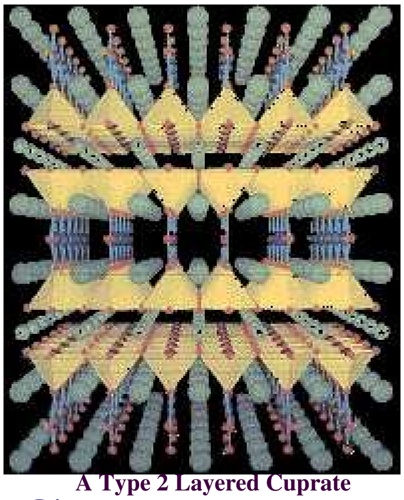


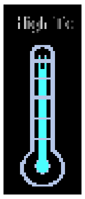
A Type 2 Layered Cuprate

Type 2 Superconductors

Except for the elements vanadium, technetium and niobium, the Type 2 category of superconductors i comprised of metallic compounds and alloys. The recently-discovered superconducting "perovskites" (metal-oxide ceramics that normally have a ratio of 2 metal atoms to every 3 oxygen atoms) belong to thi Type 2 group. They achieve higher Tc's than Type 1 superconductors by a mechanism that is still not completely understood. Conventional wisdom holds that it relates to the planar layering within the cryst structure (see above graphic). Although, other recent research suggests the holes of hypocharged oxygen in the charge reservoirs are responsible. (Holes are positively-charged vacancies within the lattice.) The superconducting cuprates (copper-oxides) have achieved astonishingly high Tc's when you consider that 1985 known Tc's had only reached 23 K. To date, the highest Tc attained at ambient pressure has been 1 K. One theory (V. Kresin, et al) predicts an upper limit of about 200 K for the layered cuprates. Others a *there is no limit*. Either way, it is almost certain that other, more-synergistic compounds still await discov among the high-temperature superconductors.

The first superconducting Type 2 compound, an alloy of lead and bismuth, was fabricated in 1930 by de Haas and J. Voogd. But, was not recognized as such until much later, after the Meissner effect had been discovered. Type 2 superconductors - also known as the "hard" superconductors - differ from Type 1 in their transition from a normal to a superconducting state is gradual across a region of "mixed state" beh A Type 2 will also allow *some* penetration by an external magnetic field into its surface. A Type 1 will not. While there are far too many to list in totality, some of the more interesting Type 2 superconductors are below by similarity and with descending Tc's.

$Hg_{0.8}Tl_{0.2}Ba_2Ca_2Cu_3O_{8.33}$*	**138 K (record-holder)**
$HgBa_2Ca_2Cu_3O_8$	**133-135 K**
$HgBa_2Ca_{1-x}Sr_xCu_2O_{6+}$	**123-124 K**
$HgBa_2CuO_4+$	**94-98 K**



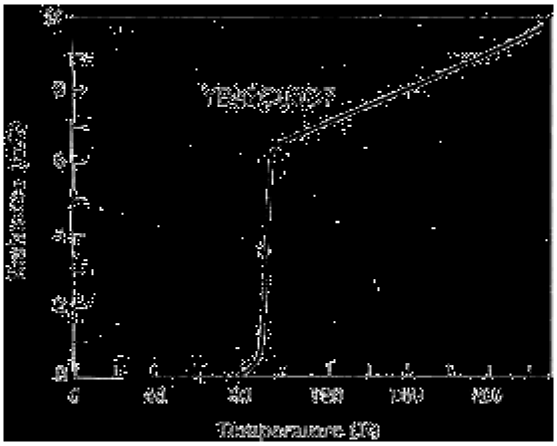
*** Note that the ratio of Hg to Tl is close to that of the eutectic of mercury when alloyed with thallium.**

$Tl_{1.6}Hg_{0.4}Ba_2Ca_2Cu_3O_{10+}$ 130 K
$Tl_2Ba_2Ca_2Cu_3O_{10}$ 127 K
$TlBa_2Ca_2Cu_3O_{9+}$ 123 K
$Tl_{0.5}Pb_{0.5}Sr_2Ca_2Cu_3O_9$ 120 K
$TlBa_2Ca_3Cu_4O_{11}$ 112 K
$Tl_2Ba_2Ca_3Cu_4O_{12}$ 112 K

$Bi_{1.6}Pb_{0.6}Sr_2Ca_2Sb_{0.1}Cu_3O_x$ 115 K (thick film on MgO substrate)
$Bi_2Sr_2Ca_2Cu_3O_{10}$ 110 K
$Bi_2Sr_2CaCu_2O_9$ 110 K (click here to see structure)
$Bi_2Sr_2CaCu_2O_8$ 80K

Note: Though not always listed as a component, a small amount of lead (x=.2-.26) is often used with bism compounds to help facilitate a higher-Tc crystalline phase.

$Ca_{1-x}Sr_xCuO_2$ 110 K (Highest-Tc 4-element compound)



$TmBa_2Cu_3O_7$ 90 - 101 K (dicrep. between sources)
$GdBa_2Cu_3O_7$ 94 K
$YBa_2Cu_3O_{7+}$ 93 K (See above graphic)
$Y_2Ba_4Cu_7O_{15}$ 93 K
$Yb_{0.9}Ca_{0.1}Ba_{1.8}Sr_{0.2}Cu_4O_8$ 86 K
$YbBa_{1.6}Sr_{0.4}Cu_4O_8$ 78 K

Note: As can be seen, most "1-2-3" superconductors have a rare-earth element in the first metal position

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$(Ba,Sr)CuO_2$	**90 K**	**(infinite layer)**

$(Sr,Ca)_5Cu_4O_{10}$	**70 K**
$Pb_2Sr_2YCu_3O_8$	**70 K**
$GaSr_2(Y, Ca)Cu_2O_7$	**70 K**
$(La,Sr,Ca)_3Cu_2O_6$	**58 K**
$(Eu,Ce)_2(Ba,Eu)_2Cu_3O_{10+}$	**43 K**
SrNdCuO**	**40 K**
$La_{1.85}Sr_{0.15}CuO_4$	**40 K**
$(La,Ba)_2CuO_4$	**35-38 K**
$La_{1.85}Ba_{.15}CuO_4$	**35 K (First ceramic SC discovered - 1986)**
$(Nd,Sr,Ce)_2CuO_4$	**35 K**
$Pb_2(Sr,La)_2Cu_2O_6$	**32 K**

**** First ceramic superconductor discovered without a non-superconducting oxide layer.**

Note: All of the above are cuprate perovskites, even though their metal-to-oxygen ratios are not exactly 2-to-3. The best performers are those compounds that contain one or more of the electron-emitters BaO, or CaO, along with a Period 6 heavy metal like mercury, thallium or bismuth.

Cs_3C_{60}	**40 K**	**(Highest-Tc Fulleride)**
MgB_2	**39 K**	**(Highest Tc Non-Fullerene Alloy)**
$Ba_{0.6}K_{0.4}BiO_3$	**30 K**	**(First 4th order phase)**

Nb_3Ge	**23.2 K**
Nb_3Si	**19 K**
Nb_3Sn	**18.1 K**
Nb_3Al	**18 K**
V_3Si	**17.1 K**
Ta_3Pb	**17 K**
V_3Ga	**16.8 K**
Nb_3Ga	**14.5 K**
V_3In	**13.9 K**

Note: Among the alloys, these are some of the best performers; combining Group 5B metals in a ratio of 3-to-1 with 4A or 3A elements.

$Nb_{0.6}Ti_{0.4}$	**9.8 K**	**(First superconductive wire)**

Nb*	**9.25 K***
Tc	**7.80 K**
V	**5.40 K**

Note: These three are the only elemental Type 2 superconductors.
*** Note2: Unlike most superconductors, the Tc of niobium goes DOWN under pressure.**

$HoNi_2B_2C$	**7.5 K**	**(Borocarbide)**
Fe_3Re_2	**6.55 K**	
$GdMo_6Se_8$	**5.6 K**	**(Chevrel)**
$CoLa_3$	**4.28 K**	
MnU_6	**2.32 K**	**(Heavy Fermion)**
$AuZn_3$	**1.21 K**	

Note: The above 6 compounds contain elements that are ferromagnetic or anti-ferromagnetic (as oxides). This makes them very reluctant (and unusual) superconductors. See the "Atypical" page for more.

$Sr_{.08}WO_3$	**2-4 K**	**(Tungsten-bronze)**
$Tl_{.30}WO_3$	**2.0-2.14 K**	**(")**
$Rb_{.27-.29}WO_3$	**1.98 K**	**(")**

$AuIn_3$	**0.00005 K**

(First superconductor discovered that's ferromagnetic while superconducting.)

Author's Comment: The Tc's noted on this page were obtained from a variety of sources including, but limited to, the CRC Handbook of Chemistry and Physics, the N.I.S.T. database, Physica C, industry new sources, and various private researchers. In cases where there was a discrepancy between sources, the hi Tc or a range of Tc's has been listed. If you desire the Tc of a compound or alloy not listed on this page, feel free to write.

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