu_3O_7$	I4/mmm; a = 3.849, c = 11.53	86
$DyBaSrCu_3O_7$	Pmmm; a = 3.802, b = 3.850, c = 11.56	90
$HoBaSrCu_3O_7$	Pmmm; a = 3.794, b = 3.849, c = 11.55	87
$ErBaSrCu_3O_7$ (multiphase)	Pmmm; a = 3.787, b = 3.846, c = 11.54	82
$TmBaSrCu_3O_7$ (multiphase)	Pmmm; a = 3.784, b = 3.849, c = 11.55	88
$YBaSrCu_3O_7$	Pmmm; a = 3.803, b = 3.842, c = 11.54	84
$HgBa_2CuO_4$	I4/mmm; a = 3.878, c = 9.507	94
$HgBa_2CaCu_2O_6$ (annealed in O_2)	I4/mmm; a = 3.862, c = 12.705	127
$HgBa_2Ca_2Cu_3O_8$	Pmmm; a = 3.85, c = 15.85	133
HgBa2Ca3Cu4O10	Pmmm; a = 3.854, c = 19.008	126

TABLE 2. Superconducting Properties

J_c (0): Critical current density extrapolated to 0 K
λ_{ab}: Penetration depth in *a*-*b* plane
k_B: Boltzmann constant

Material	Form	Energy gap (Δ) $2\Delta_{pp}/k_BT_c$*	Energy gap (Δ) $2\Delta_{fit}/k_BT_c$†	$10^{-6} \times J_c$ (0)/A cm^{-2}	λ_{ab}/Å
$YBa_2Cu_3O_7$	Single Crystal	5–6	4–5	30 (film)	1400
$Bi_2Sr_2CaCu_2O_8$	Single Crystal	8–9	5.5–6.5	2	2700
$Tl_2Ba_3CaCu_2O_8$	Ceramic	6–7	4–6	10 (film, 80 K)	2000
$La_{2-x}Sr_xCuO_4$, x = 0.15	Ceramic	7–9	4–6		
$Nd_{2-x}Ce_xCuO_4$	Ceramic	8	4–5	0.2 (film)	

* Obtained from peak to peak value.
† Obtained from fit to BCS-type relation.

TABLE 3. Normal State Properties

ρ_{ab}: Resistivity in the *a*-*b* plane
ρ_c: Resistivity along the *c* axis
+ve: ρ_c has positive temperature coefficient of resistivity
−ve: ρ_c has negative temperature coefficient of resistivity
n_H: Hall density
k: Thermal conductivity
in plane: Along *a*-*b* plane
out of plane: Perpendicular to *a*-*b* plane

Material	Form	ρ_{ab}/μΩ cm 300 K	ρ_{ab}/μΩ cm 100 K	ρ_c/mΩ cm 300 K	$d\rho_c/dT$	$10^{-21} \times n_H$/cm^{-3} 300 K	$10^{-21} \times n_H$/cm^{-3} 100 K	*k*/(mW/cm K) at 300 K in plane	*k*/(mW/cm K) at 300 K out of plane
$YBa_2Cu_3O_7$	Single crystal	110	35	5	+ve	11–16	4–6	120	3
	Film	200–300	60–100			5–9	2–3		
$YBa_2Cu_4O_8$	Single crystal	75	20	10	−ve	14			
	Film	100–200	20–50			22	17		
$Bi_2Sr_2CuO_6$	Single crystal	300	150	5000	−ve	6	5		
$Bi_2Sr_2CaCu_2O_8$	Single crystal	150	50	>1000	−ve	4	3	60	8
$Tl_2Ba_2CuO_6$	Single crystal	300–400	50–75	200–300	+ve	3.1	2.5		
$Tl_2Ba_2Ca_2Cu_3O_{10}$	Ceramic	***	**				≈ 2*		
$La_{2-x}Sr_xCuO_4$, *x* = 0.12	Single crystal	900	350	200	+ve for *T* >225 K	2.5			
$La_{2-x}Sr_xCuO_4$, *x* = 0.20	Single crystal	400	200	80	+ve for *T* >150 K	10		50 (for *x* = 0.04)	20
	Film	400	160			8.4	6.3		
$Nd_{2-x}Ce_xCuO_4$, *x* = 0.17	Single crystal	500	275			53	17		
x = 0.15	Film	140–180	35			32	11	250 (for *x* = 0.15)	

* At 200 K
** ρ ~0.4 mΩ cm at 120 K
*** ρ ~1.5 mΩ cm at 300 K