Conduction

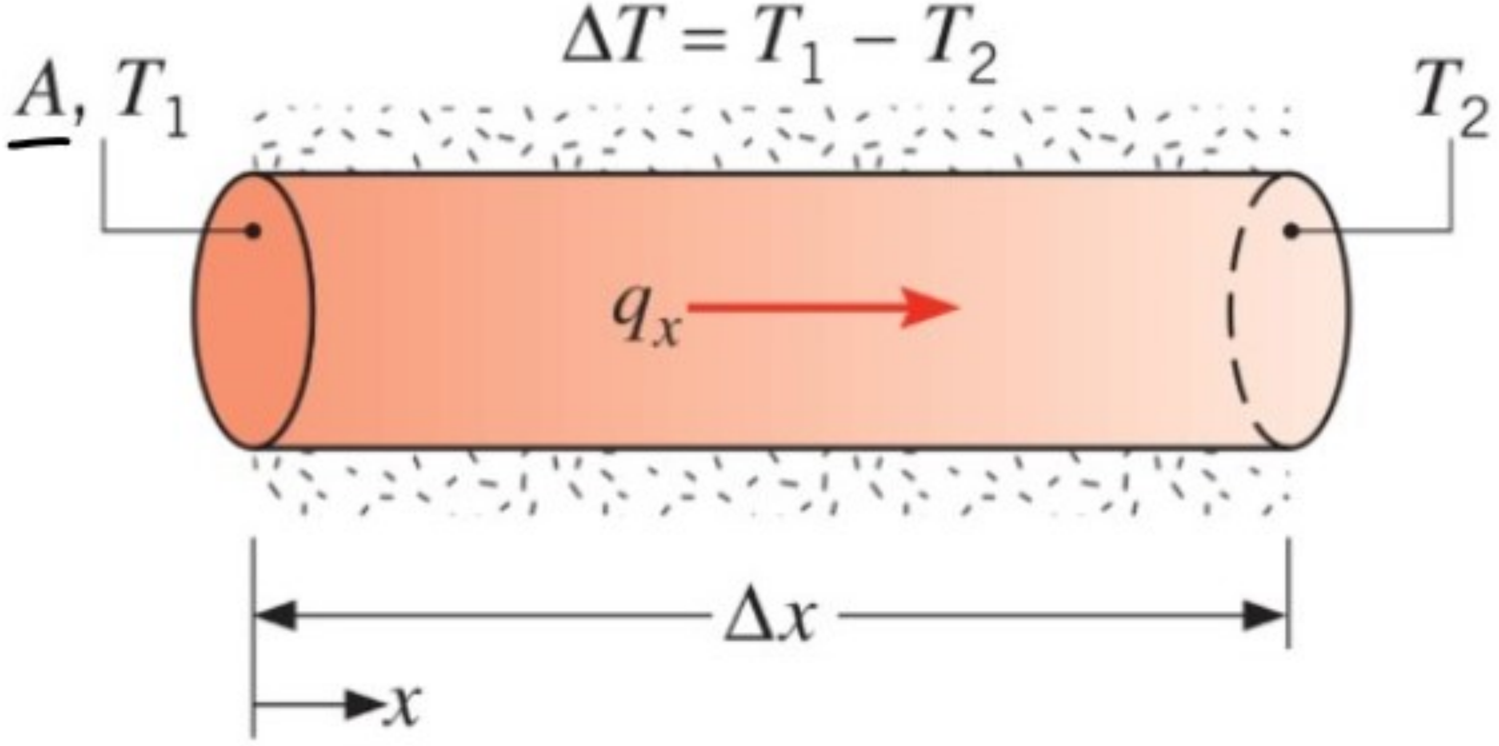
$$q''_x = \frac{q_x}{A} = -K \, dT/dx$$

$$q'' = -K \nabla T$$

$$q''_x = -K \, \partial T/\partial x$$

$$q_x = -KA \, \partial T/\partial x$$

Steve/Markus/
Massiah/
etc.



$$q'' = -k \nabla T$$
$$= -k\left(\hat{i}\frac{\partial T}{\partial x} + \hat{j}\frac{\partial T}{\partial y} + \hat{k}\frac{\partial T}{\partial z}\right)$$

$$q''_x = -k\frac{\partial T}{\partial x}$$

$$q''_y = -k\frac{\partial T}{\partial y}$$

$$q''_z = -k\frac{\partial T}{\partial z}$$

$$k_x \equiv \frac{-q_x''}{\partial T/\partial x}$$

k_x coefficient of thermal conductivity in the x direction

$k_x = k_y = k_z = k$ isotropic

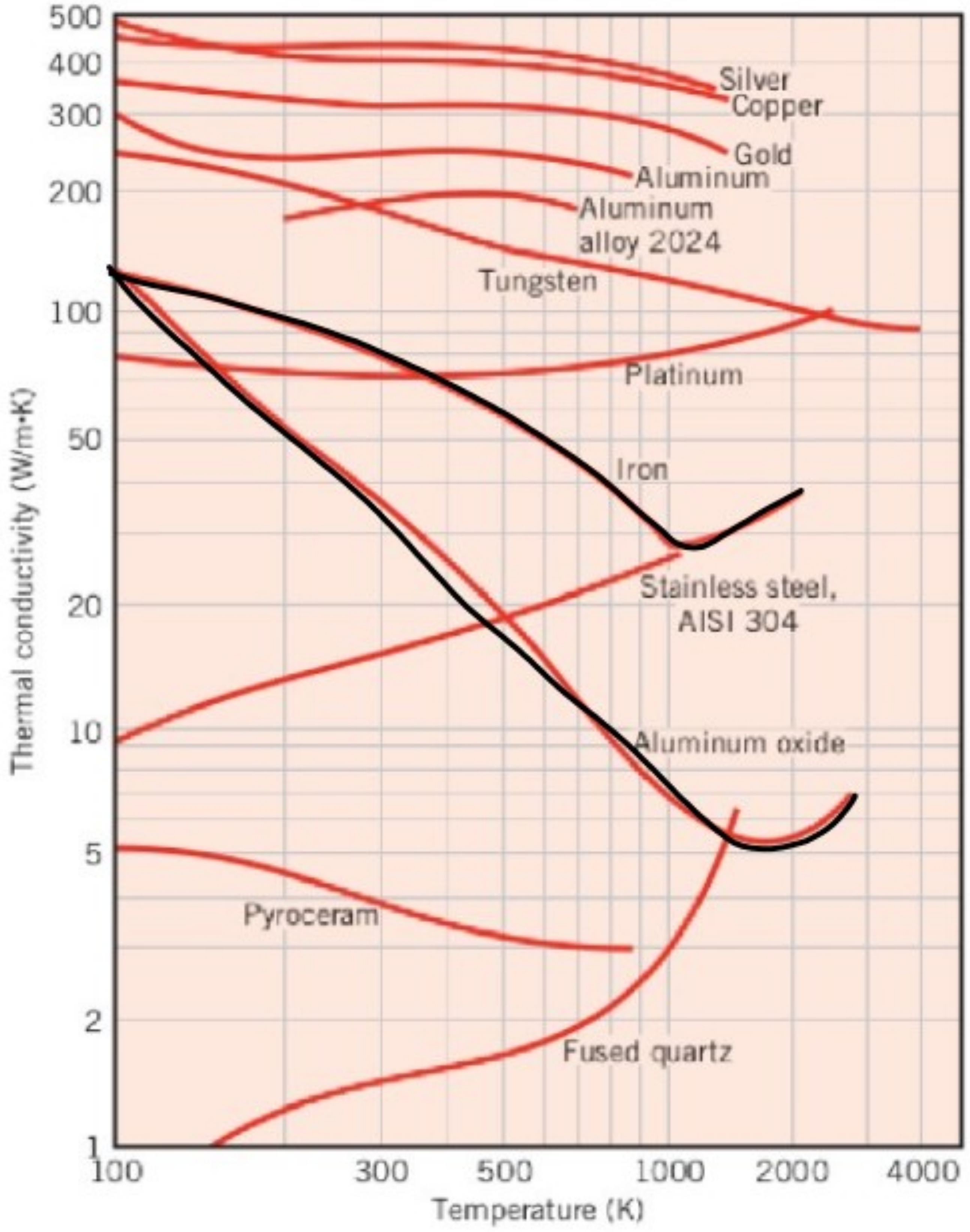
$$q'' = -\left(\frac{\partial}{\partial x}\left(k_x \frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(k_y \frac{\partial T}{\partial y}\right) + \frac{\partial}{\partial z}\left(k_z \frac{\partial T}{\partial z}\right)\right)$$

$$K = \frac{1}{3} C \bar{c} \lambda_{mfp}$$

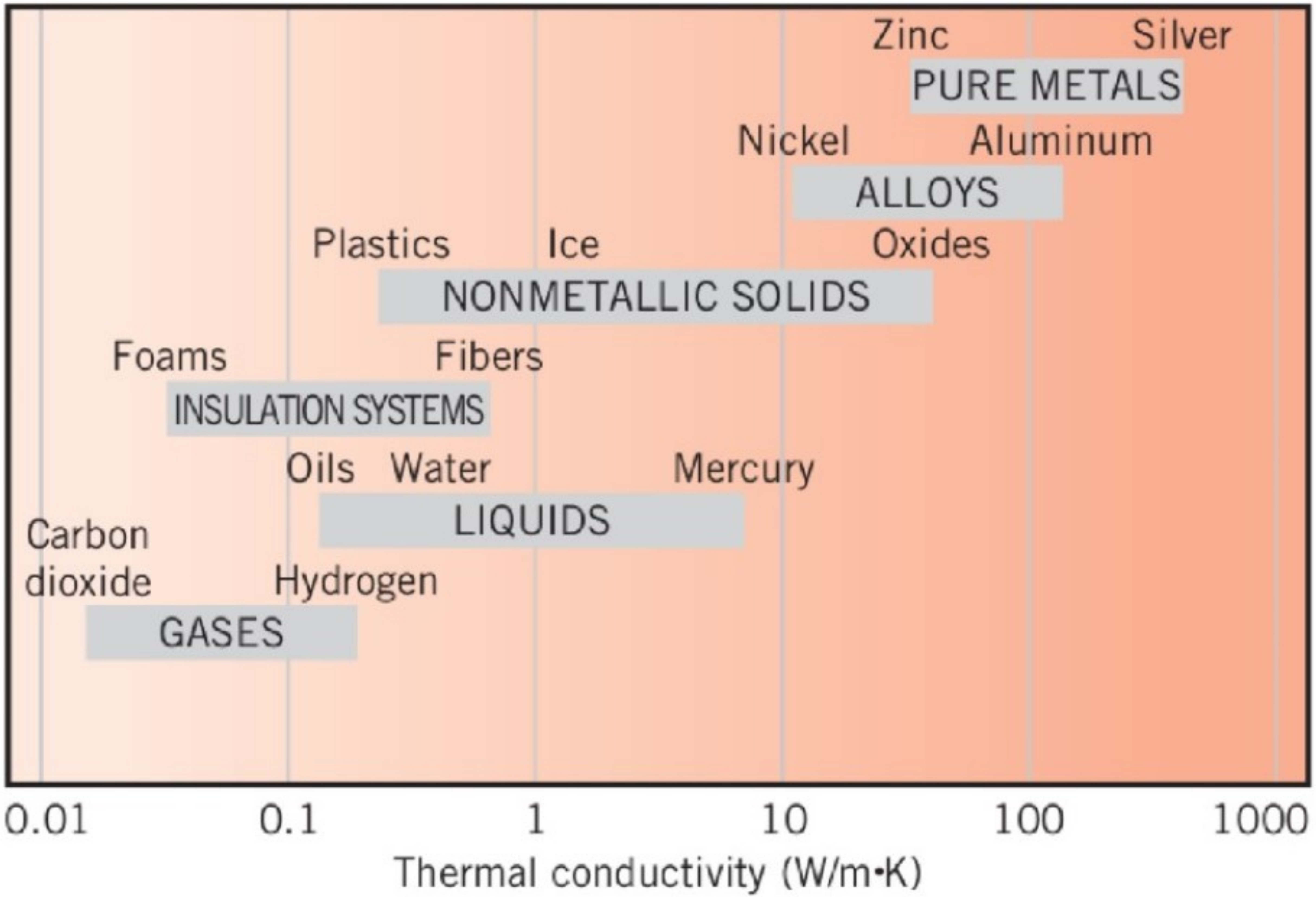
C electron specific heat per unit volume

$\bar{c}$ mean electron velocity

λ_{mfp} phonon mean free path



Silver
Copper
Gold
Aluminum
Aluminum alloy 2024
Tungsten
Platinum
Iron
Stainless steel, AISI 304
Aluminum oxide
Pyroceram
Fused quartz
Thermal conductivity (W/m•K)
Temperature (K)
500
400
300
200
100
50
20
10
5
2
1
100
300
500
1000
2000
4000


Zinc
Silver
PURE METALS
Nickel
Aluminum
ALLOYS
Plastics
Ice
Oxides
NONMETALLIC SOLIDS
Foams
Fibers
INSULATION SYSTEMS
Oils
Water
Mercury
LIQUIDS
Carbon dioxide
Hydrogen
GASES
0.01
0.1
1
10
100
1000
Thermal conductivity (W/m·K)

For fluids

$$K = \frac{1}{3} c_v \rho \bar{c} \lambda_{mfp}$$

c_v specific heat

ρ density

For ideal Gasses

$$\lambda_{mfp} = \frac{k_B T}{\sqrt{2}\, \pi d^2 p}$$

K_B Boltzmann Constant

T temperature

d dia. gas molecules

p pressure

$$K = \frac{9\gamma - 5}{4} \frac{c_v}{\pi d^2} \sqrt{\frac{M k_B T}{N \pi}}$$

$$\gamma = c_p / c_v$$

N Avagadros Number

M Molecular Weight

TABLE 2.1 **Mean free path and critical film thickness for various materials at $T \approx 300$ K [3,4]**

Material	λ_{mfp} **(nm)**	$L_{crit,x}$ **(nm)**	$L_{crit,y}$ **(nm)**
Aluminum oxide	5.08	36	22
Diamond (IIa)	315	2200	1400
Gallium arsenide	23	160	100
Gold	31	220	140
Silicon	43	290	180
Silicon dioxide	0.6	4	3
Yttria-stabilized zirconia	25	170	110