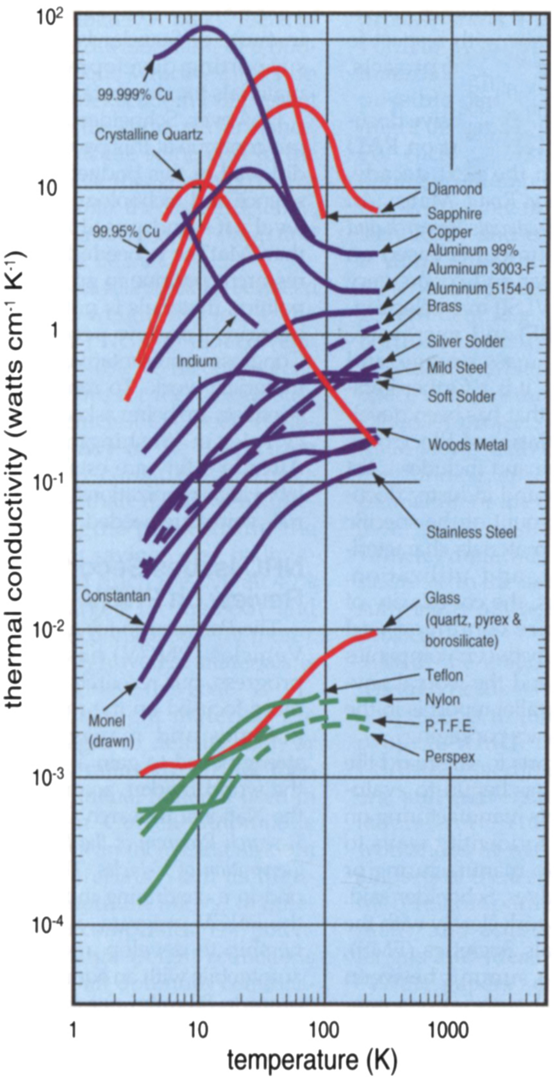
Thermal Conductivity of Common Solids



Heat is transported through solids by electrons and phonons. The overwhelming number of available electrons in metals (blue) makes them more conductive than noncrystalline solids by orders of magnitude, as evinced by the high flying curves for metals (blue) compared to glass (red—at the bottom) and polymers (green). For temperatures below the Debye temperature (above which many modes are excited), crystalline nonmetals such as sapphire conduct quite well by available phonons, which scatter only by temperature-independent processes; thus the conductivity tracks the phonon specific heat, rising as T^3. (Interestingly, perfectly harmonic, scatterless phonons would conduct heat perfectly; the microscopic anharmonicity is macroscopically evident.) Heating beyond the Debye temperature, phonon scattering excites an exponentially growing variety of formerly frozen phonons, and the conductivity drops by T^{-x} with x between 1 and 2. While pure, highly ordered metals have similar lattice mechanisms at work, most metals' low conductivity is limited by electron velocity and mean-free path, leading to a linear rise with temperature as explained by the Drude model.

This Facts & Figures contribution comes from Wright Laboratory (Ohio), a compilation from several anonymous researchers over many years.

TABLE I: Alloy Composition

(wt %)	
Al 3003-F	1.2% Mn, 98.5% Al
Al 5154-0	0.3% Cr, 3.5% Mg, 96% Al
Brass	36% Zn, 3% Pb, 1% Sn, 60% Cu
Mild Steel	0.14% C, 0.08% Si, 0.07% Mn
Soft Solder	60% Sn, 40% Pb
Woods Metal	48% Bi, 13% Sn, 13% Cd, 26% Pb
Silver Solder	50% Ag, 15.5% Cu, 16.5% Zn, 18% Cd
Constantan	60% Cu, 40% Ni
SS 303	18% Ni, 8% Ni, 2% Mn, 1% Si, 0.6% Mo, 0.15% S, 0.2% P, 0.15% C
SS 304	18% Cr, 8% Ni, 2% Mn, 1% Si, 0.08% C, 0.05% P
SS 316	16% Cr, 10% Ni, 2% Mn, 1% Si, 2% Mo, 0.1% C, 0.05% P, 0.03% S
SS 347	18% Cr, 16% Ni, 2% Mn, 1% Si, 0.1% C, 0.05% P, 0.03% S, trace Nb, Ta
Monel	68% Ni, 30% Cu, 1.4% Fe, 1% Mn

Facts & Figures presents graphs, nomographs, tables, charts, and frequently used information of the type compiled by materials researchers and often taped to the walls by their desks. These "cheat sheets" are intended to be not only interesting but useful enough to keep for reference. Please send your comments and any potential material for future publication to Alan Hurd, Sandia National Laboratories, Albuquerque, NM 87185-0609; e-mail ajhurd@sandia.gov.